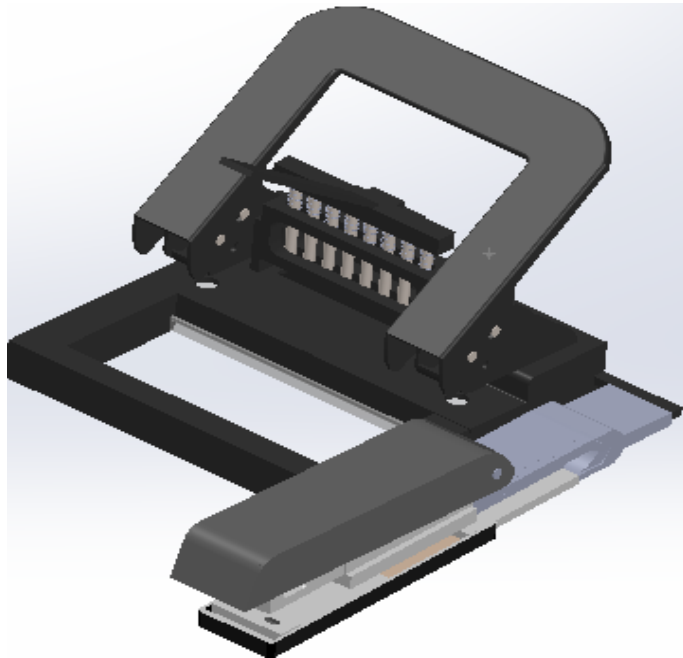




A Report on

Development of Super Binder



A Report on
Development of Super Binder

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Forwarding Letter

14 September, 2019

Dr. A.K.M Kais Bin Zaman

Professor and Head of the Department,

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Dear Sir,

It is our great pleasure to present the report entitled “Development of Super Binder” to you. We are very thankful to you for your kind help to accomplish this product design project.

We know stapler, punch machine alongside with spiral book binder are used in everyday academic works, office works etc. We tried to combine these three equipments in one so that one easily can have the access of three things together which can save our time and effort.

In this report we first made a public survey on our product. Then we did the Quality Function Deployment of our product. After that we did the black box analysis, component hierarchy, functional decomposition. After that we did a qualitative analysis of material, manufacturing process, joining process selection where we showed the material, manufacturing process and joining process needed for each part of the product. Then with help of digital logic and performance index we figured out which material, manufacturing and joining process is selected for each part. Finally we did a cost analysis and sensitivity analysis to find the total cost included to our product.

We would like to express thanks and acknowledgement to our teachers who have helped us to prepare this report.

Sincerely,

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We are also thankful to Mr. Harun of BUET machine shop for helping us with providing information on several processes and materials of our product.

We would like to thank Mr. Abdul Aziz, diploma engineer, owner of a machine shop at Tipu Sultan road, Nobabpur, Dhaka for his cordial help.

Finally, we thank all people who help us in surveying of our product.

Abstract

Stapler, punch machine, book binder are daily used in academic works along with corporate offices. As these 3 things are needed same type of work if we can combine this to a small super binder, this can save our effort and our time. In this report we did several analyses on our product “Super Binder”.

In this report we first did a survey of our product on students, accountant, officer, office assistant etc. Then we did a QFD to our product. After that we did a qualitative analysis on material selection, manufacturing process selection and joining process selection. After that using digital logic and performance index we selected the proper material, manufacturing process and joining process for every component of our product. After that cost analysis is done and sensitivity analysis is done to find all cost related to our product.

Hopefully this report will encourage students to creative designing of a product.

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Chapter 1

Introduction to Super Binder

Since ancient times, paper has been a part and parcel of our day-to-day life. And also, paper binding is a common scenario in our daily life. People of almost all the professions like students, teachers, and officials very often need to bind a bunch of papers in order to create a well-organized system. Generally we use devices like stapler, punch machine, book binder or spiral binder to bind papers together. However, all of these devices have drawbacks of their own. And also, none of these are multi-purpose devices, which mean one device is particularly used for one kind of binding operation only. This got us thinking about a device which will serve various purposes, be feasible, and also cost effective. So we were utterly motivated to create such a product that will ease the daily life operations for almost all kinds of people.

1.1 Description of Super Binder

Super Binder is an assembly of three binding products which are stapler, punch machine; spiral binder .A frame holds all of them. There is enough clearance between the punch cutting edge and the base so that page capacity of Super Binder is higher than normal punch machines. The stapler has one unique feature .It can be moved forward by sliding so that it can staple papers in any distance and position easily. After using the stapler it can be folded so that the product size remains compact to easier placement and carrying. Basically Super Binder will make the holes for the punching purpose. The insertion of spiral wire through the holes can be easily performed manually. So in order to eliminate the complexity of including an electric power system, Super Binder will just perform the punching operation required for the spiral binding.

1.2 Motivation behind Choosing Super Binder

Super Binder is a product by which we can staple, punch and spirally bind papers by a single product. These three operations are mostly used in office works and also important for students. So it is tough to carry all of them at the same time. So our motive is to develop a product which can serve all three operations simultaneously making the job very efficient. It will save time, money and space. Super Binder is capable of serving this purpose.

Again a major problem which is faced by most of the people while binding papers is that regular punch machines cannot punch stack of papers can beyond a certain limit. So for punching large

number of pages, punching needs to be carried out several times. Super Binder removes that constraint. One can punch large number of papers at a time as there is higher clearance between the punch cutting edge and the base. So it is time saving and effective.

And another constraint while stapling is that papers cannot be stapled beyond a certain distance as the normal stapler does not allow penetration of paper through the device. So sometime when it is needed to staple in middle of pages, it cannot be performed using regular staplers. But Super Binder presents a smart solution of this problem. The upper and lower parts of the stapler have a minimum clearance so that paper can penetrate through the stapler without any obstacle. The frame of stapler will slide forward to the position of stapling. This modification will help to eliminate this problem.

Normal spiral binders are huge in size. So it is not possible to carry a spiral binder. The price of a regular spiral binder is also high. The only way to perform the job is to go to the stores. But in Super Binder the size is kept small to make it compact and easy to carry. So anyone can bind their papers by their own. So they don't need to go to the binding shops and wait for a long time.

So Super Binder removes many constraints that we face every day while binding papers. As the operating process is not very complex, anyone can use it without any difficulties. And the price will be reasonable. So it will be affordable for everyone as they are getting three facilities in one product.

1.3 Challenges in Developing Super Binder

Planning about manufacturing a new product is not an easy task. There are many challenges to overcome. Firstly, the overall product is very small in size. Any product that is small in size needs more attention and precision in specifications which is very tough for a new production. Secondly, overcome the limitations of existing binding products like increasing the page capacity and better flexibility. Thirdly, a precise relative motion among components needs to be maintained. Finally, cost effectiveness has to be considered in a realistic approach. These are the main challenges that will be faced in developing the product.

Although the core functionalities of Super Binder are not new, the improvised features of super binder will make the existing products more useful and efficient. So the concept of Super Binder is selected to develop it as a product.

Chapter 2

Survey on Super Binder

Quality is customer satisfaction - so, we set out to know what the possible customers of Super Binder think about this product and what their requirements are. But before that, we prepared ourselves so that we can point out exactly what is the requirement of the customers. We tried to make a well structured and appropriately arranged questionnaire and we think we did that well because almost all the survey participants seemed to understand and answer our questions at the very first time they were asked.

2.1 Methodology

In the case of surveying 'voice of customer' for our product Super Binder, two methods have been implemented.

- i. Direct Interview
- ii. Questionnaire

Variation in methods has led us to gather more data from different types of customer more efficiently. The total number of reviewers is 116. Some important factors that we focused on during the survey are mentioned below:

1. First, we made sure that the survey participant is an appropriate participant, because not everybody requires a stapler or a binder. So we asked them first whether they possess any stapler or binder or not.
2. If they seemed appropriate and willing to participate in this survey, we asked them about lacking of the current products they use and listed them.
3. At last, we asked them their expected price for such a product.

Not all of the participants answered all the questions. So, there might be some discrepancy among the total number of participants of each question.

2.2 Profession Variety among Reviewers

Table 2.1 Profession Variety among survey participants

Profession	Frequency
Student	49
Accountant	13
Officer	25
Office Assistant	17
Research Assistant	1
Stationary Shop Keeper	11

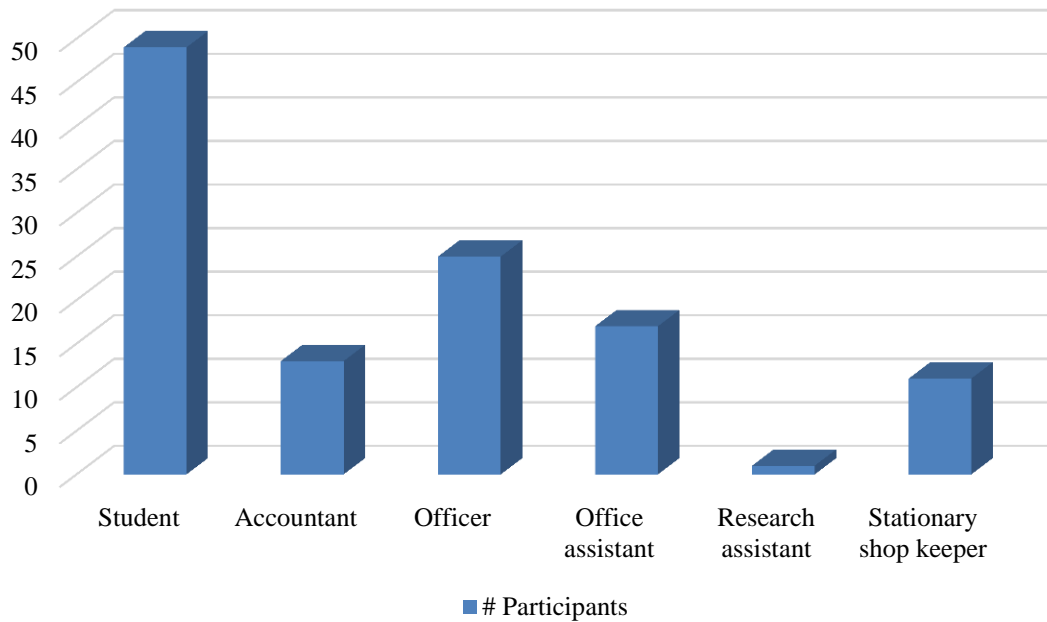


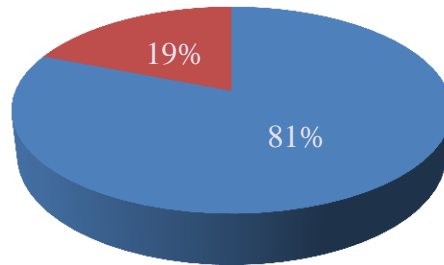
Figure 2.1 Profession Variety

2.3 Data Analysis

Question 1: Do you possess a personal stapler?

Table 2.2 Data collection table for question 1

Answer	Total Reviewer (116)	Percentage
Yes	94	81
No	22	19



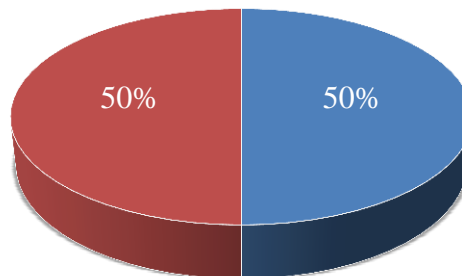
■ Yes ■ No

Figure 2.2 Reviewer opinion percentage for question 1

Question 2: Do you possess a personal puncher machine?

Table 2.3 Data collection table for question 2

Answer	Total Reviewer (112)	Percentage
Yes	56	50
No	56	50



■ Yes ■ No

Figure 2.3 Reviewer opinion percentage for question 2

Question 3: Do you have to bind your own books?

Table 2.4 Data Collection table for question 3

Answer	Total Reviewer (112)	Percentage
Yes	61	54
No	51	46

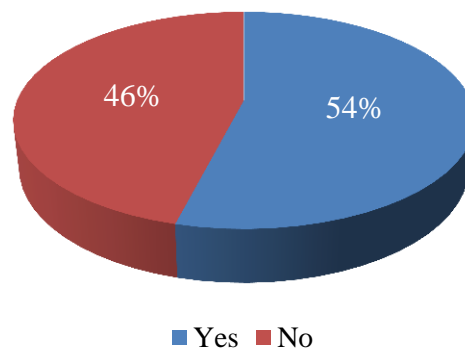


Figure 2.4 Reviewer opinion percentage for question 3

Question 4: When you need to bind some loose papers together, which one do you prefer?

Table 2.5 Data collection table for question 4

Answer	Total Reviewer (123)	Percentage
Punch Machine	41	33
Stapler	55	45
Book Binder	5	4
Depends on situation	22	18

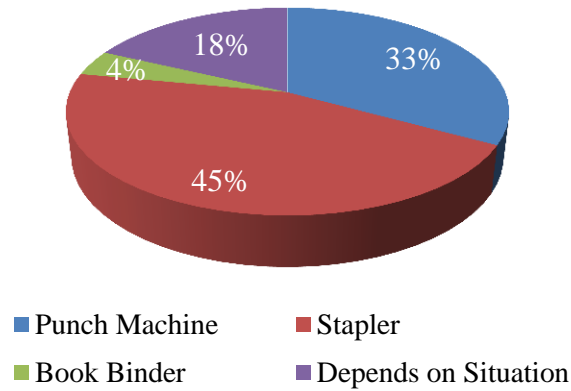


Figure 2.5 Reviewer opinion percentage for question 4

Question 5: Do you face any problem in time of using existing stapler or punch machine? If yes, please categorize it.

Table 2.6 Data collection table for question 5

Answer	Total Reviewer (114)	Percentage
Yes	78	68
No	36	32

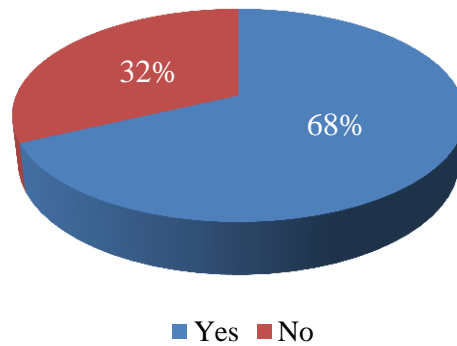


Figure 2.6 Reviewer opinion percentage for question 5

Table 2.7 Lists of problem review faced

Issue	Total reviewer	Percentage
Low paper capacity	12	15
Pin Distortion	26	33
Mechanical malfunction	15	19
Naked sharp punch machine teeth	4	5
Irregular movement of pin	2	3
No specific comments	19	24

Question 6: Do you think a combination of stapler and punch machine will make tasks easier or user friendly?

Table 2.8 Data collection table for question 6

Answer	Total Reviewer (115)	Percentage
Yes	94	82
No	21	18

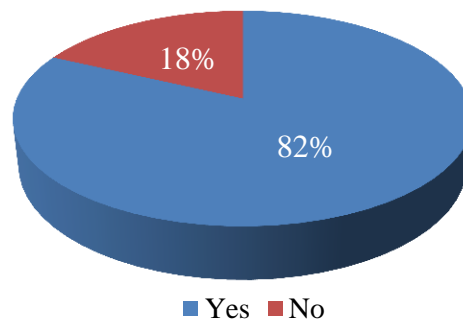


Figure 2.7 Reviewer opinion percentage for question 6

Question 7: Having such a machine described in the last question, do you think addition of a portable book binder in it is fine?

Table 2.9 Data collection table for question 7

Answer	Total Reviewer(112)	Percentage
Yes	71	63
No	41	37

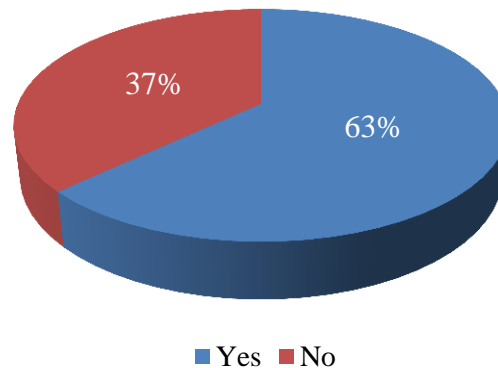


Figure 2.8 Reviewer opinion percentage for question 7

Question 8: What is your expected service life from super binder?

Table 2.10 Data collection table for question 8

Expected Service Life (years)	Total Reviewers	Percentage
1	3	2.6
2	9	7.8
3	17	14.7
4	21	18.1
5	28	24.1
6	16	13.8
7	10	8.6
8	12	10.3

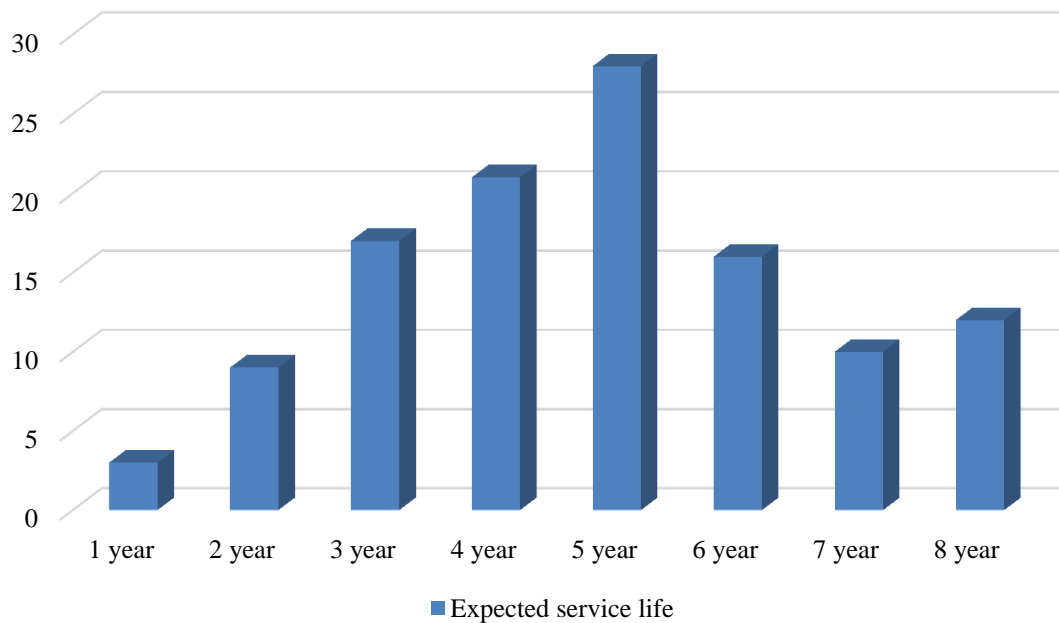


Figure 2.9 Reviewer frequency vs. Expected service life bar chart for question 8

Question 9: How much price do you think reasonable for such a product?

Table 2.11 data collection table for question 9

Expected Price Range	No. of Reviewer	Percentage
50-100	9	7.8
100-150	15	12.9
150-200	18	15.5
200-250	33	28.4
250-300	21	18.1
300-350	7	6.0
350-400	6	5.2
400-450	3	2.6
450-500	3	2.6
500-550	1	0.9

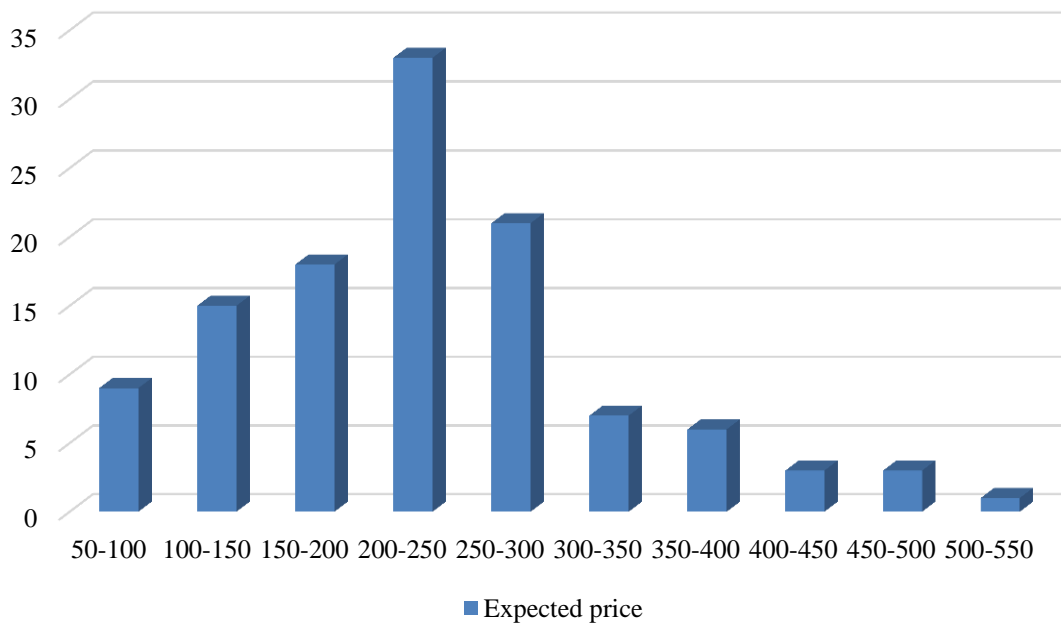


Figure 2.10 Reviewer frequency vs. expected price range bar chart for question 9

Question 10: How much page do you need to bind maximum at a time?

Table 2.12 data collection table for question 10

Expected Price Range	No. of Reviewer	Percentage
1-10	15	14.3
11-20	26	24.8
21-30	31	29.5
31-40	17	16.2
41-50	11	10.5
More than 50	5	4.8

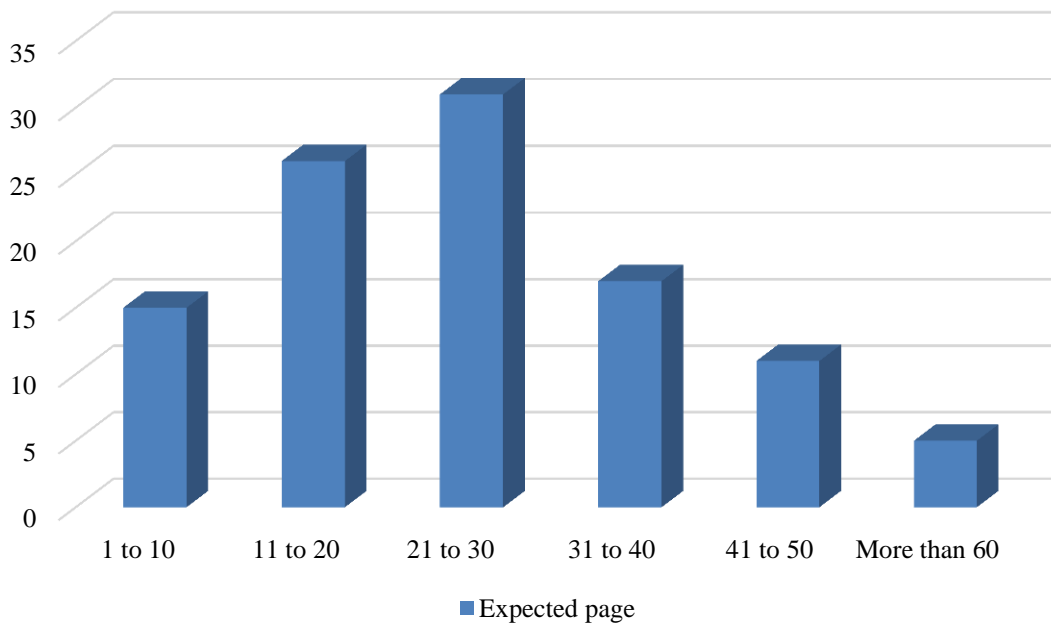


Figure 2.11 Reviewer frequency vs. expected page range bar chart for question 9

Question 11: Are you willing to buy such a product if you find the price reasonable?

Table 2.13 Data collection table for question 11

Answer	Total Reviewer (114)	Percentage
Yes	93	82
No	21	18

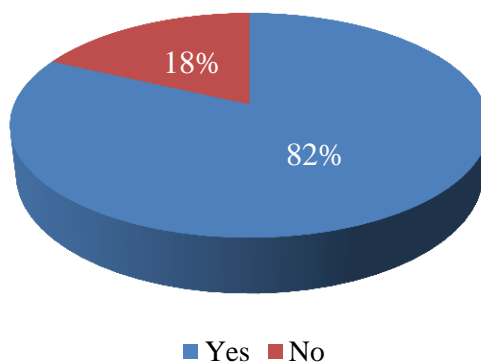


Figure 2.12 Reviewer opinion percentage for question 11

The main focal point of this survey on 'Super Binder' is to find out the voice of customer regarding the product. After compiling all the data from the survey some outcomes can be drawn

1. Most of the people don't bind their books. As a result, the proposal for adding a book binding tool seems unnecessary from practical perspective. Instead of providing a book binding tool, a spiral binding tool will assist more in workplace.
2. People are not will to pay much for the product. So it should be kept in mind that a extravagant and complex design of the product may not be economically acceptable if the design increases manufacturing cost severely.
3. People want to operate the machine at high capacity. That means if the product can bind more pages in a single cycle, people are more likely to purchase it. So a proper flexibility should be given in this regard.
4. In most of the cases, people choose stapler over punch machine or binder. So the stapler should be equipped with more efficient features.
5. According to the survey, most of the effort in designing the product should be given on merging the stapler and punch machine.
6. An 'easy to use' product will certainly attract people. Almost 82% people are eager to buy such a product within a reasonable price range. This indicates if the price can be reduced, sales volume will be increased drastically.

In line with these findings, the goal of our team is to focus on customer requirements from the very beginning and ensure a cost effective design.

Chapter 3

Quality Function Deployment

Quality function deployment (QFD) is a very important tool in 'Total Quality Management'. From TQM, we know that quality is a determinant of customer, not producer. Quality can be defined as meeting customer needs and providing superior outputs. QFD is a standard tool which converts 'Voice of Customer' into 'Voice of Engineer'. It's a structural approach to define customer needs or requirements and translate them into specific plans or products, part, process and production plan. Our product 'Super Binder' is completely a general customer based product which will be manufactured under make-to-order category. So it is imperative to implement the vital requirements in the product. The basic QFD begins with product planning; continues with product design and process design, and finishes with process control, quality control, testing, equipment maintenance, manpower, training requirements etc. As a result, this process requires multi- functional disciplines to adequately address this range of activities. Thus, it requires involvement of all departments in product development process, which is in line with the core concept of TQM.

3.1 Methodology

In order to complete the 'House of Quality', data have been imported from different sources. The core methodology can be segregated in some categories.

1. Data from survey
2. Expert opinion
3. Internet search
4. Educated guess

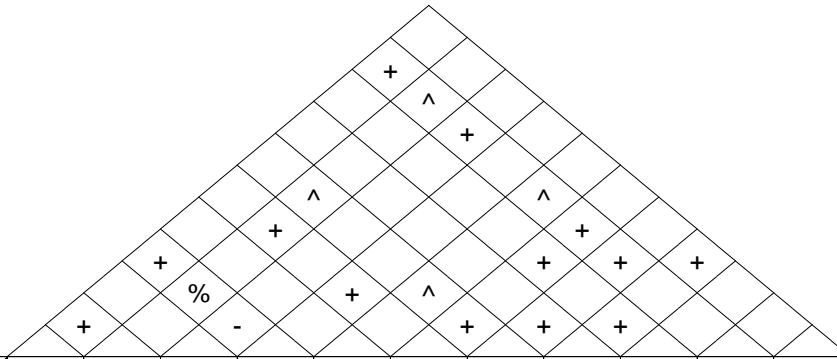
Firstly available data from survey have been analyzed and fitted in the chart. Along with this, theoretical knowledge has been used for educated guessing where related data is absent. Some expert advices have also been accumulated in our house of quality. A wide range of relevant information has been imported from internet searching. Then after several group discussions, the attributes have been chosen and the house of quality has been modeled properly with careful calculations.

3.2 House of Quality

House of quality for Super Binder is presented in the following portion of the chapter with proper explanation.

Correlations	
▲	Strong Positive
+	Weak positive
	No Relationship
-	Weak negative
%	Strong negative

Relationships	
●	Strong (8)
○	Moderate (3)
▽	Weak (1)
	No Relationship (0)



Row #	Customer Requirements (Explicit and Implicit)		Column #											Importance (10)	Competitor 1 (10) Red Swingliner	Super Binder Target (10)	Competitor 2 (10) Kangaro	Super Binder Target (10)	Competitor 3 (10) Minicoil	Super Binder Target (10)	Scores (10)	Percent Score (100)	
			Mechanical Design						Physical Aspect			Cost											
			Spring Design	Strength of Main Body	Long Lever Arm	Flexible Position of Stapler	Cutter Sharpness	Proper Screw Design	Material	Cover Design	Proper Indication	Manufacturing Cost	Operational Cost										
1	Functionability	High Page Capacity	▽	●	▽		●		▽					9	6	8	8	9	9	7	9	11	
2		No Pin Distortion		▽	○										7	7	8	6	8	0	0	7	8
3		Ease of Use	▽		●	○	▽				▽	○			10	7	9	7	8	5	8	10	12
4		Long Service Life	●	●						○			○		7	8	8	8	9	5	7	7	8
5		Noise Reduction	●						▽				●	▽	4	6	7	5	7	4	6	4	5
6		Consistant Hole Distance						▽				○			6	0	0	8	9	9	8	6	7
7	Appearance	Simple Design		▽		○		○		○	▽			8	8	9	7	9	6	7	8	10	
8		Aesthetics				▽				○			○	▽	5	7	8	7	7	6	6	5	6
9	Physical	Light Weight		●					●					7	7	9	8	9	3	8	7	8	
10		Easy Dust Removal								●					3	0	0	8	8	5	6	3	4
11	Reliability	Reliability		○			○					○		9	6	9	7	9	8	8	9	11	
12	Price	Low Cost		○					●	▽		●		8	4	7	6	7	2	7	8	10	
Score (Sum = 1354)			129	301	133	71	139	34	181	98	67	192	11	Sum = 83									
Percent Score (100)			10	22	10	5	10	2	13	7	5	14	1										

Figure 3.1 House of Quality for Super Binder

3.3 Analysis of the ‘House of Quality

As quality function deployment (QFD) is a tool to reflect the customer needs in terms of engineering design parameters, it is very obvious that there are some distinguished sections of a house of quality. Every qualitative parameter is assigned to a respective value in terms of which preference is set. Correlation among the parameters can also be displayed in a quality function deployment matrix. We have also analyzed the performance level of some of your potential competitors. The different portions of ‘House of Quality’ for Super Binder have been elaborately described below:

3.3.1 Customer Requirements

Customer requirements have been categorized into five major segments. They are functionability, appearance, physical state, reliability and price. Functionability includes six important customer needs. They are- high page capacity, no pin distortion, ease of use, long service life, noise reduction, constant hole distance. Of these ease of use is to be given the highest preference according to the customer survey. High page capacity is another most spoken issue which also should be dealt with proper importance. Customers want no pin distortion and long service life with equal importance but with an importance factor of 7. The next major segment is appearance. In appearance section, customers have highlighted on simple design and aesthetic appeal of the product. However simple design is way ahead in preference than aesthetics. Then comes the physical state segment which includes light weight and easy dust removal. Again light weight of Super Binder is much more important than the dust removal system of it. The last two segments include only one customer requirement parameter. They are reliability and low cost. Both these two factors are important to the customers.

3.3.2 Design Parameter

The design parameters for Super Binder have been segregated in three major categories. They are mechanical design, physical aspect and cost. Under mechanical design, there are six sub entities- spring design, strength of main body, long lever arm, flexible position of stapler, cutter sharpness, and proper screw design. The strength of main body has got 22% of total score which is the highest in the table. It reflects that in order to meet customer needs, the main structure of Super Binder is needed to be strong enough. Spring, long lever arm and cutter sharpness got 10% of total score each. Spring is needed for generating mechanical force where long lever arm reduces the necessity of human effort. Cutter sharpness is needed to achieve a higher page capacity per cycle. Physical aspect includes material, cover design and proper indication. Material has the third highest importance in the matrix. The quality of material is the direct determinant of several

other parameters. Cover of the product and proper indication is relatively less important in the manufacturing process. Lastly, the cost field includes manufacturing and operational cost. Of these two manufacturing cost requires higher attention.

3.3.3 QFD Matrix Development

The left portion of the matrix is to display the customer requirements from Super Binder. There are 12 rows in the main matrix each consisting a particular customer requirement parameter. The columns represent the functions or requirements in Super Binder to achieve the satisfaction from customers. In total, 12 design parameters have been chosen to deal with all functionalities expected from Super Binder. Each customer needs has been associated with one or more design parameters. Their relationship is quantified using 4 states. For demonstrating strong relationship, (●) is used with a value of 8. For moderate and weak relationships, (○) and (▽) are used with values 3 and 1 assigned to each character respectively. If there is no relation between the customer and design parameter, simply the element is kept blank with a value of 0. At the left, importance of the customer requirements has been shown at a scale of 10. At the right portion of the quality function deployment matrix, an analysis of potential competitor's current state has been demonstrated. At the right after competitor analysis, score for each customer parameter is shown. At the bottom a combined score has been calculated which expresses the priority list that should be given in designing the product.

3.3.4 Scoring System

In this house of quality, importance factor attained from customer review has been given the sole preference. For rating importance each criterion has been marked at a scale of 0 to 10. After rating each parameter, a gross score is calculated which is in this case equal to the importance factor. Then percentage of scores is calculated. In order to calculate the final score for each design parameter, relationship factor for each customer requirement parameter has been multiplied with its corresponding percentage score and summed. This gives the gross score for each design parameter. Again scores for all the design parameters are summed and a percentage for each criterion has been calculated. This percentage score gives the ultimate insight about which design parameter should be given higher preference and which can be dealt with less importance.

3.3.5 Competitor Analysis

As Super Binder is combining three major devices –stapler, punch machine and spiral binder- in a more effective way, a renowned producer of each device has been selected as potential competitor. From stapler domain, Red Swingline has been chosen. From punch machine domain, Kangaro and from spiral binding domain, Minicoil has been considered. Red Swingline lags in

high page capacity, noise reduction and reliability. So a far better target is set for these parameters. As this doesn't have punching mechanism, constant hole distance and easy dust removal are rated zero. The main issue of this is that the price is pretty high. Super binder's focus will be to reduce price drastically to step ahead in the competition. In case of Kangaro, it produces both stapler and punch machine. Yet it doesn't have a combined product like Super Binder. It has a moderate aesthetics of the product and easy dust removal system. That's why target of Super Binder is just to achieve the level of Kangaro. In rest of the cases, Super Binder aims to surpass Kangaro. The third market competitor is Minicoil that produces spiral binders. The main issue with this product is it much more heavier than the expected weight of Super Binder. The price is also very high. So Super Binder will try to design in such a way that it can surpass all of its competitors.

3.3.6 Roof Analysis

At the triangular roof up to the quality function deployment matrix, correlations between design parameters have been shown. In order to exhibit the correlations, 5 states have been chosen. For strong and weak positive correlations, (*) and (+) have been used respectively. Similarly for strong and weak negative relationship, (%) and (-) sign have been used. If there is no correlation between a particular pair of design parameters then their converging position in roof is kept empty. No numerical value is assigned to determine the correlations among the design parameters.

The goal of quality function deployment is to convert the customer requirements into design parameters. From the house of quality chart we noticed that some parameters are far more important than others. These parameters should be given more emphasis than other quality and design requirements. The main outcomes of this quality function deployment for 'Super Binder' are:

1. The structure should be able to carry the loads that will be imposed on it. According to the house of quality, this parameter is mostly connected with various customer requirements. But to do so, a huge percentage of total cost is needed. So a tradeoff between these is must.
2. Choosing an appropriate material for the stapler is another important task. The material should be chosen in a manner that it doesn't incur much cost. At the same time it fulfills the design requirements also.
3. Some precise designing of lever arm and spring will help to meet customer requirements more effectively and efficiently. As these parameters are not too much costly to be dealt

with, so a proper design of these components at the very first hours of manufacturing may eliminate some impediments.

4. Another important finding is that as customers want a higher service life from our product, the analysis for fatigue failure should also be carried out.
5. Parameters with lower score can be overlooked at first for simplicity. Later if the design has allowance to include further detailing then these parameters will be considered.

These are the core findings that are to be implemented in designing phase for better customer satisfaction.

Chapter 4

Black Box Analysis, Component Hierarchy and Functional Decomposition

In the process of product design and development, a proper sequence of methods, tools and techniques are to be applied. To develop a product properly, first of all we have to identify the main purpose of that product. After that, fragmentation of operation is another important issue. To the customers, utility of a specific function is rather more important than the components involved in carrying out the function. They just want to use a product efficiently. So focus should be given on the input parameters of the product as well as the outputs from the system to identify and implement customer friendly operations of the product. Black box analysis is very handy tool to address this issue. Black box analysis consists of input of energy, material and information in the product. On the other hand output of energy, material and information are also exhibited. The product is simply considered as a black box the mechanism of which is unknown. Energy conversion steps are very important in this regard. As soon as the functionalities expected from the product are set, a detailed analysis of the product's infrastructure is to be made. Component hierarchy shows a simple yet effective layout of components to achieve the required functionality. In this analysis, the whole product is segregated into some sub-assemblies. Then components for each sub-assembly are identified. This also gives a prediction about material cost. After that, a justification is needed for the functions and components chosen from above analysis. Functional decomposition answers the all how to why or why to how questions to satisfy all the customer requirements. As a whole, these analyses are very important in determining the physical and functional aspects at the design and planning stage.

4.1 Black Box Analysis

Black box is a method to recognize simply the inputs and outputs of a system or product without the knowledge of its internal workings. In this analysis, the internal mechanism of the product is not considered. The product is considered as a black box the mechanism of which is unknown. This is a very important tool in providing insights about what customers may want from the product. The black box diagram for Super Binder is sketched below:

4.1.1 Black Box Diagram

In the black box analysis of Super Binder, there are mainly 3 categories of inputs and 2 categories of outputs. They are energy, material and information. All of these categories is explained as follows:

Energy: The input energy is mechanical energy which comes from the user. The user exerts force on the top surface or on the handle of the device. The output energy is also a mechanical energy but in this case it comes from the machine.

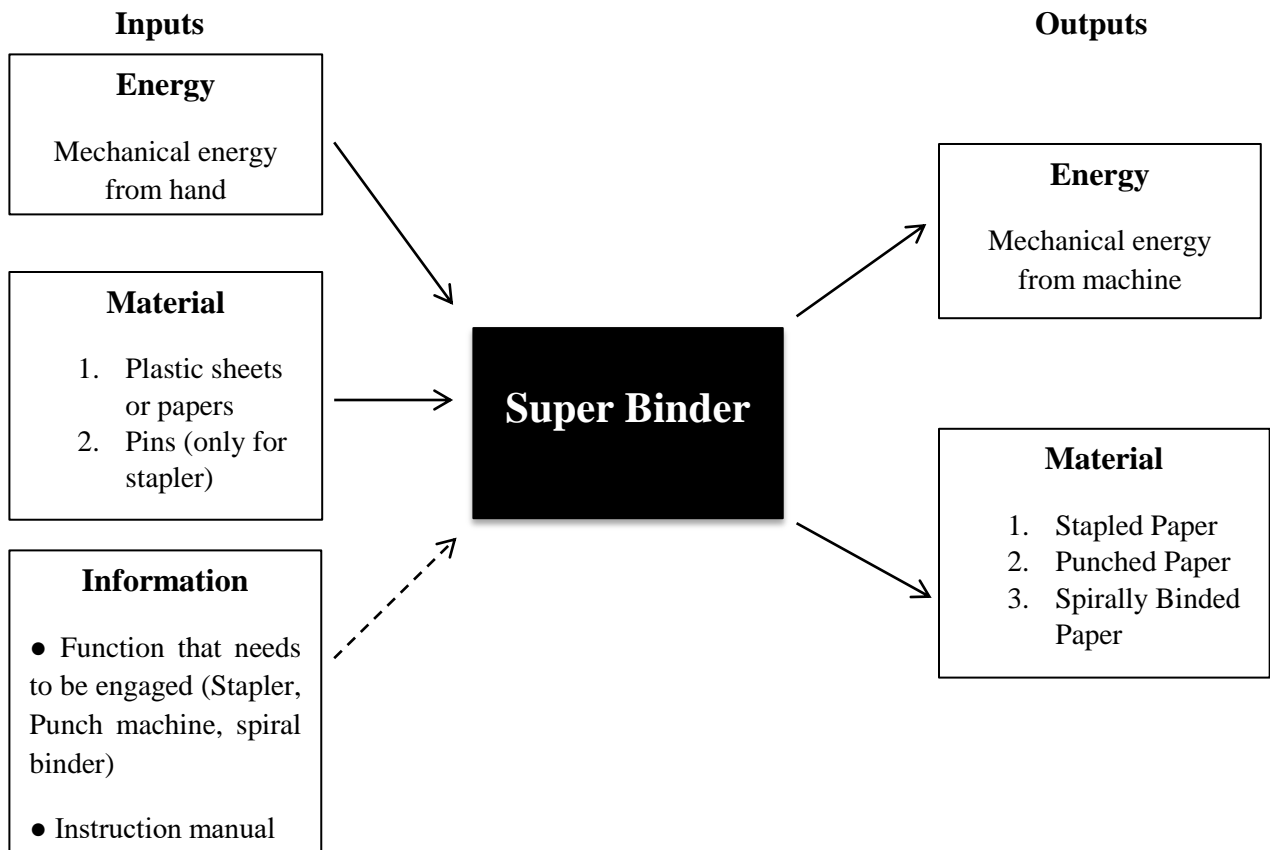


Figure 4.1 Black box diagram for super binder

Material: There are two vital material inputs in Super Binder. They are papers and pins. Plastic sheets and papers are one of the significant input materials in this machine because the main objective of Super Binder is to bind papers. For stapling, an additional input is also required which is pin. The output materials are either stapled papers, punched papers or papers with holes for spiral binding.

Information: Whenever a user will be using super binder he/she needs to select whether the papers are to be stapled, punched or spirally binded. This information is also required to operate the product. There is no output information for the product.

4.2 Component Hierarchy

Component hierarchy is a very effective method of listing the components required in Super Binder. The component hierarchy methodology simply distinguishes between the core portions of the product and then lists the components for those portions. The portions are typically termed as sub-assembly. The number of components is also mentioned in this list. It gives an overview about the material required as well as the level of complexity or simplicity of the product. The more components there are the more complex the product will be. Super Binder is designed to perform 3 different tasks. As a result it is supposed to have 3 core sub-assemblies i.e stapling unit, punching unit and spiral binding unit. Along with these, a body frame is required to combine all these three sub-assemblies. The component hierarchy for Super Binder has been illustrated in the following paragraphs.

4.2.1 Diagram of Sub-assemblies

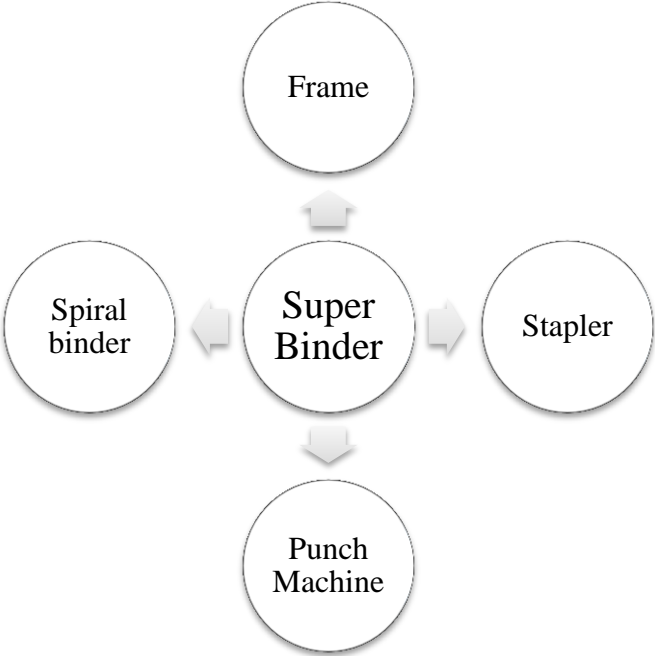


Figure 4.2 Sub-assemblies for Super Binder

4.2.2 Components of Stapler

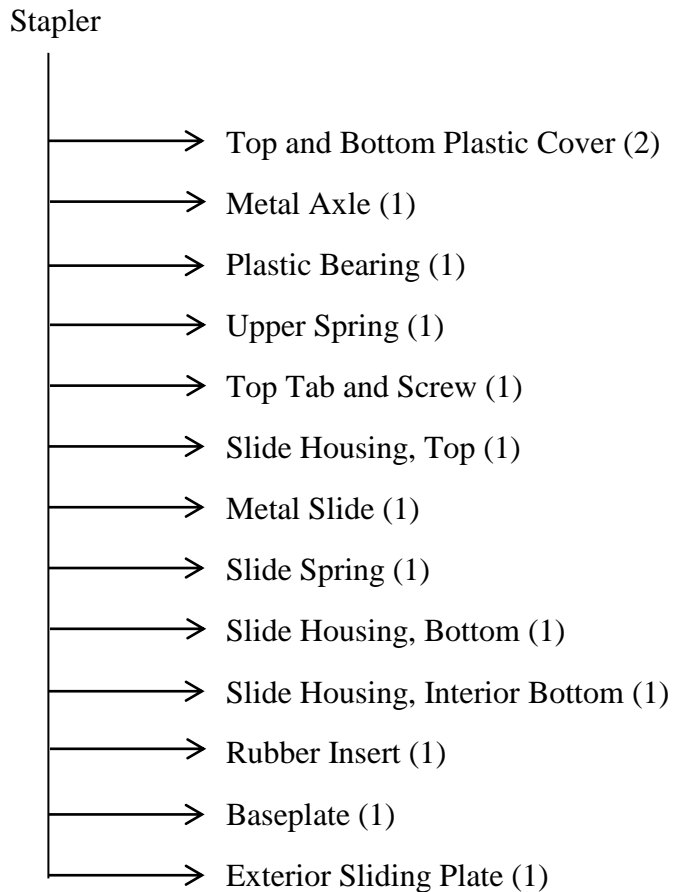


Figure 4.3 List of components for sub-assembly 1 (Stapler)

4.2.3 Description of Components of Stapler

1. **Top Plastic Cover:** It allows user to have a more comfortable way to staple, and makes stapler more aesthetically pleasing.
2. **Metal Axle:** It allows the stapling mechanism to hinge from the base.
3. **Plastic Bearing:** It allows top part of stapler to remain centered on the axle and reduces friction during movement.
4. **Upper Spring:** It allows the stapler to bounce back to original position after stapling.
5. **Top Tab and Screw:** Tab, when pressed, pushes a staple down through the slide housing and onto the paper to be stapled.
6. **Slide Housing, Top:** This keeps staples contained during use.

7. **Metal Slide:** It ensures that staples are always towards the front of the slide housing during use.
8. **Slide Spring:** This provides tension and movement to metal slide in order to keep staplers in the correct area for use.
9. **Slide Housing, Bottom:** This is a surface for which the metal slides and staples to sit on.
10. **Slide Housing, Interior Bottom:** This allows metal slide to stay in place (somewhat like a track).
11. **Rubber Insert, Base:** It keeps base from slipping/moving during use.
12. **Baseplate:** It provides a surface for papers to be stapled on; bends staples to stay in place.
13. **Exterior Sliding Plate:** The element that helps to slide the stapler and move forward.

4.2.4 Components of Punch Machine

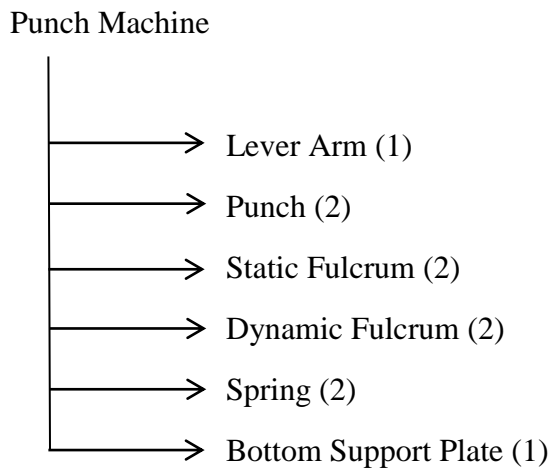


Figure 4.4 List of Components for sub-assembly 2 (Punch Machine)

4.2.5 Description of Components of Punch Machine

1. **Lever Arm:** It is used to push a bladed cylinder.
2. **Punch:** It goes straight through one or more sheets of paper and then through a close fitting hole in the die.
3. **Static Fulcrum:** As the vertical travel distance of the cylinder is only a few millimeters, it can be positioned within a centimeter of the lever fulcrum.
4. **Dynamic Fulcrum:** This fulcrum moves in the applied force direction.

5. **Spring:** Spring is a part of the punch which is used to ensure spontaneous movement of the punch
6. **Bottom Support Plate:** This plate is used as a base support for the papers that are to be punched.

4.2.6 Components of Spiral Binder

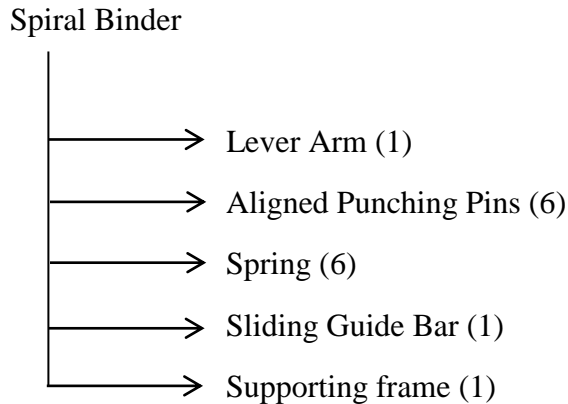


Figure 4.5 Lists of Components for sub-assembly 3 (Spiral Binder)

4.2.7 Description of Components of Spiral Binder

1. **Lever Arm:** This component helps to press the punching pins through papers.
2. **Aligned Punching Pins:** It is a group of cutters that make the hole for spiral binding
3. **Spring:** This allows the hole making punches to bounce back to original position after making holes.
4. **Sliding Guide Bar:** It guides the direction of punching.
5. **Supporting Frame:** This is a fixed i frame which holds the sub-assembly.

4.2.8 Components of Frame

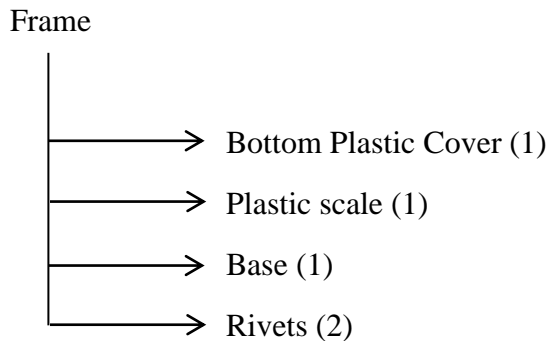


Figure 4.6 Lists of components for sub-assembly 4 (Frame)

4.2.9 Description of Components of Frame

1. **Bottom Plastic Cover:** This stores the wasted portion of papers and ensures easy removal of them.
2. **Plastic Scale:** It helps to align pages perfectly and precisely.
3. **Base:** It is used to hold the other sub-assemblies.
4. **Rivets:** It is used to join the base and the bottom support plate of punch machine.

4.3 Functional Decomposition

Generally functional decomposition is a method of analysis that dissects a complex process to show its individual elements. In mathematics, functional decomposition is the process of resolving a functional relationship into its constituent parts in such a way that the original function can be reconstructed from those parts. However, the functional design is the most important part in product design and the purpose of functional decomposition is to decompose the complex overall product features into a number of smaller, relatively simple sub-functions, and to solve these sub-functions. Then we can use a combination of these solutions to solve the total design.

Our product Super Binder has four subassemblies: main frame, stapler, punch machine and spiral binder. We proceeded by asking questions like 'how' and 'why'. We built a connection between why we gave our inputs such as power, force and how we gained our outputs. This has helped us to observe the process in individual assemblies and finally come to a temporary conclusion about the whole product

4.3.1 Functional decomposition for stapler

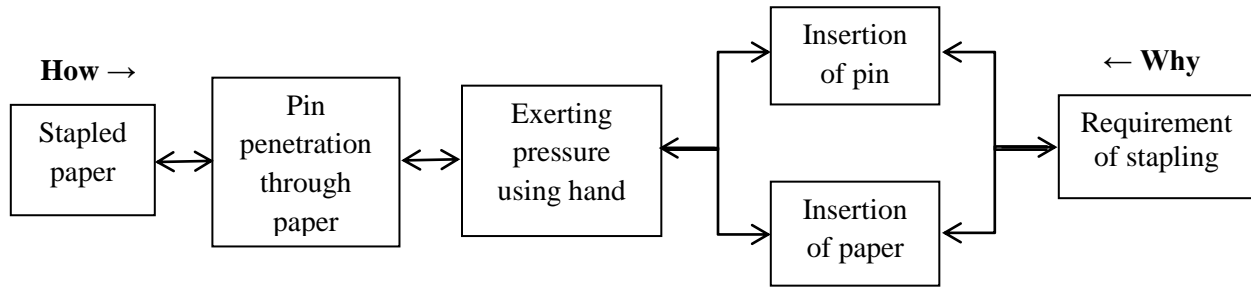


Figure 4.7 Functional decomposition for sub-assembly 1 (Stapler)

This diagram gives the answer for ‘how’ questions for stapling in the forward direction and ‘why’ questions in the backward direction. It shows that papers are stapled because pin is penetrated through the papers. This occurs because of exerting pressure on the stapler. This pressure is required as pin and papers are inserted into the stapling device as stapling is required by the user. That’s how this diagram works for the ‘how’ questions for this sub-assembly. The vice versa is applicable for ‘why’ questions.

4.3.2 Functional decomposition for Punch Machine

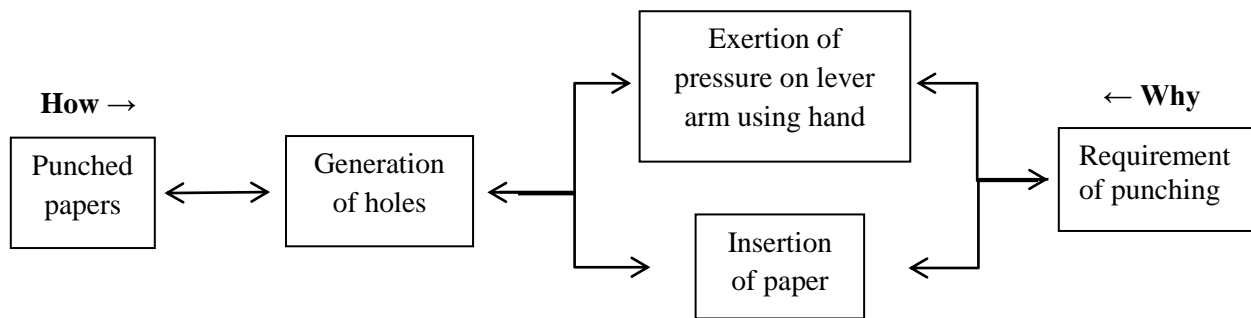


Figure 4.8 Functional decomposition for sub-assembly 2 (Punch Machine)

This functional decomposition diagram exhibits the ‘how’ and ‘why’ answers for the punch machine sub assembly. A set of punched paper is desired from this sub-assembly. It is possible as the holes are generated. These holes are generated because of the insertion of papers and exertion of pressure on the lever arm. This is performed when the user wants to make punch holes on the papers.

4.3.3 Functional decomposition for Spiral Binder

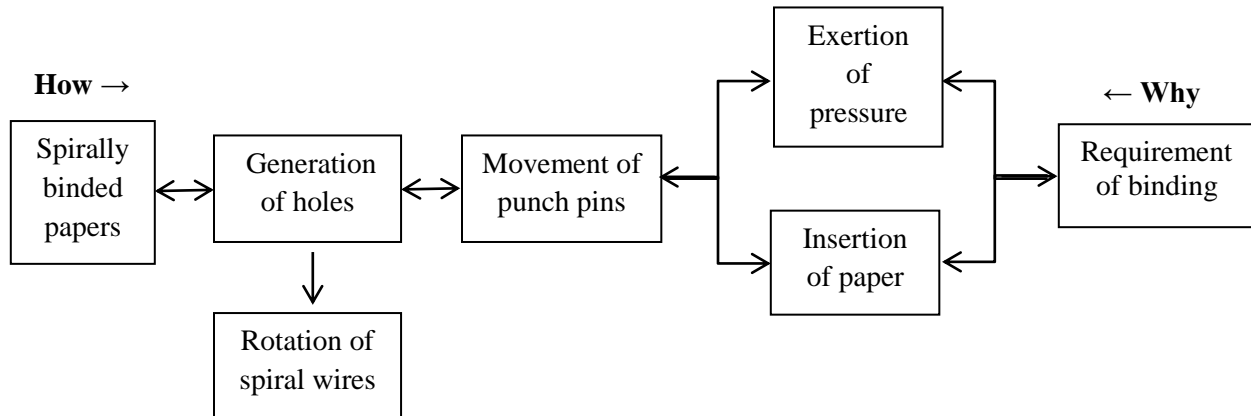


Figure 4.9 Functional decomposition for sub-assembly 3 (Spiral Binder)

This diagram displays the ‘how’ and ‘why’ answers for the spiral binding sub-assembly. Spirally binded papers are made from this sub-assembly. It is possible as the holes are generated and the spiral wire is rotated through the holes. These holes for spiral binding are made because of the insertion of papers and pull on the handle of the binder. This is performed when the user wants to make punch holes on the papers.

In this functional decomposition we have three functions: stapling, punching and spiral binding. In this flowchart, from left to right we get the answer of how to accomplish those functions and from right to left we can see why these functions have to be done. In order to get those functions done this functional flow must be followed sequentially. In the stapling process first we have to insert pin and put the papers in correct position and then we have to give pressure manually by hand and we can get stapled papers by penetration of pins through papers. In punch machine to create discrete hole we have to give pressure by pressing the lever arm and need maintain constant distance between holes. In spiral binding pressure is also given by hand .By sharp paper cutter the continuous holes are made for spiral binding of papers.

Chapter 5

Design of Components and Assemblies

After all the analysis of material, manufacturing process and joining method selection, a prototype design of Super Binder has been developed. Designing has been carried out considering all the real constraints of motion and friction. Each part is designed as per the original dimensions. All the components of Super Binder have been exhibited in this chapter.

5.1 Design of Components

5.1.1 Components of Punch Machine

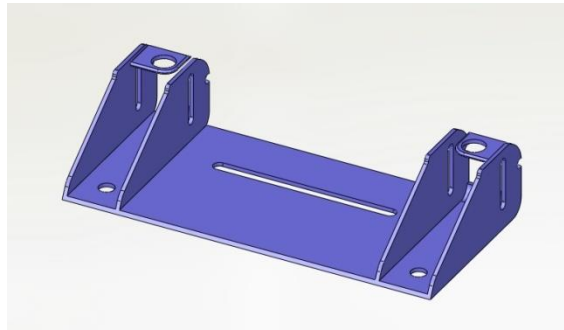


Figure 5.1 Bottom Support Plate



Figure 5.2 Punch

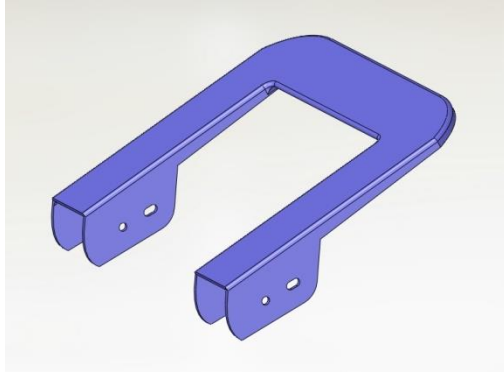


Figure 5.3 Lever Arm

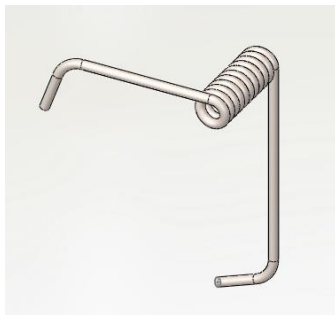


Figure 5.4 Spring

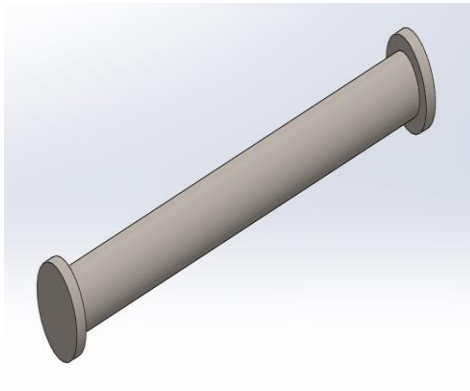


Figure 5.5 Fulcrum

5.1.2 Components of Stapler

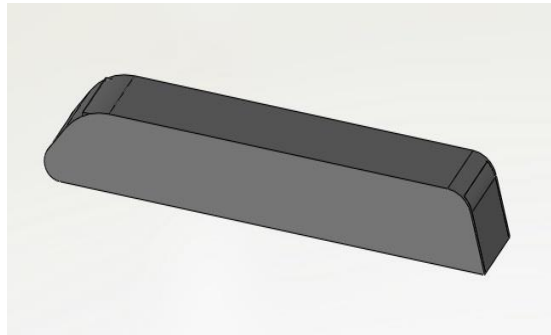


Figure 5.6 Top Plastic Cover

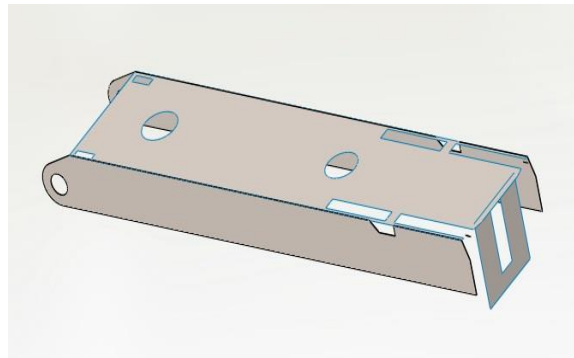


Figure 5.7 Top Tab with Top Slide Housing

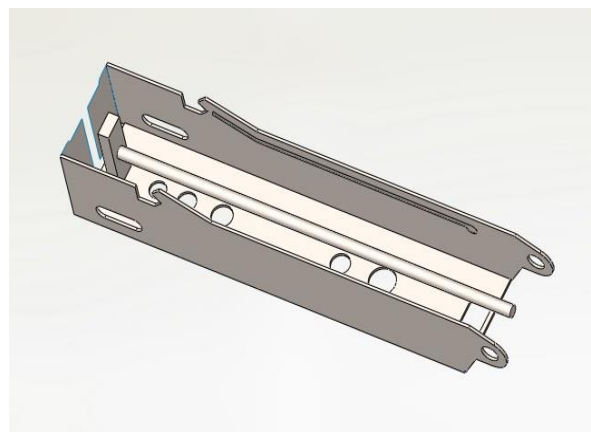


Figure 5.8 Bottom Slide Housing with Metal Axle

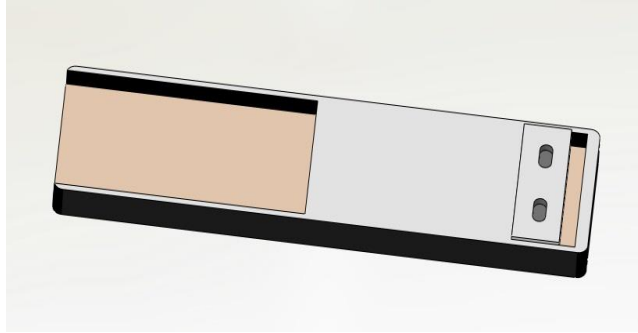


Figure 5.9 Base Plate



Figure 5.10 Slide Spring

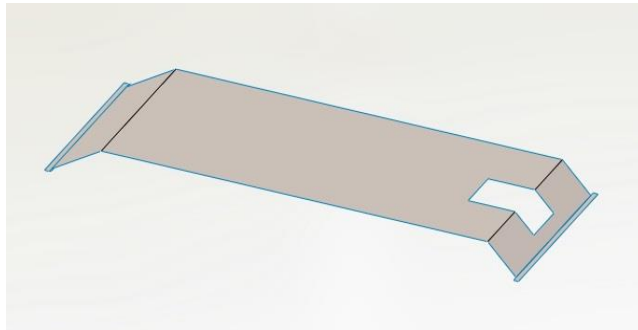


Figure 5.11 Bottom Slide

5.1.3 Components of Spiral Binder

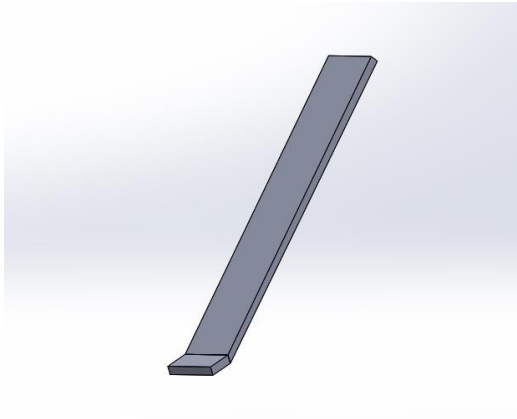


Figure 5.12 Lever Arm

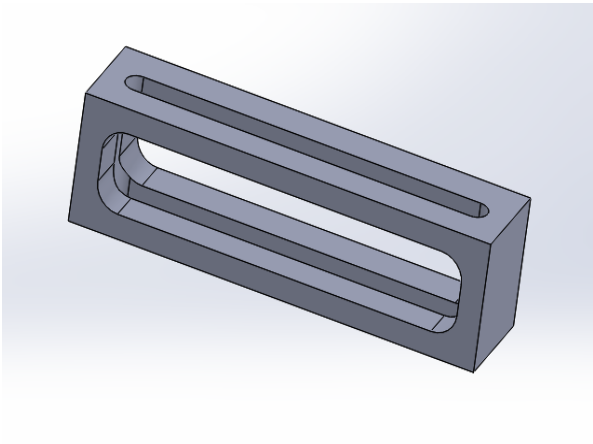


Figure 5.13 Supporting Frame

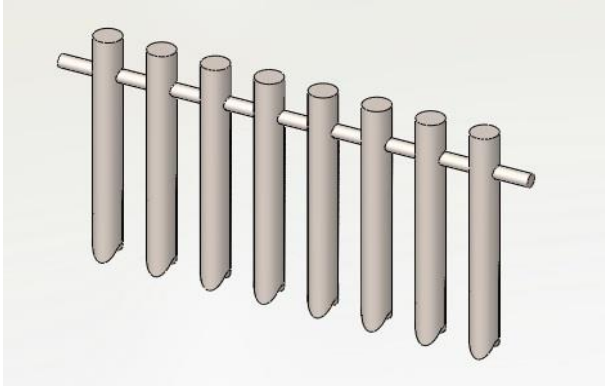


Figure 5.144 Spiral Punch with Sliding Guide Bar



Figure 5.15 Spring

5.1.4 Components of Main Body Frame

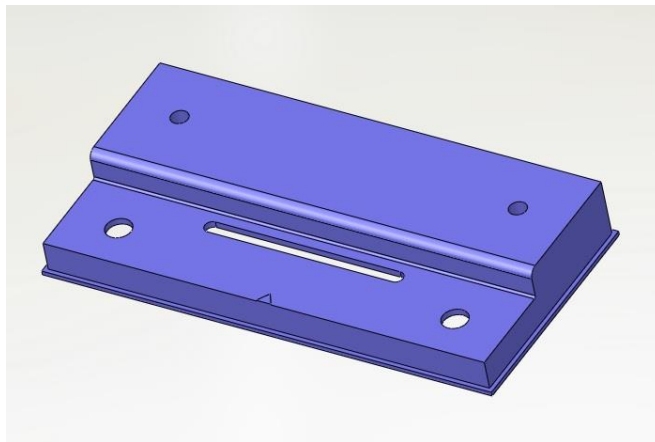


Figure 5.16 Base

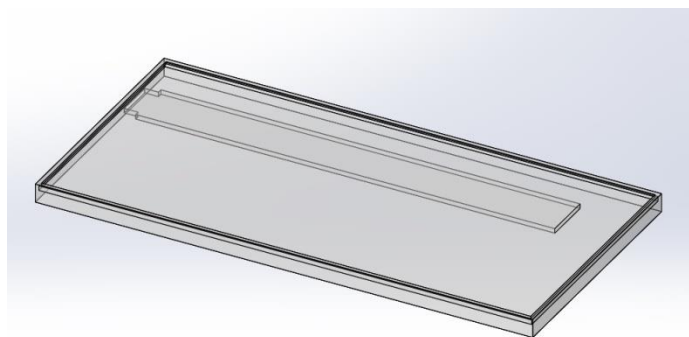


Figure 5.17 Bottom Plastic Cover

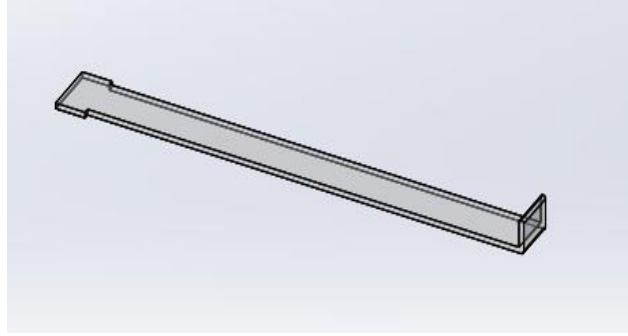


Figure 5.18 Plastic Scale



Figure 5.19 Rivet

5.2 Design of Main Assembly

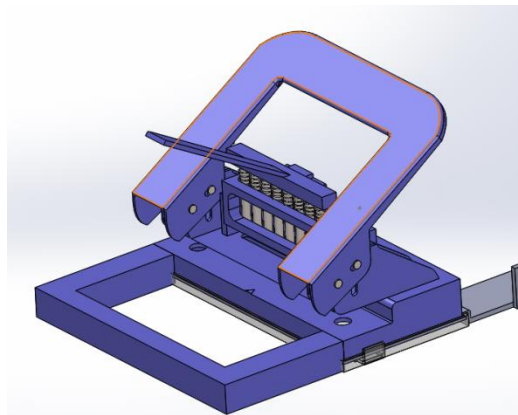


Figure 5.20 Super Binder from Front Isometric View

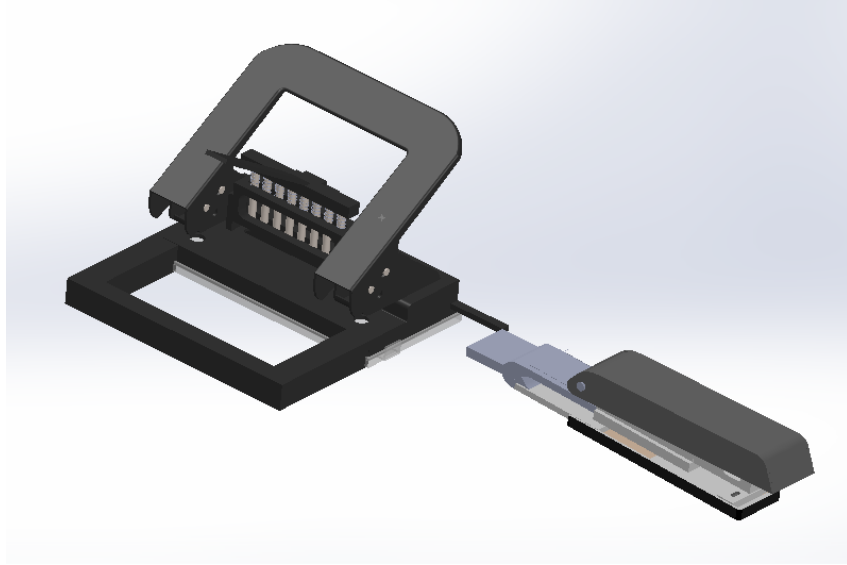


Figure 5.21 Super Binder's Isometric View

Chapter 6

Qualitative Analysis of Material, Manufacturing Process and Joining Process Selection

As the conceptual development of Super Binder is advancing, it is imperative to assign specific materials to every parts of the product. The functionalities that the product is supposed to perform have already been determined in the quality function deployment phase. Now material should be chosen for parts in such a way that the part is capable of performing required functionalities and also have sufficient mechanical strength. In order to do that, a qualitative selection of materials is required. As soon as the materials are selected, a proper manufacturing process is to be determined for every part. There are several processes of manufacturing a particular part. But in time of selecting the proper method, flexibility of the method as well as cost effectiveness should be taken into consideration. After determining the manufacturing processes, joining processes for each part and each sub-assembly should be figured out. A point to be noted, in qualitative analysis of material, manufacturing process and joining method selection, all the tasks are performed based on the basic knowledge of material properties and manufacturing methods. No numerical value is needed to perform this phase.

6.1 Qualitative Analysis of Material Selection

6.1.1 Material Selection for Stapler

Table 6.1 Qualitative material selection for stapler sub-assembly

Section	Parts	Material selection	Option for other material	Reasons behind selection
Stapler	Top and Bottom Plastic Cover	Nylon	PVC, Silicon Rubber	High toughness, excellent abrasion resistance and a high melting point

Section	Parts	Material selection	Option for other material	Reasons behind selection
Stapler	Metal Axle	Stainless Steel	Mild Steel, High Carbon Steel	Very strong, high resistance to breakage, ductile
	Plastic Bearing	Rubber reinforced by steel	PVC, Silicon Rubber	Low coefficient of friction, high fatigue strength, high compressive strength
	Upper Spring	High Carbon Steel	Mild Steel, Stainless Steel	Suitable for cyclic applications, shock application
	Top Tab	Stainless Steel	Mild Steel, High Carbon Steel	Moderate strength, cost effective
	Top Slide Housing, Metal Slide, Bottom Slide Housing, Interior Bottom Slide Housing, Exterior Slide Plates	Stainless steel	Mild Steel, High Carbon Steel	Corrosion resistance, ductility, high strength
	Slide Spring	High Carbon Steel	Mild Steel, Stainless Steel	Easy to bend, high elasticity
	Base	Stainless steel	Mild Steel, High Carbon Steel	Corrosion resistance, ductility, high strength

The stapler sub-assembly has relatively more complex design than rest of the sub-assemblies. Moreover it is expected to function under higher load. That is why stainless steel is selected for the main parts of this sub-assembly. Though the price of stainless steel is higher than mild steel or Aluminium, it is selected to give the strength in the structure. The springs will be made of

mild steel wire. For the top cover and base, nylon is thought to be the best alternative for its toughness and aesthetic appeal. In time of selecting materials, materials with higher flexibility in joining processes have been given preference.

6.1.2 Material Selection for Punch Machine

Table 6.2 Material selection for punch machine sub-assembly

Section	Parts	Material selection	Option for other material	Reasons behind selection
Punch machine	Lever arm	Mild Steel	Stainless Steel, Cast Iron	Better ductility, toughness, weldability, less cost
	Punch	Stainless Steel	Mild Steel, Cast Iron	Better strength, hardness
	Static fulcrum	Mild Steel	Stainless Steel, Cast Iron	Better ductility, toughness, weldability, less cost
	Dynamic fulcrum	Mild Steel	Stainless Steel, Cast Iron	Better ductility, toughness, weldability, less cost
	Spring	High Carbon Steel	Mild Steel, Stainless Steel	Easy to bend, high elasticity
	Bottom Support Plate	Mild Steel	Stainless Steel, Cast Iron	Better ductility, Corrosion Resistance, Toughness, weldability, less cost

For the punch machine, mild steel is selected as material for most of the parts because it is capable enough to bear the load. The punch should be strong and sharp. That is why stainless steel is used for making punch. The guide is simply a path indicator which does not require much strength. So Aluminium is selected for this purpose. Again materials with better joining have been given the preference.

6.1.3 Material Selection for Spiral Binder

Table 6.3 Material selection for spiral binder sub-assembly

Section	Parts	Material selection	Option for other material	Reasons behind selection
Spiral binder	Lever arm	Mild Steel	Stainless Steel, Cast Iron	Better ductility, Corrosion Resistance, Toughness, weldability, less cost
	Aligned Punching Pins	Stainless Steel	Mild Steel, High Carbon Steel	Better ductility, toughness, Heat Resistant, less cost
	Spring	High Carbon Steel	Stainless Steel, Mild Steel	Corrosion Resistance, Better ductility, toughness, weldability, less cost
	Sliding Guide Bar	Stainless Steel	Stainless Steel, Aluminum, Brass, Bronze	Better ductility, toughness, weldability, less cost
	Supporting Frame	Mild Steel	Stainless Steel, Cast Iron	Better ductility, Corrosion Resistance, Toughness, weldability, less cost

For the spiral binder sub-assembly, material selection criteria are almost similar as the punch machine sub-assembly. For covers and handle, nylon is the best possible alternative. Most of the metallic body is made of mild steel except the aligned punch pins which is made of stainless steel.

6.1.4 Material Selection for Main Frame

Table 6.4 Material selection for the main frame

Section	Parts	Material selection	Option for other material	Reasons behind selection
Main frame	Bottom Plastic Cover	Nylon	PVC	Moderate transparency, more flexible
	Plastic scale	Nylon	PVC	Moderate transparency, more flexible
	Base	Mild Steel	Stainless Steel, Cast Iron	Better ductility, Corrosion Resistance, Toughness, weldability, less cost
	Rivet	Stainless Steel	Mild Steel, Cast Iron	Better strength, hardness

The main frame consists of some external parts. The material for bottom plastic cover is PVC as it is relatively cheaper and flexible. It is also transparent which will enhance the aesthetic view of Super Binder. The plastic scale will also be made of PVC. The material for repeater is mild still as it has moderate strength to support as connector.

6.2 Qualitative Analysis of Manufacturing Process Selection

A particular part can be manufactured in several ways. But in time of designing a commercial product like Super Binder, cost effectiveness as well as mechanical properties is to be considered with higher importance. There are several other considerations that are to be considered in time of manufacturing a part such as shape complexity, method availability, expertise etc. In the following portion, a qualitative analysis of manufacturing process selection for all the sub-assemblies of Super Binder has been presented.

6.2.1 Manufacturing Process Selection for Stapler

Table 6.5 Manufacturing process selection for various parts of stapler

Section	Components	Possible Manufacturing Processes	Make or buy	Manufacturing process selection	Reasons behind selection
Stapler	Top Plastic Cover	Casting, Molding	Make	Injection Molding	Cheaper to perform
	Metal Axle	Turning, Casting	Make	Turning	Easy to perform, Less cost
	Top Tab	Casting, Forging, Shaping	Make	Shaping	Cost effective, Available method
	Slide Housing, Top, Metal Slide, Slide Housing, Bottom, Slide Housing, Interior Bottom	Casting, Forging, Shaping	Make	Casting and Machining	Less time required, Easy, Less cost
	Rubber Insert	Casting, Molding	Make	Casting	Cheaper to perform
	Base		Buy		
	Plastic Bearing		Buy		
	Upper Spring, slide spring		Buy		
	Exterior Sliding Plate	Casting, Shaping, Forging	Make	Forging	High strength, easy to perform

This table exhibits the make or buys decision of the parts of stapler sub-assembly. It also shows various manufacturing processes for the parts that have to be manufactured. For plastic material, the only method available is casting as molding equipments are unavailable. Cylindrical shaped metal axle will be manufactured by turning. For top tab, shaping has been selected as the shape of tab is not so complex. Hence it will be cost effective.

6.2.2 Manufacturing Process Selection for Punch Machine

Table 6. 6 Manufacturing process selection for various parts of punch machine

Section	Components	Possible Manufacturing Processes	Make or buy	Manufacturing Process Selected	Reasons behind selection
Punch Machine	Lever arm	Forging, Bending, Casting,	Make	Forging	Easy to perform, Better surface finish
	Punch	Turning	Make	Turning	Easy to perform, Less cost
	Static fulcrum	Casting, Forging, Extrusion	Make	Turning	Easy to perform, Less cost
	Dynamic fulcrum	Casting, Forging, Extrusion	Make	Turning	Easy to perform, Less cost
	Bottom Support Plate	Forging, Bending, Casting,	Make	Bending and Machining	Easy to perform, Better surface finish
	Spring		Buy		

There are mainly two types of manufacturing processes in this sub-assembly. The cylindrical shaped parts will be manufactured by turning process as it is quite easy to perform using a lathe machine. The main frame is needed to be manufactured in forging method due to its shape. Some common part like spring will be bought from the market.

6.2.3 Manufacturing Process Selection for Spiral Binder

Table 6.7 Manufacturing process selection for various parts of spiral binder

Section	Components	Possible Manufacturing Processes	Make or buy	Manufacturing process selection	Reasons behind selection
Spiral Binder	Lever Arm	Casting, Grinding	Make	Casting and Shaping	Less cost, easy to perform
	Aligned Punching Pins	Casting, Turning	Make	Turning	Less cost, Easy to perform
	Spring		Buy		
	Sliding Guide Bar	Casting, Turning	Make	Turning	Less cost, Easy to perform
	Supporting Frame	Casting, Grinding	Make	Casting and Shaping	Easy to perform, Cost effective

The cylindrical components will be manufactured by turning. The top plastic cover is needed to be manufactured in injection molding method as there are curvatures on the cover. Upper exterior and bottom interior frame will be prepared by casting and then shaping will be performed on the casted job. Again, spring will be bought from the market.

6.2.4 Manufacturing Process Selection for Main Body Frame

Table 6.8 Manufacturing process selection for various parts of main body frame

Section	Components	Possible Manufacturing Processes	Make or buy	Manufacturing process selection	Reasons behind selection
Main Body Frame	Bottom Plastic Cover	Casting, Injection Molding	Make	Injection Molding	Easy to implement intricate shapes
	Plastic scale	Casting, Injection Molding	Make	Injection Molding	Less complexity
	Base	Shaping, Forging, Casting, Shaping	Make	Casting and Shaping	Easy to perform, Cost effective
	Rivet		Buy		

There are only two components in this sub-assembly. Both the components are of similar genre. Both the components will be manufactured through casting.

6.3 Qualitative Analysis of Parts Joining Method Selection

Joints are basically of three types- permanent, semi-permanent and temporary. In the process of joining the parts of different sub-assemblies of Super Binder, only permanent and temporary joints are required. A working knowledge on various manufacturing knowledge is implemented here to determine the joining methods qualitatively. The joining method selection tables for Super Binder are as follows.

6.3.1 Parts Joining Method Selection for Stapler

Table 6.9 Join method selection table for stapler

Joining Parts	Type of Joint	Joining Method Options	Joint Selected	Reason behind Selection
Top Plastic Cover and Top Slide Housing	Permanent	Epoxy Adhesive, Laser Joining, Hot glue	Epoxy Adhesive	Cheap, Provides sufficient strength

Joining Parts	Type of Joint	Joining Method Options	Joint Selected	Reason behind Selection
Top Slide Housing and Top Tab	Permanent	Spot Welding, Arc Welding, TIG, MIG	TIG Welding	Better joining strength, Precision in joining
Base and Bottom Cover, Base and exterior sliding plate	Permanent	Epoxy Adhesive, Laser Joining, Hot glue	Epoxy Adhesive	Cheap, Provides sufficient strength to the joint
Upper Spring and Base	Permanent	Spot Welding, Arc Welding, TIG, MIG	TIG Welding	Better surface finish, Precision in joining
Top Slide Housing, Bottom Slide Housing, Base and Metal Axle	Temporary	Hinge	Hinge	Ease of rotation, less friction
Long Metal Axle and Bottom Slide Housing	Permanent	Arc welding, TIG, MIG	TIG Welding	Precision in joining
Slide Spring and Bottom Slide Housing	Permanent	Arc welding, TIG, MIG	TIG Welding	Better joining strength, Precision in joining
Slide Spring and Metal Slide	Permanent	Arc welding, TIG, MIG	TIG Welding	Better joining strength, Precision in joining
Metal Slide and Bottom Slide Housing	Temporary	Slide	Slide	Easy to move, less friction

In this sub-assembly, most of the joints are permanent joints. For joining metal with plastic epoxy adhesive is selected. For metal-metal joint, TIG welding is selected. There are two

temporary joints. One is a hinge joint and the other is a slide joint. These joints can move freely in its guide path.

6.3.2 Parts Joining Method Selection for Punch Machine

Table 6.10 Join method selection table for punch machine

Joining Parts	Type of Joint	Joining Method Options	Joint Selected	Reason behind Selection
Bottom Support Plate and Main Body Frame	Permanent	Spot Welding, Arc Welding, TIG, MIG	TIG Welding	Better surface finish, High joining strength
Dynamic Fulcrum, Lever Arm and Bottom Support plate	Temporary	Bolted, Nut-Bolt, Arc, Welding	Rivet	Higher strength than other joints
Static Fulcrum and Lever Arm	Temporary	Bolted, Nut-Bolt, Arc, Welding	Rivet	Higher strength than other joints, Better appearance

In this sub-assembly, all the joints are permanent joint. Of these two are bolted joints. From welding section, Spot welding is selected for one joining and rest two joints are supposed to be made using TIG welding.

6.3.3 Parts Joining Method Selection for Spiral Binder

Table 6.11 Joining method selection table for spiral binder

Joining Parts	Type of Joint	Joining Method Options	Joint Selected	Reason behind Selection
Aligned Punching pins and Sliding Guide Bar	Permanent	Arc welding, TIG, MIG	TIG Welding	Better joining strength, Precision in joining

Joining Parts	Type of Joint	Joining Method Options	Joint Selected	Reason behind Selection
Supporting frame and Main Base	Permanent	Arc Welding, TIG, MIG	TIG Welding	Precision in joining
Lever arm and Sliding Guide Bar	Permanent	Arc welding, TIG, MIG	TIG Welding	Better joining strength, Precision in joining
Spring and Supporting Frame	Permanent	Arc welding, TIG, MIG	TIG Welding	Precision in joining

6.5.4 Parts Joining Method Selection for Frame

Table 6.12 Joining method selection table for main body frame

Joining Parts	Type of Joint	Joining Method Options	Joint Selected	Reason behind Selection
Bottom Plate Cover, Base and Rivet	Permanent	Spot Welding, Arc Welding, TIG, MIG	TIG	Better surface finish, High joining strength

All but one joints of this sub-assembly is supposed to be made using TIG welding for precision welding joint. Only one joint will be made using arc welding. The plastic cover and scale is in temporary joint just using the elasticity of nylon plastic.

The qualitative analysis of material, manufacturing process and joining process selection provides an insight about the overall production process of Super Binder. Before moving to a quantitative analysis, a qualitative discussion helps to reduce computational effort in the further stages by eliminating erroneous choices for materials, manufacturing process and joining method. This qualitative approach of selection may not be meticulous as intuitions have been applied to create it but it certainly leads the way of production. Thus a more specific goal can be set and more accurate and precise data can be gathered regarding the selection procedures. In a nutshell, this qualitative approach has made about fifty percent of conceptual design of Super Binder.

Chapter 7

Determination of Relative Importance of Selection Property of Materials using Digital Logic and Selection of Materials using Performance Index

In the previous segment, a qualitative analysis on material, manufacturing process and joining method selection has been carried out. But qualitative analysis is nothing but applying intuitive knowledge. Therefore, a quantitative analysis for selection criteria is imperative to manufacture a better product. There are several methods for quantifying the properties of a material. Here in this analysis, digital logic method has been applied and materials are selected on the basis of their performance indices. An elaborate process is required to carry out the selection process. Some formulas are also necessary to calculate performance index. In this chapter, material selection process is implemented for each and every part of Super Binder.

7.1 List of Parts for Each Sub-assembly

7.1.1 Stapler

1. Top and Bottom Plastic Cover
2. Metal Axle
3. Upper Spring
4. Top Tab
5. Top Slide Housing
6. Bottom Slide Housing
7. Bottom Interior Slide Housing
8. Metal Slide
9. Slide Spring
10. Base
11. Exterior Slide Plates

7.1.2 Punch Machine

1. Lever Arm
2. Punch

3. Static Fulcrum
4. Dynamic Fulcrum
5. Spring
6. Bottom Support Plate

7.1.3 Spiral Binder

1. Lever Arm
2. Aligned Punching Pins
3. Spring
4. Sliding Guide Bar
5. Supporting Frame

7.1.4 Main Body Frame

1. Bottom plastic cover
2. Plastic Scale
3. Base
4. Rivet

7.2 Equations

1. Relative Emphasis Coefficient, $\alpha = (\text{No. of positive decisions acquired by a criteria}) / (\text{Total no. of positive decisions})$

2. For properties to be maximized,
Scaled Property, $\beta = (\text{Numerical value of property} / \text{Maximum value in list}) \times 100$

3. For properties to be minimized,
Scaled Property, $\beta = (\text{Minimum value in list} / \text{Numerical value of property}) \times 100$

4. Weighted score = Relative emphasis coefficient (α) * Scaled property (β)

5. Performance index, $\gamma = \sum \text{Weighted score } (\alpha * \beta)$

7.3 Quantitative Analysis of Material Selection of Stapler Sub-assembly

7.3.1 Top Plastic Cover and Bottom Plastic Cover

Table 7.1 Lists of selection criteria with numerical values or value from Likert scale for Top Plastic Cover and Bottom Plastic Cover

Selection Criteria	PVC	Nylon	Silicon Rubber
Tensile Strength (MPa)	52	80	13
Corrosion resistance	5	4	4
Surface finish	3	2	3
Toughness (MPa/m ²)	650	800	500
Light weight	25	1.06	2.25
Cost	5	40	50
Availability	4	4	3
Elastic modulus (GPa)	2.9	3.3	1.9

Table 7.2 Likert Scale for comparing material selection of Top Plastic Cover and Bottom Plastic Cover

Very Good	5
Good	4
Moderate	3
Poor	2
Very Poor	1

Material Selection for Top Plastic Cover and Bottom Plastic Cover of Stapler

Table 7.3 Determination of relative importance of material selection criteria for Top Plastic Cover and Bottom Plastic Cover using Digital Logic Method

Selection Criteria	Number of positive decisions, $N = n(n-1)/2 = 8(8-1)/2 = 28$																												Positive decisions	Relative emphasis coefficient, α	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28			
Strength	0	0	0	1	0	0	0																							1	0.036
Corrosion resistance	1							1	0	0	1	0	1																	4	0.143
Surface finish		1						0						1	1	1	0	1												5	0.179
Toughness			1						1					0					1	1	0	1							5	0.179	
Light weight				0						1					0				0				0	0	1				2	0.07	
Cost					1						0					0					0			1			0	1	3	0.107	
Availability						1						1					1					1			1		1	1	7	0.25	
Elastic modulus							1						0					0				0			0		0	0	1	0.036	
Total number of positive decisions																												28	$\sum\alpha=1.0$		

This chart shows the digital logic method for material selection of two similar components of stapler. Of all the criteria, availability has the highest number of positive decisions. As a result it has a highest value of relative emphasis coefficient. Surface finish and toughness has the second highest positive responses. On the other hand, strength and elastic modulus have the least number of positive responses which results in attaining the lowest value of relative emphasis coefficient.

Table 7.4: Calculation of the performance index for material selection of Top Plastic Cover and Bottom Plastic Cover of Stapler

Selection Criteria	Relative Emphasis Coefficient α	PVC		Nylon		Silicon Rubber	
		Scaled property β	Weighted score $A\beta$	Scaled property β	Weighted score $\alpha\beta$	Scaled property B	Weighted score $\alpha\beta$
Strength	0.036	65	2.34	100	3.6	16.25	0.59
Corrosion resistance	0.143	75	10.73	100	14.3	100	14.3
Surface finish	0.179	75	13.43	100	17.9	75	13.43
Hardness	0.179	81.25	14.54	100	17.3	62.5	11.19
Light weight	0.07	61.33	4.27	47.11	3.29	100	7
Cost	0.107	50	5.35	80	8.56	100	10.7
Availability	0.25	60	15	75	18.75	60	15
Elastic modulus	0.036	87.88	3.16	100	3.6	57.58	2.07
Material Performance Index			68.82		87.3		74.28

For the manufacturing of top and bottom plastic cover, nylon has been selected as per the calculations from PVC, nylon and Silicon rubber. Nylon has a better weighted score than rest of the two materials. Thus nylon is selected.

7.3.2 Top Tab, Base, Slide Housing (top, bottom, interior), Exterior Sliding Plates and Metal Slide

Table 7.5 List of selection criteria with numerical values or value from Likert scale for Top Tab, Base, Slide Housing (top, bottom, interior) and Metal Slide

Selection Criteria	Stainless steel	Mild steel	High Carbon Steel
Tensile Strength (MPa)	505	440	540
Corrosion resistance	5	3	3
Surface finish	5	4	2
Hardness (Metric)	138	126	380
Light weight	7.95	7.87	4.22
Cost (BDT/kg)	180	55	45
Availability	3	5	5
Elastic modulus (GPa)	196	205	125

Table 7.6 Likert Scale for comparing material selection of Top Tab, Base, Slide Housing (top, bottom, interior) and Metal Slide

Very Good	5
Good	4
Moderate	3
Poor	2
Very Poor	1

Material Selection for Top Tab, Base, Slide Housing (top, bottom, interior) and Metal Slide of Stapler

Table 7.7 Determination of relative importance of material selection criteria for Tab, Base, Slide Housing (top, bottom, interior) and Metal Slide using Digital Logic Method

Selection Criteria	Number of positive decisions, $N = n(n-1)/2 = 8(8-1)/2 = 28$																												Positive decisions	Relative emphasis coefficient α	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28			
Strength	1	1	1	1	1	0	1																							6	0.214
Corrosion resistance	0						1	0	1	0	0	1																		3	0.107
Surface finish		0					0						0	1	0	0	0													1	0.036
Hardness			0					1					1					1	1	0	0								4	0.143	
Light weight				0						0				0				0				0	0	1					1	0.036	
Cost					1						1					1				0			1			0	0		4	0.107	
Availability						1						1					1				1			1		1		1	7	0.25	
Elastic modulus							0						0					1				1			0		1	0	3	0.107	
Total number of positive decisions																												28	$\sum\alpha=1.0$		

This chart shows the digital logic method for material selection of several components of stapler. All of these possess the same selection criteria. Of all the criteria, availability has the highest number of positive decisions. As a result it has a highest value of relative emphasis coefficient. Strength has the second highest positive responses. On the other hand, light weight and surface finish have the least number of positive responses which results in attaining the lowest value of relative emphasis coefficient.

Table 7.8 Calculation of the performance index for material selection of Top Tab, Base, Slide Housing (top, bottom, interior) and Metal Slide

Selection criteria	Relative emphasis coefficient α	Stainless Steel		High Carbon Steel		Mild Steel	
		Scaled property β	Weighted score $A\beta$	Scaled property β	Weighted score $\alpha\beta$	Scaled property B	Weighted score $\alpha\beta$
Strength	0.214	98.52	21.08	100	21.4	87.12	18.64
Corrosion resistance	0.107	100	10.7	60	10.7	60	6.42
Surface finish	0.036	100	3.6	40	1.44	80	2.88
Toughness	0.143	100	14.3	36	5.148	41.6	5.95
Light weight	0.036	100	3.6	53.08	1.91	98.99	3.56
Cost	0.107	100	10.7	25	2.68	30.56	3.27
Availability	0.25	60	25	100	6.25	100	25
Elastic modulus	0.107	95.6	10.7	60.97	6.52	100	10.7
Material Performance Index			99.68		56.05		76.42

For manufacturing top tab, base, slide housing (top, bottom, and interior) and metal slide of stapler, three materials have been compared- mild steel, stainless steel and high carbon steel. Calculating relative emphasis coefficient for each selection criteria and scaled property of each material for all criteria, material performance index has been calculated. Of three, stainless steel has the highest material performance index. Therefore, stainless steel has been chosen for manufacturing these three components.

7.3.3 Metal Axle

Table 7.9 List of selection criteria with numerical values or value from Likert scale for Metal Axle of Stapler

Selection Criteria	Mild Steel	Stainless Steel	High Carbon Steel
Tensile Strength, UTS (MPa)	440	505	540
Corrosion Resistance	3	5	3
Surface Finish	4	5	2
Brinell Hardness, Metric	126	138	380
Toughness (MPa/m ²)	104	250	90
Cost (BDT/kg)	55	180	45
Availability	5	3	5
Machinability	4	2	3
Modulus of Elasticity (GPa)	205	196	125

Table 7.10 Likert Scale for comparing material selection of Metal Axle of Stapler

Very Good	5
Good	4
Moderate	3
Poor	2
Very Poor	1

Material Selection for Metal Axle of Stapler

Table 7.11 Determination of relative importance of material selection criteria for metal axle using Digital Logic Method

Selection Criteria	Number of positive decisions, $N= n(n-1)/2=9(9-1)/2=36$																																				Positive decisions	Relative emphasis coefficient, α		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36				
Tensile Strength, UTS	1	1	0	0	1	1	1	0																														5	0.1389	
Corrosion Resistance	0							1	0	0	1	1	1	0																									4	0.1111
Surface Finish		0						0							0	0	0	1	1	0																			2	0.0556
Brinell Hardness, Metric			1						1						1						0	1	1	0	0													6	0.1667	
Toughness				1						1						1					1						1	1	0	1								7	0.1944	
Cost					0						0						1					0					0				1	0	1					3	0.0833	
Availability						0						0						0					0					0			0			1	0			1	0.0278	
Machinability							0						0						0					1				1			1		1		0		0	3	0.0833	
Modulus of Elasticity								1					1							1					1				0			0			1	1		6	0.1667	
Total number of positive decisions																																				36	$\sum \alpha = 1.0$			

This chart shows the digital logic method for material selection of metal axle of stapler. Of all the criteria, toughness has the highest number of positive decisions. As a result these have a highest value of relative emphasis coefficient. On the other hand, availability has the least number of positive responses which results in attaining the lowest value of relative emphasis coefficient.

Table 7.12 Calculation of the performance index for material selection of Metal Axle of Stapler

Selection criteria	Relative emphasis coefficient A	Mild steel		Stainless steel		High Carbon Steel	
		Scaled property β	Weighted score $\alpha\beta$	Scaled property β	Weighted score $\alpha\beta$	Scaled property B	Weighted score $\alpha\beta$
Tensile Strength, UTS	0.1389	81	11.2509	95	13.1955	100	13.89
Corrosion Resistance	0.1111	60	6.666	100	11.11	60	6.666
Surface Finish	0.0556	80	4.448	100	5.56	40	2.224
Brinell Hardness, Metric	0.1667	33	5.5011	37	6.1679	100	16.67
Toughness	0.1944	42	8.1648	100	19.44	36	6.9984
Cost	0.0833	82	6.8306	31	2.5823	100	8.33
Availability	0.0278	100	2.78	60	1.668	100	2.78
Machinability	0.0833	100	8.33	50	4.165	75	6.2475
Modulus of Elasticity	0.1667	100	16.67	96	16.0032	61	10.1687
Material Performance Index			70.6414		79.8919		73.9746

For manufacturing top metal axle of stapler, three materials have been compared- mild steel, stainless steel and High Carbon Steel. Calculating relative emphasis coefficient for each selection criteria and scaled property of each material for all criteria, material performance index has been calculated. Of three, mild steel has the highest material performance index. Therefore, mild steel has been chosen for manufacturing these three components.

7.4 Quantitative Analysis of Material Selection of Punch Machine Sub-assembly

7.4.1 Static and Dynamic Fulcrum

Table 7.13 List of selection criteria with numerical values or value from Likert scale for Static and Dynamic Fulcrum

Selection Criteria	Mild Steel	Stainless Steel	Cast Iron
Tensile Strength, UTS (MPa)	440	505	276
Ductility	35	20	25
Toughness (MPa/m ²)	104	250	200
Density (g/cm ³)	7.87	7.95	7.15
Cost (BDT/kg)	55	180	110
Availability	5	3	4
Weldability	5	3	2

Table 7.14 Likert Scale for comparing material selection of Static and Dynamic fulcrum

Very Good	5
Good	4
Moderate	3
Poor	2
Very Poor	1

Material Selection for Static and Dynamic Fulcrum of Punch Machine

Table 7.15 Determination of relative importance of material selection criteria for static and dynamic fulcrum of punch machine using Digital Logic Method

Selection Criteria	Number of positive decisions, $N = n(n-1)/2 = 7(7-1)/2 = 21$																					Positive decisions	Relative emphasis coefficient, α
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21		
Strength	1	1	0	1	0	0																3	0.1429
Toughness	0						0	1	1	0	0											2	0.0952
Ductility		0					1					1	1	0	0							3	0.1429
Cost			1					0				0				1	0	0				2	0.0952
Light weight				0					0				0			0			1	0		1	0.0476
Availability					1					1				1			1		0		0	4	0.1905
Weldability						1					1				1			1		1	1	6	0.2857
Total number of positive decisions																					21	1	

This chart shows the digital logic method for material selection of two components of punch machine. The reason of combining two components is the selection considerations of these components are same. Of all the criteria, weldability has the highest number of positive decisions. As a result it has a highest value of relative emphasis coefficient. On the other hand, light weight has the least number of positive responses which results in attaining the lowest value of relative emphasis coefficient.

Table 7.16 Calculation of the performance index for material selection of Static and Dynamic Fulcrum of Punch Machine

Selection criteria	Relative emphasis coefficient A	Mild steel		Stainless steel		Cast Iron	
		Scaled property β	Weighted score $\alpha\beta$	Scaled property β	Weighted score $\alpha\beta$	Scaled property β	Weighted score $\alpha\beta$
Strength	.1429	87	12.43	100	14.29	54	7.7
Toughness	.0952	41	3.9	100	9.52	80	7.61
Ductility	.1429	100	14.29	57	8.1	71	8.19
Cost	.0952	100	9.52	31	2.95	50	4.76
Weight	.0476	91	4.33	89	4.23	100	4.76
Availability	.1905	100	19.05	60	11.43	80	15.24
Weldability	.2857	100	28.57	60	17.14	40	11.4
Material Performance Index			92.09		67.68		59.66

For manufacturing of static and dynamic fulcrum of punch machine, three materials have been compared- mild steel, stainless steel and cast iron. Calculating relative emphasis coefficient for each selection criteria and scaled property of each material for all criteria, material performance index has been calculated. Of three, mild steel has the highest material performance index. Therefore, mild steel has been chosen for manufacturing these three components.

7.4.2 Punch

Table 7.17 List of selection criteria with numerical values or value from Likert scale for Punch of Punch Machine

Selection Criteria	Mild Steel	Stainless Steel	Cast Iron
Tensile Strength, UTS (MPa)	440	505	276
Corrosion Resistance	3	5	2
Surface Finish	4	5	3
Brinell Hardness, Metric	126	138	210
Toughness (MPa/m ²)	104	250	200
Density (g/cm ³)	7.87	7.95	7.15
Cost (BDT/kg)	55	180	110
Availability	5	3	4
Machinability	4	2	5

Table 7.18 Likert Scale for comparing material selection of Punch of Punch Machine

Very Good	5
Good	4
Moderate	3
Poor	2
Very Poor	1

Material Selection for punch of punch machine

Table 7.19 Determination of relative importance of material selection criteria for punch of punch machine using Digital Logic Method

Selection Criteria	Number of positive decisions, $N = n(n-1)/2 = 9(9-1)/2 = 36$																																				Positive decisions	Relative emphasis coefficient, α		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36				
Strength	1	1	0	0	1	1	0	1																													5	0.1389		
Corrosion resistance	0								0	0	0	1	0	0	1																							2	0.0556	
Surface finish		0						1								0	0	1	0	0	0																	2	0.0556	
Hardness			1						1							1						0	1	1	1	1												7	0.1944	
toughness				1						1							1					1						1	1	1	1								8	0.2222
Light weight					0						0							0					0					0			0	0	1					1	0.0278	
Cost						0						1						1					0					0			1			0	0			3	0.0833	
Availability							1						1					1						0				0		0		1		1	1		1		6	0.1667
Machinability								0					0							1						0			0			0		0	0	0			2	0.0556
Total number of positive decisions																																				36	$\sum \alpha = 1.0$			

This chart shows the digital logic method for material selection of three components of punch of punch machine. The reason of combining three components is the selection considerations of these components are same. Of all the criteria, toughness has the highest number of positive decisions. As a result it has a highest value of relative emphasis coefficient. On the other hand, light weight has the least number of positive responses which results in attaining the lowest value of relative emphasis coefficient.

Table 7.20 Calculation of the performance index for material selection of punch of Punch Machine

Selection criteria	Relative emphasis coefficient A	Mild steel		Stainless steel		Cast Iron	
		Scaled property β	Weighted score $\alpha\beta$	Scaled property B	Weighted score $\alpha\beta$	Scaled property β	Weighted score $\alpha\beta$
Strength	.1389	87	12	100	13.89	54.65	7.59
Corrosion resistance	.0556	60	3.33	100	5.56	40	2.22
Surface finish	.0556	80	4.4	100	5.56	60	3.33
Hardness	.1944	60	.11.6	65	12.77	100	19.4
toughness	.2222	40	9	100	22.22	80	18
Light weight	.0278	90	2.5	89	2.5	100	2.7
Cost	.0833	100	8.33	30	2.5	50	4.2
Availability	.1667	100	16.67	60	10	80	13
Machinability	.0556	80	4.4	40	2.2	100	5.5
Material Performance Index			60.63		77.21		75.94

For manufacturing punch of punch machine, three materials have been compared- mild steel, stainless steel and Cast Iron. Calculating relative emphasis coefficient for each selection criteria and scaled property of each material for all criteria, material performance index has been calculated. Of three, stainless steel has the highest material performance index. Therefore, stainless steel has been chosen for manufacturing these three components.

7.4.3 Lever Arm and Bottom Support Plate

Table 7.21 List of selection criteria with numerical values or value from Likert scale for Lever Arm and Bottom Support Plate of Punch Machine

Selection Criteria	Mild Steel	Stainless Steel	Cast Iron
Strength UTS (MPa)	505	440	276
Corrosion resistance	5	3	2
Surface Finish	5	4	3
Toughness(MPa/m ²)	250	104	200
Weight(g/cm ³)	7.95	7.87	7.15
Cost(BDT/kg)	55	180	110
Availability	3	5	4
Elastic Modulus(GPa)	193	200	160
Strength UTS (MPa)	505	440	276

Table 7.22 Likert Scale for comparing material selection of Lever Arm and Bottom Support Plate of Punch Machine

Very Good	5
Good	4
Moderate	3
Poor	2
Very Poor	1

Material Selection for Lever arm and Bottom Support Plate of Punch machine

Table 7.23 Determination of relative importance of material selection criteria for lever arm of Punch Machine using Digital Logic Method

Selection Criteria	Number of positive decisions, $N = n(n-1)/2 = 8(8-1)/2 = 28$																												Positive decisions	Relative emphasis coefficient, α	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28			
Strength	1	1	0	1	1	0	1																							5	0.1786
Corrosion resistance	0							1	0	0	0	0	0																	1	0.0357
Surface finish		0						0					0	1	0	0	0													1	0.0357
toughness			1						1				1					1	1	0	0									5	0.1786
Light weight				0						1				0				0					1	0	0					2	0.0714
Cost					0						1				1					0			0			0	1			3	0.1071
Availability						1						1					1				1			1		1		0		6	0.2143
Elastic modulus							0						1				1					1			1		0	1		5	0.1786
Total number of positive decisions																												28	$\sum \alpha = 1.0$		

This chart shows the digital logic method for material selection of lever arm and bottom support plate of punch machine. Of all the criteria, availability has the highest number of positive decisions. As a result it has a highest value of relative emphasis coefficient. On the other hand, Corrosion resistance and surface finish have the least number of positive responses which results in attaining the lowest value of relative emphasis coefficient.

Table 7.24 Calculation of the performance index for material selection of lever arm and bottom support plate of punch machine

Selection criteria	Relative emphasis coefficient A	Mild steel		Stainless steel		Cast Iron	
		Scaled property β	Weighted score $\alpha\beta$	Scaled property B	Weighted score $\alpha\beta$	Scaled property β	Weighted score A β
Strength	0.1786	100	17.86	87	15.54	55	9.82
Corrosion Resistance	0.0357	100	3.57	60	2.14	40	1.43
Surface Finish	0.0357	100	3.57	80	2.86	60	2.14
Toughness	0.1786	100	17.86	42	7.5	80	14.29
Weight	0.0714	90	6.426	91	6.49	100	7.14
Cost	0.1071	100	10.71	31	3.32	50	5.36
Availability	0.2143	60	12.86	100	21.43	80	17.14
Elastic Modulus	.1786	97	17.32	100	17.86	80	14.29
Material performance Index			90.18		77.14		71.61

For manufacturing lever arm and bottom support plate, three materials have been compared- mild steel, stainless steel and Cast Iron. Calculating relative emphasis coefficient for each selection criteria and scaled property of each material for all criteria, material performance index has been calculated. Of three, mild steel has the highest.

7.5 Quantitative Analysis of Material Selection of Spiral Binding Sub-assembly

7.5.1 Lever Arm

Table 7.25 List of selection criteria with numerical values or value from Likert scale for Lever Arm of Spiral Binder

Selection Criteria	Mild Steel	Stainless Steel	Cast Iron
Tensile Strength, UTS (MPa)	440	505	276
Corrosion Resistance	3	5	2
Surface Finish	4	5	3
Brinell Hardness, Metric	126	138	210
Toughness (MPa/m ²)	104	250	200
Cost (BDT/kg)	55	180	110
Availability	5	3	4
Weldability	5	3	2
Modulus of Elasticity (GPa)	205	196	150

Table 7.26 Likert Scale for comparing material selection of Lever Arm of Spiral Binder

Very Good	5
Good	4
Moderate	3
Poor	2
Very Poor	1

Material Selection for Upper Exterior Frame and Bottom Interior Frame

Table 7.27 Determination of relative importance of material selection criteria for Upper Exterior Frame and Bottom Interior Frame

Selection Criteria	Number of positive decisions, $N = n(n-1)/2 = 9(9-1)/2 = 36$																																				Positive decisions	Relative emphasis coefficient, α		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36				
Tensile Strength, UTS	0	0	1	1	1	1	0	1																														5	0.1389	
Corrosion Resistance	1							1	0	0	0	1	1	0																									4	0.1111
Surface Finish		1						0							0	1	0	1	1	0																			4	0.1111
Brinell Hardness, Metric			0						1						1						0	0	0	1	0													3	0.0833	
Toughness				0						1						0					1							0	0	0	0								2	0.0556
Cost					0						1						1					1						1				1	1	1					7	0.1944
Availability						0						0						0					1					1			0			1	0				3	0.0833
Weldability							1						0					0					0						1			0	0		1	0			3	0.0833
Modulus of Elasticity								0					1						1					1					1			1		0		1	0		5	0.1389
Total number of positive decisions																																					36	$\sum \alpha = 1$		

This chart shows the digital logic method for Lever Arm of spiral binder. The reason of combining three components is the selection considerations of these components are same. Of all the criteria, cost has the highest number of positive decisions. As a result it has a highest value of relative emphasis coefficient. Tensile strength and modulus of elasticity has the second highest positive responses. On the other hand, toughness has the least number of positive responses which results in attaining the lowest value of relative emphasis coefficient.

Table 7.28 Calculation of the performance index for material selection of Lever Arm of Spiral Binder

Selection criteria	Relative emphasis coefficient A	Mild steel		Stainless steel		Cast Iron	
		Scaled property β	Weighted score $\alpha\beta$	Scaled property B	Weighted score $\alpha\beta$	Scaled property y β	Weighted score A β
Tensile Strength, UTS	0.1389	87	12.0843	100	13.89	55	7.6395
Corrosion Resistance	0.1111	60	6.666	100	11.11	40	4.444
Surface Finish	0.1111	80	8.888	100	11.11	60	6.666
Brinell Hardness, Metric	0.0833	100	8.33	91.3	7.60529	63	5.2479
Toughness	0.0556	42	2.3352	100	5.56	80	4.448
Cost	0.1944	100	19.44	30.5	5.9292	50	9.72
Availability	0.0833	100	8.33	60	4.998	80	6.664
Weldability	0.0833	100	8.33	60	4.998	40	3.332
Modulus of Elasticity	0.1389	100	13.89	95.6	13.27884	73	10.1397
Material Performance Index			88.2935		78.47933		58.3011

For manufacturing Lever Arm of Spiral Binder, three materials have been compared- mild steel, stainless steel and Cast Iron. Calculating relative emphasis coefficient for each selection criteria

and scaled property of each material for all criteria, material performance index has been calculated. Of three, mild steel has the highest material performance index. Therefore, mild steel has been chosen for manufacturing these three components.

7.5.2 Aligned Punching Pins

Table 7.29 List of selection criteria with numerical values or value from Likert scale for Aligned Punching Pins of Spiral Binder

Selection Criteria	Mild Steel	Stainless Steel	High Carbon Steel
Tensile Strength, UTS (MPa)	440	505	540
Corrosion Resistance	3	5	3
Surface Finish	4	5	2
Brinell Hardness, Metric	126	138	380
Toughness (MPa/m ²)	104	250	90
Cost (BDT/kg)	55	180	45
Availability	5	3	5
Machinability	4	2	3
Modulus of Elasticity (GPa)	205	196	125

Table 7.30 Likert Scale for comparing material selection of Aligned Punching Pins of Spiral Binder

Very Good	5
Good	4
Moderate	3
Poor	2
Very Poor	1

Material Selection for Aligned Punching Pins of Spiral Binder

Table 7.31 Determination of relative importance of material selection criteria for Aligned Punching Pins

Selection Criteria	Number of positive decisions, $N= n(n-1)/2=9(9-1)/2=36$																																				Positive decisions	Relative emphasis coefficient, α	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36			
Tensile Strength, UTS	1	1	0	0	1	1	1	0																													5	0.1389	
Corrosion Resistance	0							1	0	0	1	1	1	0																								4	0.1111
Surface Finish		0						0							0	0	0	1	1	0																		2	0.0556
Brinell Hardness, Metric			1					1						1						0	1	1	0	0													6	0.1667	
Toughness				1						1						1				1							1	1	0	1							7	0.1944	
Cost					0						0						1				0						0				1	0	1				3	0.0833	
Availability						0						0						0				0						0			0			1	0		1	0.0278	
Machinability							0						0						0					1				1			1		1	0		0	3	0.0833	
Modulus of Elasticity								1						1						1					1					0			0		1	1	6	0.1667	
Total number of positive decisions																																				36	$\sum\alpha=1.0$		

This chart shows the digital logic method for material selection of aligned punching pins of spiral binder. Of all the criteria, toughness has the highest number of positive decisions. As a result these have a highest value of relative emphasis coefficient. On the other hand, availability has the least number of positive responses which results in attaining the lowest value of relative emphasis coefficient.

Table 7.32 Calculation of the performance index for material selection of Aligned Punching Pins of Spiral Binder

Selection criteria	Relative emphasis coefficient A	Mild steel		Stainless steel		High Carbon Steel	
		Scaled property β	Weighted score $\alpha\beta$	Scaled property B	Weighted score $\alpha\beta$	Scaled property β	Weighted score $\alpha\beta$
Tensile Strength, UTS	0.1389	81	11.2509	95	13.1955	100	13.89
Corrosion Resistance	0.1111	60	6.666	100	11.11	60	6.666
Surface Finish	0.0556	80	4.448	100	5.56	40	2.224
Brinell Hardness, Metric	0.1667	33	5.5011	37	6.1679	100	16.67
Toughness	0.1944	42	8.1648	100	19.44	36	6.9984
Cost	0.0833	82	6.8306	31	2.5823	100	8.33
Availability	0.0278	100	2.78	60	1.668	100	2.78
Machinability	0.0833	100	8.33	50	4.165	75	6.2475
Modulus of Elasticity	0.1667	100	16.67	96	16.0032	61	10.1687
Material Performance Index			70.6414		79.8919		73.9746

For manufacturing Aligned Punching Pins of Spiral Binder, three materials have been compared- mild steel, stainless steel and High Carbon Steel. Calculating relative emphasis coefficient for each selection criteria and scaled property of each material for all criteria, material performance index has been calculated. Of three, mild steel has the highest material performance index. Therefore, mild steel has been chosen for manufacturing these three components.

7.5.3 Sliding Guide Bar

Table 7.33 List of selection criteria with numerical values or value from Likert scale for Sliding Guide Bar

Selection Criteria	Mild Steel	Stainless Steel	High Carbon Steel
Tensile Strength, UTS (MPa)	440	505	540
Corrosion Resistance	3	5	3
Machinability	4	2	3
Brinell Hardness, Metric	126	138	380
Toughness (MPa/m ²)	104	250	90
Cost (BDT/kg)	55	180	45
Availability	5	3	5
Modulus of Elasticity (GPa)	205	196	125

Table 7.34 Likert Scale for comparing material selection of Sliding Guide Bar

Very Good	5
Good	4
Moderate	3
Poor	2
Very Poor	1

Material Selection for Sliding Guide Bar of Spiral Binder

Table 7.35 Determination of relative importance of material selection criteria for Sliding Guide Bar using Digital Logic Method

Selection Criteria	Number of positive decisions, $N = n(n-1)/2 = 8(8-1)/2 = 28$																												Positive decisions	Relative emphasis coefficient, α
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28		
Tensile Strength,	0	0	1	1	1	1	1																						5	.1785
Corrosion Resistance	1							1	0	0	0	1	0																3	.1071
Machinability		1						0					0	1	0	0	1												3	.1071
Brinell Hardness, Metric			0					1					1					0	0	0	0							2	.0714	
Toughness				0						1				0				1				0	0	0				2	.0714	
Cost					0						1					1				1			1			1	1		6	.214
Availability						0						0					1				1			1		0		0	3	.1071
Modulus of Elasticity							0						1					0				1			1		0	1	4	.1428
Total number of positive decisions																												28	$\sum \alpha = 1.0$	

This chart shows the digital logic method for material selection of Sliding Guide Bar of spiral binder. Of all the criteria, cost has the highest number of positive decisions. As a result it has a highest value of relative emphasis coefficient. Tensile strength has the second highest positive responses. On the other hand, toughness and Brittle Hardness has the least number of positive responses which results in attaining the lowest value of relative emphasis coefficient.

Table 7.36 Calculation of the performance index for material selection of Sliding Guide Bar of Spiral Binder

Selection criteria	Relative emphasis coefficient α	Mild steel		Stainless steel		High Carbon Steel	
		Scaled property β	Weighted score $\alpha\beta$	Scaled property B	Weighted score $\alpha\beta$	Scaled property β	Weighted score $\alpha\beta$
Tensile Strength, UTS	0.1785	82	14.637	94	16.78	100	17.85
Corrosion Resistance	0.1071	60	6.426	100	10.71	60	6.426
Machinability	0.1071	100	10.71	50	5.36	75	8.0325
Brinell Hardness, Metric	0.0714	33	2.36	36.3	2.59	100	7.14
Toughness	0.0714	42	2.99	100	7.14	36	2.57
Cost	0.214	31	6.634	100	21.4	25	5.35
Availability	0.1071	100	10.71	60	6.43	100	10.71
Modulus of Elasticity	0.1428	100	14.28	95.6	13.65	61	8.71
Material Performance Index			68.74		84.06		66.79

For manufacturing of Sliding Guide Bar of spiral binder, three materials have been compared- mild steel, stainless steel and High carbon steel. Calculating relative emphasis coefficient for each selection criteria and scaled property of each material for all criteria, material performance index has been calculated. Of three, Stainless steel has the highest material performance index. Therefore, Stainless steel has been chosen for manufacturing this component.

7.5.4 Supporting Frame

Table 7.37 List of selection criteria with numerical values or value from Likert scale for Supporting Frame of Spiral Binder

Selection Criteria	Mild Steel	Stainless Steel	Cast Iron
Tensile Strength, UTS (MPa)	440	505	276
Corrosion Resistance	3	5	2
Surface Finish	4	5	3
Brinell Hardness, Metric	126	138	210
Toughness (MPa/m ²)	104	250	200
Cost (BDT/kg)	55	180	110
Availability	5	3	4
Weldability	5	3	2
Modulus of Elasticity (GPa)	205	196	150

Table 7.38 Likert Scale for comparing material selection of Supporting Frame of Spiral Binder

Very Good	5
Good	4
Moderate	3
Poor	2
Very Poor	1

Material Selection for Supporting Frame of Spiral Binder

Table 7.39 Determination of relative importance of material selection criteria for Supporting Frame of Spiral Binder

Selection Criteria	Number of positive decisions, $N= n(n-1)/2=9(9-1)/2=36$																																				Positive decisions	Relative emphasis coefficient, α					
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36							
Tensile Strength, UTS	0	0	1	1	1	1	0	1																														5	0.1389				
Corrosion Resistance	1							1	0	0	0	1	1	0																									4	0.1111			
Surface Finish		1						0							0	1	0	1	1	0																				4	0.1111		
Brinell Hardness, Metric			0						1						1						0	0	0	1	0														3	0.0833			
Toughness				0						1						0					1							0	0	0	0									2	0.0556		
Cost					0						1						1					1						1				1	1	1						7	0.1944		
Availability						0						0						0					1					1			0			1	0						3	0.0833	
Weldability							1						0						0					0					1			0	0			1	0					3	0.0833
Modulus of Elasticity								0						1						1						1				1			0		1	0						5	0.1389
Total number of positive decisions																																					36	$\sum\alpha=1$					

This chart shows the digital logic method for Supporting Frame of Spiral Binder. The reason of combining three components is the selection considerations of these components are same. Of all the criteria, cost has the highest number of positive decisions. As a result it has a highest value of relative emphasis coefficient. Tensile strength and modulus of elasticity has the second highest positive responses. On the other hand, toughness has the least number of positive responses which results in attaining the lowest value of relative emphasis coefficient.

Table 7.40 Calculation of the performance index for material selection of Supporting Frame of Spiral Binder

Selection criteria	Relative emphasis coefficient A	Mild steel		Stainless steel		Cast Iron	
		Scaled property β	Weighted score $\alpha\beta$	Scaled property B	Weighted score $\alpha\beta$	Scaled property β	Weighted score $\alpha\beta$
Tensile Strength, UTS	0.1389	87	12.0843	100	13.89	55	7.6395
Corrosion Resistance	0.1111	60	6.666	100	11.11	40	4.444
Surface Finish	0.1111	80	8.888	100	11.11	60	6.666
Brinell Hardness, Metric	0.0833	100	8.33	91.3	7.60529	63	5.2479
Toughness	0.0556	42	2.3352	100	5.56	80	4.448
Cost	0.1944	100	19.44	30.5	5.9292	50	9.72
Availability	0.0833	100	8.33	60	4.998	80	6.664
Weldability	0.0833	100	8.33	60	4.998	40	3.332
Modulus of Elasticity	0.1389	100	13.89	95.6	13.27884	73	10.1397
Material Performance Index			88.2935		78.47933		58.3011

For manufacturing Supporting Frame of Spiral Binder, three materials have been compared- mild steel, stainless steel and Cast Iron. Calculating relative emphasis coefficient for each selection

criteria and scaled property of each material for all criteria, material performance index has been calculated. Of three, mild steel has the highest material performance index. Therefore, mild steel has been chosen for manufacturing these three components.

7.6 Quantitative Analysis of Material Selection of Main Body Frame Sub-assembly

7.6.1 Bottom Plastic Cover and Plastic Scale

Table 7.41 List of selection criteria with numerical values or value from Likert scale for Bottom Plastic Cover and Plastic Scale

Selection Criteria	PVC	Nylon	Silicon Rubber
Tensile Strength (MPa)	52	80	13
Corrosion resistance	5	4	4
Surface finish (Likert scale)	3	2	3
Toughness (MPa/m ²)	650	800	500
Light weight (Likert scale)	25	1.06	2.25
Cost	5	40	50
Availability (Likert scale)	4	4	3
Elastic modulus (GPa)	2.9	3.3	1.9

Table 7.42 Likert Scale for comparing material selection of Bottom Plastic Cover and Plastic Scale

Very Good	5
Good	4
Moderate	3
Poor	2
Very Poor	1

Material Selection for Bottom Plastic Cover and Plastic Scale of Main Body Frame

Table 7.43 Determination of relative importance of material selection criteria for Bottom Plastic Cover and Plastic Scale of Main Body Frame using Digital Logic Method

Selection Criteria	Number of positive decisions, $N = n(n-1)/2 = 8(8-1)/2 = 28$																												Positive decisions	Relative emphasis coefficient, α	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28			
Strength	0	0	0	1	0	0	0																							1	0.036
Corrosion resistance	1							1	0	0	1	0	1																	4	0.143
Surface finish		1						0						1	1	1	0	1												5	0.179
Toughness			1					1						0					1	1	0	1							5	0.179	
Light weight				0						1					0				0				0	0	1				2	0.07	
Cost					1							0					0				0			1			0	1	3	0.107	
Availability						1							1					1				1			1		1	1	7	0.25	
Elastic modulus							1						0					0				0			0		0	0	1	0.036	
Total number of positive decisions																												28	$\sum\alpha=1.0$		

This chart shows the digital logic method for material selection of two similar components of stapler. Of all the criteria, availability has the highest number of positive decisions. As a result it has a highest value of relative emphasis coefficient. Surface finish and toughness has the second highest positive responses. On the other hand, strength and elastic modulus have the least number of positive responses which results in attaining the lowest value of relative emphasis coefficient.

Table 7.44 Calculation of the performance index for material selection of Bottom Plastic Cover and Plastic Scale of Main Body Frame

Selection criteria	Relative emphasis coefficient α	PVC		Nylon		Silicon Rubber	
		Scaled property β	Weighted score $\alpha\beta$	Scaled property B	Weighted score $\alpha\beta$	Scaled property β	Weighted score $\alpha\beta$
Strength	0.036	65	2.34	100	3.6	16.25	.59
Corrosion resistance	0.143	75	10.73	100	14.3	100	14.3
Surface finish	0.179	75	13.43	100	17.9	75	13.43
Hardness	0.179	81.25	14.54	100	17.3	62.5	11.19
Light weight	0.07	61.33	4.27	47.11	3.29	100	7
Cost	0.107	100	10.7	12.5	1.3375	10	1.07
Availability	0.25	60	15	75	18.75	60	15
Elastic modulus	0.036	87.88	3.16	100	3.6	57.58	2.07
Material Performance Index			74.17		80.08		64.65

For the manufacturing of Bottom Plastic Cover and Plastic Scale of Main Body Frame, nylon has been selected as per the calculations from PVC, nylon and Silicon rubber. Nylon has a better weighted score than rest of the two materials. Thus nylon is selected.

7.6.2 Base

Table 7.45 List of selection criteria with numerical values or value from Likert scale for Base of Main Frame

Selection Criteria	Mild Steel	Stainless Steel	Cast Iron
Tensile Strength, UTS (MPa)	440	505	276
Corrosion Resistance	3	5	2
Surface Finish	4	5	3
Brinell Hardness, Metric	126	138	210
Toughness (MPa/m ²)	104	250	200
Cost (BDT/kg)	55	180	110
Availability	5	3	4
Weldability	5	3	2
Modulus of Elasticity (GPa)	205	196	150

Table 7.46 Likert Scale for comparing material selection of Base of Main Frame

Very Good	5
Good	4
Moderate	3
Poor	2
Very Poor	1

Material Selection for Base of Main Frame

Table 7.47 Determination of relative importance of material selection criteria for Base of Main Frame using Digital Logic Method

Selection Criteria	Number of positive decisions, $N = n(n-1)/2 = 8(8-1)/2 = 28$																												Positive decisions	Relative emphasis coefficient, α	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28			
Strength	1	1	0	1	1	0	1																							5	0.1786
Corrosion resistance	0						1	0	0	0	0	0																		1	0.0357
Surface finish		0					0						0	1	0	0	0													1	0.0357
toughness			1					1					1					1	1	0	0								5	0.1786	
Light weight				0					1					0				0				1	0	0					2	0.0714	
Cost					0					1					1				0			0			0	1			3	0.1071	
Availabi- lity						1						1					1			1			1		1		1	0	6	0.2143	
Elastic modulus							0						1					1				1			1		0	1	5	0.1786	
Total number of positive decisions																												28	$\sum \alpha = 1.0$		

This chart shows the digital logic method for material selection of Base of Main Frame. Of all the criteria, availability has the highest number of positive decisions. As a result it has a highest value of relative emphasis coefficient. On the other hand, Corrosion resistance and surface finish have the least number of positive responses which results in attaining the lowest value of relative emphasis coefficient.

Table 7.48 Calculation of the performance index for material selection of Base of Main Frame

Selection criteria	Relative emphasis coefficient α	Mild steel		Stainless steel		Cast Iron	
		Scaled property	Weighted score	Scaled property	Weighted score	Scaled property	Weighted score
		β	$\alpha\beta$	β	$\alpha\beta$	β	$\alpha\beta$
Strength	0.1786	100	17.86	87	15.54	55	9.82
Corrosion Resistance	0.0357	100	3.57	60	2.14	40	1.43
Surface Finish	0.0357	100	3.57	80	2.86	60	2.14
Toughness	0.1786	100	17.86	42	7.5	80	14.29
Weight	0.0714	90	6.426	91	6.49	100	7.14
Cost	0.1071	100	10.71	31	3.3201	50	5.36
Availability	0.2143	60	12.86	100	21.43	80	17.14
Elastic Modulus	0.1786	97	17.32	100	17.86	80	14.29
Material Performance Index			90.18		77.14		71.61

For manufacturing Base of Main Frame, three materials have been compared- mild steel, stainless steel and Cast Iron. Calculating relative emphasis coefficient for each selection criteria and scaled property of each material for all criteria, material performance index has been calculated. Of three, mild steel has the highest.

7.6.3 Rivet

Table 7.49 List of selection criteria with numerical values or value from Likert scale for Rivet of Main Body Frame

Selection Criteria	Mild Steel	Stainless Steel	High Carbon Steel
Tensile Strength, UTS (MPa)	440	505	540
Corrosion Resistance	3	5	3
Machinability	4	2	3
Brinell Hardness, Metric	126	138	380
Toughness (MPa/m ²)	104	250	90
Cost (BDT/kg)	55	180	45
Availability	5	3	5
Modulus of Elasticity (GPa)	205	196	125

Table 7.50 Likert Scale for comparing material selection of Rivet of Main Body Frame

Very Good	5
Good	4
Moderate	3
Poor	2
Very Poor	1

Material Selection for Rivet of Main Body Frame

Table 7.51 Determination of relative importance of material selection criteria for Rivet of Main Body Frame using Digital Logic Method

Selection Criteria	Number of positive decisions, $N = n(n-1)/2 = 8(8-1)/2 = 28$																												Positive decisions	Relative emphasis coefficient, α
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28		
Tensile Strength,	0	0	1	1	1	1	1																						5	.1785
Corrosion Resistance	1							1	0	0	0	1	0																3	.1071
Machinability		1						0						0	1	0	0	1											3	.1071
Brinell Hardness, Metric			0						1					1					0	0	0	0							2	.0714
Toughness				0						1					0				1				0	0	0				2	.0714
Cost					0						1					1				1			1				1	1	6	.214
Availability						0						0					1				1			1		0		0	3	.1071
Modulus of Elasticity							0						1					0				1			1		0	1	4	.1428
Total number of positive decisions																												28	$\sum \alpha = 1.0$	

This chart shows the digital logic method for material selection of Rivet of Main Body Frame. Of all the criteria, cost has the highest number of positive decisions. As a result it has a highest value of relative emphasis coefficient. Tensile strength has the second highest positive responses. On the other hand, toughness and Brittle Hardness has the least number of positive responses which results in attaining the lowest value of relative emphasis coefficient.

Table 7.52 Calculation of the performance index for material selection of Rivet of Spiral Binder

Selection criteria	Relative emphasis coefficient α	Mild steel		Stainless steel		High Carbon Steel	
		Scaled property β	Weighted score $\alpha\beta$	Scaled property β	Weighted score $\alpha\beta$	Scaled property β	Weighted score $\alpha\beta$
Tensile Strength, UTS	0.1785	82	14.637	94	16.78	100	17.85
Corrosion Resistance	0.1071	60	6.426	100	10.71	60	6.426
Machinability	0.1071	100	10.71	50	5.36	75	8.0325
Brinell Hardness, Metric	0.0714	33	2.36	36.3	2.59	100	7.14
Toughness	0.0714	42	2.99	100	7.14	36	2.57
Cost	0.214	31	6.634	100	21.4	25	5.35
Availability	0.1071	100	10.71	60	6.43	100	10.71
Modulus of Elasticity	0.1428	100	14.28	95.6	13.65	61	8.71
Material Performance Index			68.74		84.06		66.79

For manufacturing of Rivet of Main Body Frame, three materials have been compared- mild steel, stainless steel and High carbon steel. Calculating relative emphasis coefficient for each selection criteria and scaled property of each material for all criteria, material performance index has been calculated. Of three, Stainless steel has the highest material performance index. Therefore, Stainless steel has been chosen for manufacturing this component.

Chapter 8

Determination of Relative Importance of Selection Property of Materials using Digital Logic and Selection of Manufacturing Process and Joining Method using Performance Index

Manufacturing is the center of any production. Hence a proper selection of manufacturing method is very imperative for better efficiency in terms of cost and design parameters. In the previous segment, a quantitative analysis on material selection has been carried out using digital logic method and performance index. A similar approach has been followed in this chapter for the selection of manufacturing process and joining method. Digital logic is a very advantageous method for determination of relative importance of selection property. On the other hand, performance index provides a numerical measure for process selection. An elaborate process is required to carry out the selection process. Some formulas are also necessary to calculate performance index. In this chapter, manufacturing process and joining method selection process is implemented for each and every part of Super Binder that are to be manufactured rather than buying.

8.1 List of Manufacturing Processes and Joining Methods

8.1.1 Manufacturing Methods Used

1. Casting
2. Forging
3. Turning
4. Shaping
5. Bending
6. Injection Molding
7. Machining

8.1.2 Joining Methods Used

1. TIG welding
2. Epoxy adhesive
3. Hinge
4. Rivet

8.2 Quantitative Analysis of Manufacturing Process Selection

8.2.1 Manufacturing Process Selection for Metal Plate, Side Cover, Slide Housing, Top, Metal Slide, Slide Housing, Bottom, Slide Housing Interior Bottom and Top Tab of Stapler

Table 8.1 List of selection criteria with value from Likert scale for manufacturing of some parts of stapler sub-assembly

Selection Criteria	Forging	Casting and Machining
Strength	5	3
Surface roughness	2	5
Dimensional accuracy	5	3
Cost	4	5
Defect rate	3	5
Specific design requirement	5	4
Operational complexity	3	5

Table 8.2 Likert Scale for comparing manufacturing process selection of manufacturing of some parts of stapler sub-assembly

Very Good	5
Good	4
Moderate	3
Poor	2
Very Poor	1

Manufacturing Process Selection for Slide Housing Top, Metal Slide, Slide Housing Bottom, Slide Housing Interior Bottom, Rubber Insert of Stapler, Upper Exterior Frame and Bottom Interior Frame of Spiral Binder and Base of Main Body Frame

Table 8.3 Determination of relative importance of manufacturing process selection criteria for above mentioned parts of stapler sub-assembly

Selection Criteria	Number of positive decisions, $N = n(n-1)/2 = 7(7-1)/2 = 21$																					Positive decision	Relative emphasis coefficient, α
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21		
Strength	1	0	0	1	0	0																2	0.0952
Surface roughness	0						1	0	1	0	0											2	0.0952
Dimensional accuracy		1					0					0	1	1	0							3	0.1429
Cost			1					1				1				1	1	0				5	0.2381
Defect rate				0					0				0			0			1	0		1	0.0476
Specific design requirement					1						1				0			0		0	0	2	0.0952
Operational complexity						1						1				1			1		1	6	0.2857
Total number of positive decisions																					21	$\sum\alpha=1$	

This chart shows the digital logic method for manufacturing process for Top Plastic Cover, Slide Housing Top, Metal Slide, Slide Housing Bottom, Slide Housing Interior Bottom and Rubber Insert. From all the criteria, operational complexity has the highest number of positive decisions. As a result it has a highest value of relative emphasis coefficient. Cost has the second highest positive responses. On the other hand, defect rate has the least number of positive responses which results in attaining the lowest value of relative emphasis coefficient.

Table 8.4 Calculation of the performance index for manufacturing of some parts of stapler sub-assembly

Selection criteria	Relative emphasis coefficient α	Forging		Casting and Machining	
		Scaled property β	Weighted score $\alpha\beta$	Scaled property β	Weighted score $A\beta$
Strength	0.0952	100	9.52	40	3.81
Surface roughness	0.0952	67	6.38	100	9.52
Dimensional accuracy	0.1429	100	14.29	40	5.72
Cost	0.2381	75	17.86	100	23.81
Defect rate	0.0476	67	3.19	100	4.76
Specific design requirement	0.0952	100	9.52	40	3.81
Operational complexity	0.2857	67	19.14	100	28.57
Performance Index			79.9		80.0

For manufacturing Metal Plate, Side Cover, Slide Housing, Top, Metal Slide, Slide Housing, Bottom, Slide Housing Interior Bottom and top tab, two manufacturing processes have been compared—forging and casting with machining. Calculating relative emphasis coefficient for each selection criteria and scaled property of each process for all criteria, process performance index has been calculated. Among three, casting with machining has the highest process performance index.

8.2.2 Manufacturing Process Selection for Exterior Sliding Plate of Stapler and Lever Arm of Punch Machine

Table 8.5 List of selection criteria with value from Likert scale for manufacturing of Exterior Sliding Plate of Stapler and Lever Arm of Punch Machine

Selection Criteria	Forging	Casting	Bending
Strength	5	3	2
Surface roughness	2	5	3
Dimensional accuracy	5	3	2
Cost	4	5	3
Defect rate	3	5	2
Specific design requirement	5	4	3
Operational complexity	3	5	2

Table 8.6 Likert Scale for comparing manufacturing process selection of manufacturing of Exterior Sliding Plate of Stapler and Lever Arm of Punch Machine

Very Good	5
Good	4
Moderate	3
Poor	2
Very Poor	1

Manufacturing Process Selection for Exterior Sliding Plate of Stapler and Lever Arm of Punch Machine

Table 8.7 Determination of relative importance of manufacturing process selection criteria for Exterior Sliding Plate of Stapler and Lever Arm of Punch Machine

Selection Criteria	Number of positive decisions, $N = n(n-1)/2 = 7(7-1)/2 = 21$																					Positive decisions	Relative emphasis coefficient, α
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21		
Strength	1	1	1	0	1	1																5	0.2381
Surface roughness	0						1	1	1	0	0											3	0.1429
Dimensional accuracy		0					0					1	0	1	0							2	0.0952
cost			0					0				0				0	0	1				1	0.0476
Defect rate				1					0				1			1			1	0		4	0.1905
Specific design requirement					0					1				0			1		0		1	3	0.1429
Operational complexity						0					1				1			0		1	0	3	0.1429
Total number of positive decisions																					21	$\sum \alpha = 1$	

This chart shows the digital logic method for manufacturing process for exterior sliding plates of stapler and lever arm of punch machine. Comparing all the criteria, strength has the highest number of positive decisions. As a result it has a highest value of relative emphasis coefficient. Tensile strength has the second highest positive responses. On the other hand, cost has the least number of positive responses which results in attaining the lowest value of relative emphasis coefficient.

Table 8.8 Calculation of the performance index for manufacturing process of Exterior Sliding Plate of Stapler and Lever Arm of Punch Machine

Selection criteria	Relative emphasis coefficient α	Forging		Casting		Bending	
		Scaled property β	Weighted score $\alpha\beta$	Scaled property β	Weighted score $\alpha\beta$	Scaled property B	Weighted score $\alpha\beta$
Strength	0.2381	100	23.81	60	14.286	40	9.524
Surface roughness	0.1429	100	14.29	40	5.716	67	9.57
Dimensional accuracy	0.0952	100	9.53	60	5.712	40	3.808
Cost	0.0476	75	3.57	60	2.856	100	4.76
Defect rate	0.1905	67	12.76	40	7.62	100	19.05
Specific design requirement	0.1429	100	14.29	80	11.432	60	8.574
Operational complexity	0.1429	67	9.57	40	5.716	100	14.29
Performance Index			87.82		53.34		69.58

For manufacturing exterior sliding plate of stapler and lever arm of punch machine, three manufacturing processes have been compared- forging, casting and bending. Calculating relative emphasis coefficient for each selection criteria and scaled property of each process for all criteria, process performance index has been calculated. Among three, forging has the highest process performance index.

8.2.3 Manufacturing Process Selection for Metal Axle of Stapler, Punch, Static Fulcrum, Dynamic Fulcrum of Punch Machine, Sliding Guide Bar of Spiral Binder

Table 8.9 List of selection criteria with value from Likert scale for manufacturing of Metal Axle of Stapler, Punch, Static Fulcrum, Dynamic Fulcrum of Punch Machine, Sliding Guide Bar of Spiral Binder

Selection Criteria	Turning	Extrusion	Casting
Surface roughness (μ Inch)	16-125	100-250	300-600
Tolerance (μ Inch)	0.001	0.03	0.03
Cost	2	5	2
Operation complexity	2	5	3
Material compatibility	4	2	5
Dimensional accuracy	5	3	2

Table 8.10 Likert Scale for comparing manufacturing process selection of manufacturing of Metal Axle of Stapler, Punch, Static Fulcrum, Dynamic Fulcrum of Punch Machine, Sliding Guide Bar of Spiral Binder

Very Good	5
Good	4
Moderate	3
Poor	2
Very Poor	1

Manufacturing Process Selection for Metal Axle of Stapler, Punch, Static Fulcrum, Dynamic Fulcrum of Punch Machine, Sliding Guide Bar of Spiral Binder

Table 8.11 Determination of relative importance of manufacturing process selection criteria for Metal Axle of Stapler, Punch, Static Fulcrum, Dynamic Fulcrum of Punch Machine, Sliding Guide Bar of Spiral Binder

Selection Criteria	Number of positive decisions, $N = n(n-1)/2 = 6(6-1)/2 = 15$															Positive decisions	Relative emphasis coefficient, α
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		
Surface finish	1	1	0	0	0											2	0.133
Tolerance	0					0	0	1	0							1	0.067
Material compatibility		0				1				1	0	0				2	0.133
Operational complexity			1				1			0			1	0		3	0.200
Cost				1				0			1		0		0	2	0.133
Dimensional accuracy					1				1			1		1	1	5	0.334
Total number of positive decisions																$\Sigma = 15$	$\Sigma = 1$

This chart shows the digital logic method for manufacturing process for Metal Axle of Stapler, Punch, Static Fulcrum, Dynamic Fulcrum of Punch Machine, Sliding Guide Bar of Spiral Binder. Comparing all the criteria, dimensional accuracy has the highest number of positive decisions. As a result it has a highest value of relative emphasis coefficient. Operational complexity has the second highest positive responses. On the other hand, tolerance has the least number of positive responses which results in attaining the lowest value of relative emphasis coefficient.

Table 8.12 Calculation of the performance index for manufacturing process of Metal Axle of Stapler, Punch, Static Fulcrum, Dynamic Fulcrum of Punch Machine, Sliding Guide Bar of Spiral Binder

Selection criteria	Relative emphasis coefficient α	Turning		Extrusion		Casting	
		Scaled property, β	Weighted score, $\alpha\beta$	Scaled property, β	Weighted score, $\alpha\beta$	Scaled property, β	Weighted score, $\alpha\beta$
Surface roughness	0.133	100	13.3	40.28	5.357	15.67	2.083
Tolerance	0.067	3.33	0.223	100	6.7	100	6.7
Material compatibility	0.133	80	10.64	40	5.32	100	13.3
Operation complexity	0.200	100	20	40	8	66.67	13.3
Cost	0.133	100	13.3	40	5.32	100	13.3
Dimensional accuracy	0.334	100	33.4	60	20.04	40	13.34
Performance Index			90.86		50.74		62.02

For manufacturing Metal Axle of Stapler, Punch, Static Fulcrum, Dynamic Fulcrum of Punch Machine, Sliding Guide Bar of Spiral Binder, three manufacturing processes have been compared- turning, extrusion and casting. Calculating relative emphasis coefficient for each selection criteria and scaled property of each process for all criteria, process performance index has been calculated. Among three, turning has the highest process performance index. Therefore, turning has been selected as the manufacturing process.

8.2.4 Manufacturing Process Selection for Bottom Support Plate of Punch Machine

Table 8.13 List of selection criteria with value from Likert scale for manufacturing of bottom support plate

Selection Criteria	Forging	Casting	Bending
Strength	5	3	2
Surface roughness	2	5	3
Dimensional accuracy	5	3	2
Cost	4	5	3
Defect rate	3	5	2
Specific design requirement	5	4	3
Operational complexity	3	5	2

Table 8.14 Likert Scale for comparing manufacturing process selection of manufacturing of Bottom Support Plate of Punch Machine

Very Good	5
Good	4
Moderate	3
Poor	2
Very Poor	1

Manufacturing Process Selection for Bottom Support Plate of Punch Machine

Table 8.15 Determination of relative importance of manufacturing process selection criteria for Bottom Support Plate of Punch Machine

Selection Criteria	Number of positive decisions, $N = n(n-1)/2 = 7(7-1)/2 = 21$																					Positive decisions	Relative emphasis coefficient, α
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21		
Strength	1	1	1	0	1	0																4	0.1905
Surface roughness	0						1	1	1	0	0											3	0.1429
Dimensional accuracy		0					0					1	0	1	0							2	0.0952
cost			0					0				0				0	1	0				1	0.0476
Defect rate				1					0				1			1			1	0		4	0.1905
Specific design requirement					0					1				0			0		0		0	1	0.0476
Operational complexity						1					1				1			1		1	1	6	0.2857
Total number of positive decisions																					21	$\sum \alpha = 1$	

This chart shows the digital logic method for manufacturing process for bottom support plate. Of all the criteria, operational complexity has the highest number of positive decisions. As a result it has a highest value of relative emphasis coefficient. Strength and defect rate has the second highest positive responses. On the other hand, cost and specific design requirements have the least number of positive responses which results in attaining the lowest value of relative emphasis coefficient.

Table 8.16 Calculation of the performance index for manufacturing process selection of bottom support plate

Selection criteria	Relative emphasis coefficient (Weighting factor) α	Forging		Casting		Bending	
		Scaled property β	Weighted score $\alpha\beta$	Scaled property β	Weighted score $\alpha\beta$	Scaled property B	Weighted score $\alpha\beta$
Strength	0.2381	100	23.81	60	14.286	40	9.524
Surface roughness	0.1429	67	9.57	40	5.716	100	14.29
Dimensional accuracy	0.0952	100	9.52	60	5.712	40	3.802
Cost	0.0476	75	3.57	60	2.856	100	4.76
Defect rate	0.1905	67	12.763	40	7.62	100	19.05
Specific design requirement	0.1429	100	14.29	80	11.4	60	8.59
Operational complexity	0.1429	67	9.57	40	5.716	100	14.29
Performance Index			70.33		53.31		74.31

For manufacturing bottom support plate, three manufacturing processes have been compared- forging, casting and bending. Calculating relative emphasis coefficient for each selection criteria and scaled property of each process for all criteria, process performance index has been calculated. Among three, bending has the highest process performance index. So bending is the manufacturing process for this part.

8.2.5 Manufacturing Process Selection for Top Plastic Cover of Stapler, Rubber Insert, Bottom Plastic Cover and Plastic Scale

Table 8.17 List of selection criteria with numerical values on manufacturing Process Selection for Top Plastic Cover of Stapler, Rubber Insert, Bottom Plastic Cover and Plastic Scale

Selection Criteria	Casting	Injection Molding
Strength	2	5
Surface Roughness	5	3
Dimensional accuracy	2	5
Cost	3	5
Defect rate	5	3
Specific design requirement	3	5
Operational complexity	4	2

Table 8.18 Likert Scale for comparing manufacturing process selection of manufacturing of Top Plastic Cover of Stapler, Rubber Insert, Bottom Plastic Cover and Plastic Scale

Very Good	5
Good	4
Moderate	3
Poor	2
Very Poor	1

Manufacturing Process Selection for Top Plastic Cover of Stapler Rubber Insert, Bottom Plastic Cover and Plastic Scale

Table 8.19 Determination of relative importance of manufacturing process selection criteria for Top Plastic Cover of Stapler, Rubber Insert, Bottom Plastic Cover and Plastic Scale

Selection Criteria	Number of positive decisions, $N = n(n-1)/2 = 7(7-1)/2 = 21$																					Positive decisions	Relative emphasis coefficient, α
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21		
Strength	1	1	1	0	1	1																5	0.2381
Surface roughness	0						1	1	1	0	0											3	0.1429
Dimensional accuracy		0					0					1	0	1	0							2	0.0952
Cost			0					0				0				0	0	1				1	0.0476
Defect rate				1					0				1			1			1	0		4	0.1905
Specific design requirement					0					1				0			1		0		1	3	0.1429
Operational complexity						0					1				1			0		1	0	3	0.1429
Total number of positive decisions																					21	$\sum\alpha=1$	

This chart shows the digital logic method for manufacturing process for Top Plastic Cover, Rubber Insert, Bottom Plastic Cover and Plastic scale. Comparing all the criteria, strength has the highest number of positive decisions. As a result it has a highest value of relative emphasis coefficient. On the other hand, cost has the least number of positive responses which results in attaining the lowest value of relative emphasis coefficient.

Table 8.20 Calculation of the performance index for Manufacturing for Top Plastic Cover of Stapler, Rubber Insert, Bottom Plastic Cover and Plastic Scale

Selection criteria	Relative emphasis coefficient (Weighting factor) α	Casting		Injection Molding	
		Scaled property β	Weighted score $\alpha\beta$	Scaled property β	Weighted score $\alpha\beta$
Strength	.0952	40	3.81	100	9.52
Surface Roughness	.0952	60	5.71	100	9.52
Dimensional accuracy	.1429	40	5.72	100	14.29
Cost	.2381	100	23.81	60	14.29
Defect rate	.0476	60	2.86	100	4.76
Specific design requirement	.0952	60	5.71	100	9.52
Operational complexity	.2857	50	14.29	100	28.57
Process Performance Index			61.91		90.47

For manufacturing Top Plastic Cover, Rubber Insert, Bottom Plastic Cover and Plastic scale, two manufacturing processes have been compared-casting and injection molding. Calculating relative emphasis coefficient for each selection criteria and scaled property of each process for all criteria, process performance index has been calculated. Among three, bending has the highest process performance index. So casting is the manufacturing process for this part.

8.2.6 Manufacturing Process Selection for Aligned Punching Pins of Spiral Binder

Table 8.21 List of selection criteria with numerical values on manufacturing Process Selection for aligned punching pins of spiral binder

Selection Criteria	Turning and Machining	CNC
Strength	4	5
Dimensional accuracy	3	5
Cost	1	5
Manufacturability	4	5
Operational complexity	5	3

Table 8.22 Likert Scale for comparing manufacturing process selection of manufacturing of aligned punching pins of spiral binder

Very Good	5
Good	4
Moderate	3
Poor	2
Very Poor	1

Manufacturing Process Selection for Aligned Punching Pins of Spiral Binder

Table 8.23 Determination of relative importance for manufacturing of aligned punching pins of spiral binder

Selection Criteria	Number of positive decisions=$n(n-1)/2=5(5-1)/2=10$										Positive decisions	Relative emphasis coefficient, α
	1	2	3	4	5	6	7	8	9	10		
Strength	1	0	0	0							1	0.1
Dimensional accuracy	0				1	0	0				1	0.1
Cost		1			0			0	1		2	0.2
Manufacturability			1			1		1		1	4	0.4
Operational complexity				1			1		0	0	2	0.2
Total number of positive decisions											10	$\sum\alpha=1$

This chart shows the digital logic method for manufacturing of aligned punching pins. From all the criteria, manufacturability has the highest number of positive decisions. As a result it has a highest value of relative emphasis coefficient. On the other hand, strength and dimensional accuracy has the least number of positive responses which results in attaining the lowest value of relative emphasis coefficient.

Table 8.24 Calculation of the performance index for manufacturing of aligned punching pins

Selection criteria	Relative emphasis coefficient α	Turning and Machining		CNC	
		Scaled property β	Weighted score $\alpha\beta$	Scaled property β	Weighted score $\alpha\beta$
Strength	0.1	80	8	100	10
Dimensional accuracy	0.1	60	6	100	10
Cost	0.2	100	20	20	4
Manufacturability	0.4	80	32	100	40
Operational complexity	0.2	60	12	100	20
Performance Index			78		84

For joining of manufacturing of aligned punching pins of spiral binder, two processes have been compared—turning and CNC. Calculating relative emphasis coefficient for each selection criteria and scaled property of each process for all criteria, process performance index has been calculated. Among two, CNC has the highest performance index.

8.3 Quantitative Analysis of Joining Method Selection

8.3.1 Joining Method Selection for the Listed Joints

List: Top Slide Housing and Top Tab, Upper Spring and Base, Long Metal Axle and Bottom Slide Housing, Slide Spring and Bottom Slide Housing, Slide Spring and Metal Slide of Stapler, Bottom Support Plate and Main Body Frame of Punch Machine, Aligned Punching pins and Sliding Guide rod, Upper exterior Cover and Spring, Spring and Bottom Interior Cover, Spring and Sliding Guide Rod of Spiral Binder, Bottom Plate Cover, Base and Rivet of Main Body Frame

Table 8.25 List of selection criteria with numerical values or value from Likert scale for joining method selection for above mentioned joints of stapler, punch machine, spiral machine and main body

Selection Criteria	TIG	MIG	Arc Welding
Cost	5	4	2
Surface Finish	5	4	2
Strength	4	5	4
Welding Time	3	2	4
Defect Rate	1	2	4

Table 8.26 Likert Scale for joining method selection for above mentioned joints of stapler, punch machine, spiral machine and main body

Very Good	5
Good	4
Moderate	3
Poor	2
Very Poor	1

Joining Method Selection for Top Slide Housing and Top Tab, Upper Spring and Base, Long Metal Axle and Bottom Slide Housing, Slide Spring and Bottom Slide Housing, Slide Spring and Metal Slide of Stapler, Bottom Support Plate and Main Body Frame of Punch Machine, Aligned Punching pins and Sliding Guide rod, Upper Exterior Cover and Spring, Spring and Bottom Interior Cover, Spring and Sliding Guide Rod of Spiral Binder, Bottom Plate Cover, Base and Rivet of Main Body Frame

Table 8.27 Determination of relative importance of joining method selection criteria for above mentioned joints of stapler, punch machine, spiral machine and main body

Selection Criteria	Number of positive decisions, $N = n(n-1)/2 = 7(7-1)/2 = 21$																					Positive decisions	Relative emphasis coefficient, α
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21		
Strength	1	1	1	0	1	1																5	0.2381
Surface roughness	0						1	1	1	0	0											3	0.1429
Dimensional accuracy		0					0					1	0	1	0							2	0.0952
cost			0					0				0				0	0	1				1	0.0476
Defect rate				1					0				1			1			1	0		4	0.1905
Specific design requirement					0					1				0			1		0		1	3	0.1429
Operational complexity						0					1				1			0		1	0	3	0.1429
Total number of positive decisions																					21	$\sum\alpha=1$	

This chart shows Joining Method Selection for Top Slide Housing, Upper Spring, Slide Spring of Stapler, Rack , Pinion, Bottom Support Plate of Punch Machine, Sliding Guide Bar, Punching Pins, Top Cover and Spring, Spring and Side cover by the digital logic method for of spiral binder. The reason of combining these components is the selection consideration of these components joining process is same. Of all the criteria, cost and strength have the highest number of positive decisions. As a result they have a highest value of relative emphasis coefficient. Defect Rate has the second highest positive responses. On the other hand, surface finish and welding time have the least number of positive responses which results in attaining the lowest value of relative emphasis coefficient.

Table 8.28 Calculation of the performance index for joining method selection of above mentioned joints of stapler, punch machine, spiral machine and main body

Selection criteria	Relative emphasis coefficient A	TIG		MIG		Arc Welding	
		Scaled property	Weighted score	Scaled property	Weighted score	Scaled property	Weighted score
		β	$\alpha\beta$	β	$\alpha\beta$	β	$\alpha\beta$
Cost	0.2	40	8	50	10	100	20
Surface Finish	0.2	100	20	80	16	40	8
Strength	0.3	80	24	100	30	80	24
Welding Time	0.1	67	6.7	100	10	50	5
Defect Rate	0.2	100	20	50	10	25	5
Process Performance Index			78.7		76		62

For Joining of Top Slide Housing, Upper Spring, Slide Spring of Stapler, Bottom Support Plate of Punch Machine, Sliding Guide Bar, Punching Pins, Top Cover and Spring, Spring and Side cover of spiral binder, three process have been compared- TIG, MIG, Arc Welding . Calculating relative emphasis coefficient for each selection criteria and scaled property of each process for all criteria, Process performance index has been calculated. Of three, TIG has the highest process performance index. Therefore, TIG has been chosen for joining these components.

8.3.2 Joining Method Selection for Static Fulcrum and Dynamic Fulcrum, Static Fulcrum with Lever Arm and Dynamic Fulcrum with Lever Arm

Table 8.29 List of selection criteria with numerical values or value from Likert scale for joining of Static Fulcrum and Dynamic Fulcrum with Lever Arm

Selection Criteria	Rivet	Nut-bolt
Surface finish	2	1
Light weight	4	3
Cost	2	3
Availability	5	1
Joint strength	5	3
Future maintenance advantage	2	5

Table 8.30 Likert Scale for selection parameters for joining of Static and Dynamic Fulcrum with Lever Arm

Very Good	5
Good	4
Moderate	3
Poor	2
Very Poor	1

Joining Method Selection for Static Fulcrum and Dynamic Fulcrum, Static Fulcrum with Lever Arm and Dynamic Fulcrum with Lever Arm

Table 8.31 Determination of relative importance of joining method selection criteria for Static Fulcrum and Dynamic Fulcrum with Lever Arm

Selection Criteria	Number of positive decisions, $N = n(n-1)/2 = 6(6-1)/2 = 15$															Positive decisions	Relative emphasis coefficient, α
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		
Joint strength	0	1	1	0	0											2	0.133
Future maintenance advantage	1					1	0	0	0							2	0.133
Surface finish		0				0				1	0	0				1	0.067
Cost			0				1			0			0	0		1	0.067
Availability				1				1			1		1		1	5	0.333
Joint strength					1				1			1		1	0	4	0.267
Total number of positive decisions																$\Sigma = 15$	$\Sigma = 1$

This chart shows the digital logic method for joining process selection of Static and Dynamic Fulcrum with Lever Arm. Comparing all the criteria, flexible with design has the highest number of positive decisions. As a result it has a highest value of relative emphasis coefficient. On the other hand, surface finish, strength, operational complexity and welding time have the least number of positive responses which results in attaining the lowest value of relative emphasis coefficient.

Table 8.32 Calculation of the performance index for joining method selection of Static Fulcrum and Dynamic Fulcrum, Static Fulcrum with Lever Arm and Dynamic Fulcrum with Lever Arm

Selection Criteria	Relative emphasis coefficient α	Rivet		Nut-bolt	
		Scaled property β	Weighted score $\alpha\beta$	Scaled property β	Weighted score $\alpha\beta$
Surface finish	0.133	66.67	8.87	33.33	4.43
Light weight	0.133	100	13.3	75	9.975
Cost	0.067	100	6.7	66.67	4.467
Availability	0.067	100	6.7	20	1.34
Joint strength	0.333	100	13.3	60	19.98
Future maintenance advantage	0.267	100	26.7	100	26.67
Process Performance Index			75.57		66.86

For joining Static and Dynamic Fulcrum with Lever Arm, two joining processes have been compared-Rivet and Nut bolt. Calculating relative emphasis coefficient for each selection criteria and scaled property of each process for all criteria, process performance index has been calculated. Among three, rivet has the highest process performance index.

8.3.3 Joining Method Selection for Top Plastic Cover and Top Slide Housing, Base and Bottom Cover, Base and exterior sliding plate of Stapler

Table 8.33 List of selection criteria with value from Likert scale for joining of Top Plastic Cover and Top Slide Housing, Base and Bottom Cover, Base and exterior sliding plate of Stapler

Selection Criteria	Epoxy Adhesive	Hot glue
Strength	5	4
Longevity	4	2
Adhesiveness	4	3
Cost	5	3
Compatibility	3	5

Table 8.34 Likert Scale for comparing adhesive for joining of Top Plastic Cover and Top Slide Housing, Base and Bottom Cover, Base and exterior sliding plate of Stapler

Very Good	5
Good	4
Moderate	3
Poor	2
Very Poor	1

Joining Method Selection for Top Plastic Cover and Top Slide Housing, Base and Bottom Cover, Base and exterior sliding plate of Stapler

Table 8.35 Determination of relative importance of adhesive for joining of Top Plastic Cover and Top Slide Housing, Base and Bottom Cover, Base and exterior sliding plate of Stapler

Selection Criteria	Number of positive decisions= $n(n-1)/2=5(5-1)/2=10$										Positive decisions	Relative emphasis coefficient, α
	1	2	3	4	5	6	7	8	9	10		
Strength	1	0	0	0							1	0.1
Longevity	0				0	1	1				2	0.2
Adhesiveness		1			1			1	1		4	0.4
Cost			1			0		0		1	2	0.2
Compatibility				1			0		0	0	1	0.1
Total number of positive decisions											10	$\sum\alpha=1$

This chart shows the digital logic method for joining of top plastic cover with top metal slide. From all the criteria, adhesiveness has the highest number of positive decisions. As a result it has a highest value of relative emphasis coefficient. On the other hand, strength and compatibility has the least number of positive responses which results in attaining the lowest value of relative emphasis coefficient.

Table 8.36 Calculation of the performance index of adhesive for joining of Top Plastic Cover and Top Slide Housing, Base and Bottom Cover, Base and exterior sliding plate of Stapler

Selection criteria	Relative emphasis coefficient A	Epoxy Adhesive		Hot Glue	
		Scaled property β	Weighted score $\alpha\beta$	Scaled property β	Weighted score $\alpha\beta$
Strength	0.1	100	10	80	8
Longevity	0.2	100	20	50	10
Adhesiveness	0.4	100	40	75	30
Cost	0.2	60	12	100	20
Compatibility	0.1	60	6	100	10
Performance Index			88		78

For joining of Top Plastic Cover and Top Slide Housing, Base and Bottom Cover, Base and exterior sliding plate of Stapler, two adhesives have been compared-epoxy adhesive and hot glue. Calculating relative emphasis coefficient for each selection criteria and scaled property of each process for all criteria, process performance index has been calculated. Among two, epoxy adhesive has the highest performance index.

Chapter 9

Structural Design Analysis

Structural design analysis validates the specifications of a product. Some specifications are very important that they should be under control to satisfy the customer needs as well as maintain proper functionality. Structural design analysis is basically a simulation method to demonstrate the possible outcomes in its stated operating conditions. While designing Super Binder, a thorough structural design analysis has been carried out. For this purpose, Ansys is used as the simulation platform.

9.1 Analysis of Design

9.1.1 Analysis of Aligned Punching Pins with Metal Axle

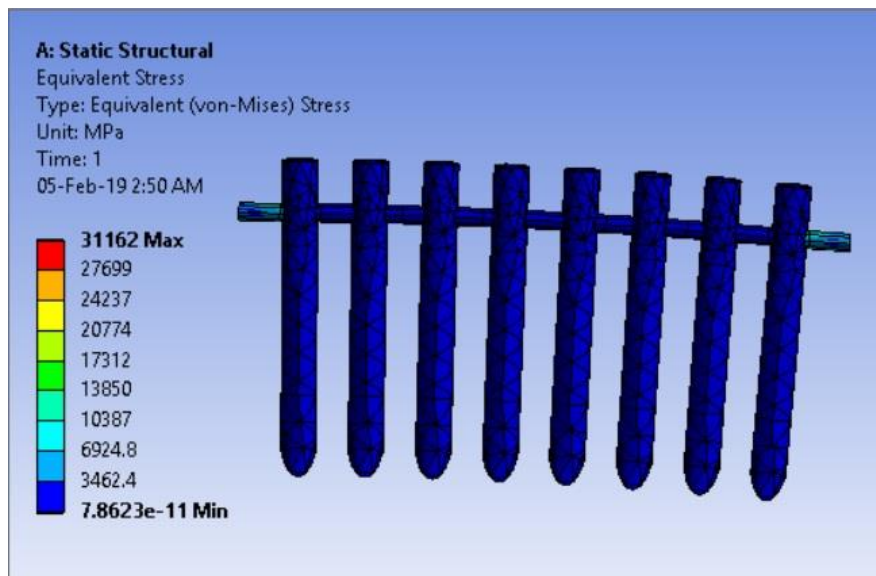


Figure 9.1 Equivalent Stress on Aligned Punch pins with Metal Axle

Equivalent stress output of aligned punching pins is as follows:

Maximum equivalent (von-Mises) stress = 31,162 MPa

Minimum equivalent (von-Mises) stress = 7.8623×10^{-11} MPa

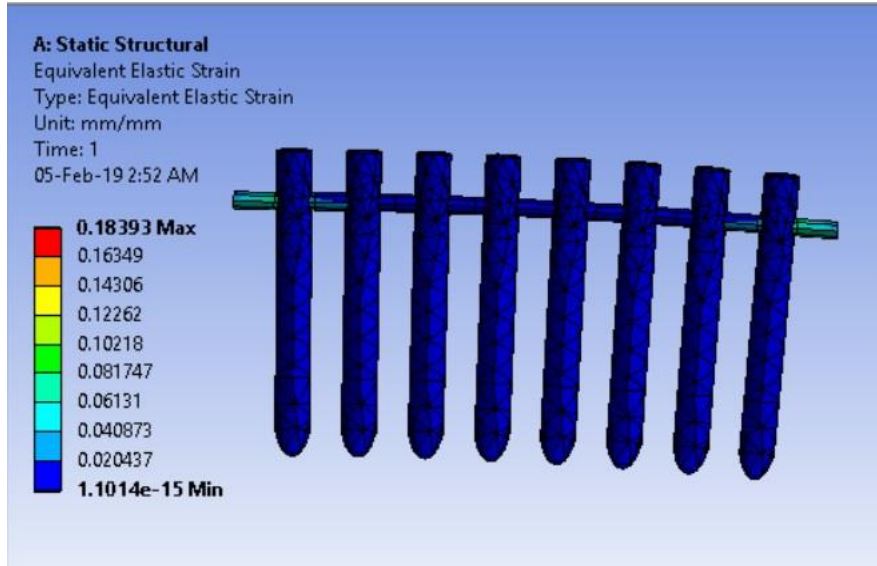


Figure 9.2 Equivalent Elastic Strain on Aligned Punch pins with Metal Axle

Equivalent elastic strain output of aligned punching pins is as follows:

Maximum equivalent elastic strain = 0.18393 mm/mm

Minimum equivalent (von-Mises) stress = 1.10146×10^{-15} mm/mm

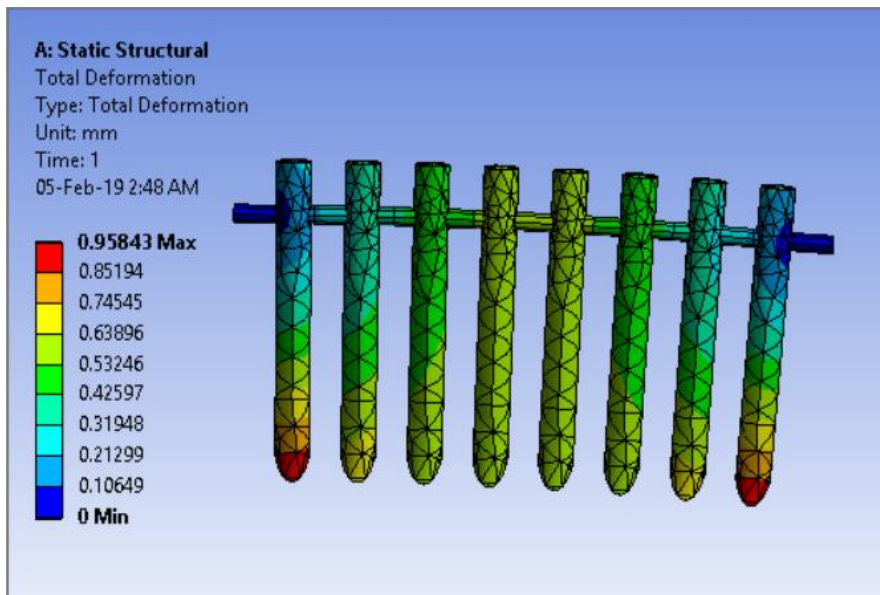


Figure 9.3 Total Deformation on Aligned Punch pins with Metal Axle

Total deformation of aligned punching pins is as follows:

Maximum total deformation = 0.95843 mm

Minimum total deformation = 0 mm

9.1.2 Analysis of Sliding Plate of Stapler

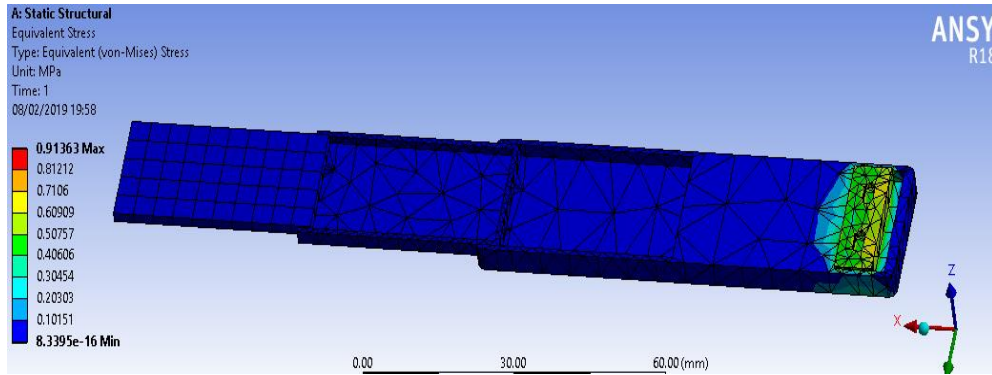


Figure 9.4 Equivalent Stresses on Sliding Plate of Stapler

Equivalent stress output of sliding plate of stapler is as follows:

Maximum equivalent (von-Mises) stress = 0.91363 MPa

Minimum equivalent (von-Mises) stress = 8.3395×10^{-16} MPa

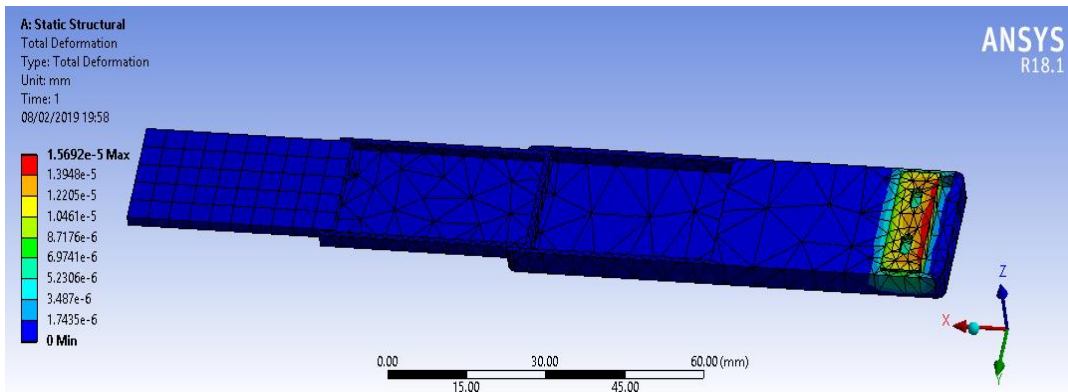


Figure 9.5 Total Deformation of Sliding Plate of Stapler

Total deformation output of sliding plate of stapler is as follows:

Maximum total deformation = 1.5692×10^{-5} mm

Minimum total deformation = 0 mm

9.1.3 Analysis of Slide Housing of Stapler

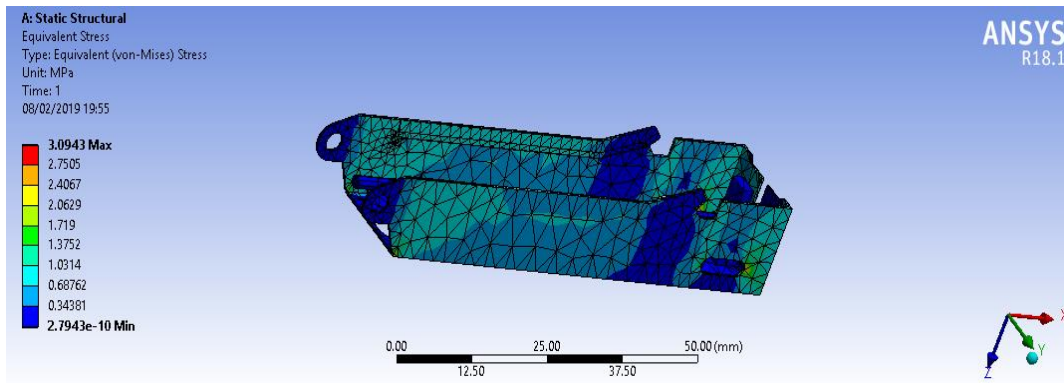


Figure 9.6 Equivalent Stresses on Slide Housing of Stapler

Equivalent stress output of slide housing of stapler is as follows:

Maximum equivalent (von-Mises) stress = 3.0943 MPa

Minimum equivalent (von-Mises) stress = 2.7943×10^{-10} MPa

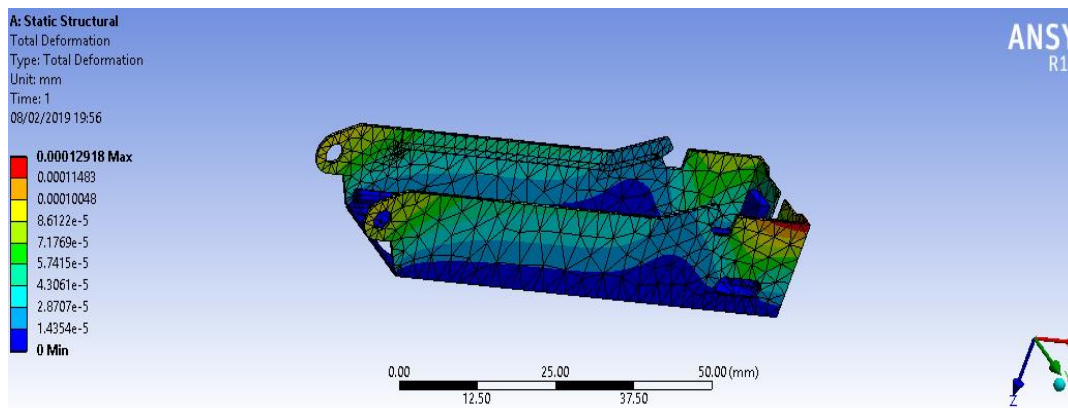


Figure 9.7 Total Deformation of Slide Housing of Stapler

Total deformation output of slide housing of stapler is as follows:

Maximum total deformation = 0.00012918 mm

Minimum total deformation = 0 mm

9.1.4 Analysis of Stapler Connector

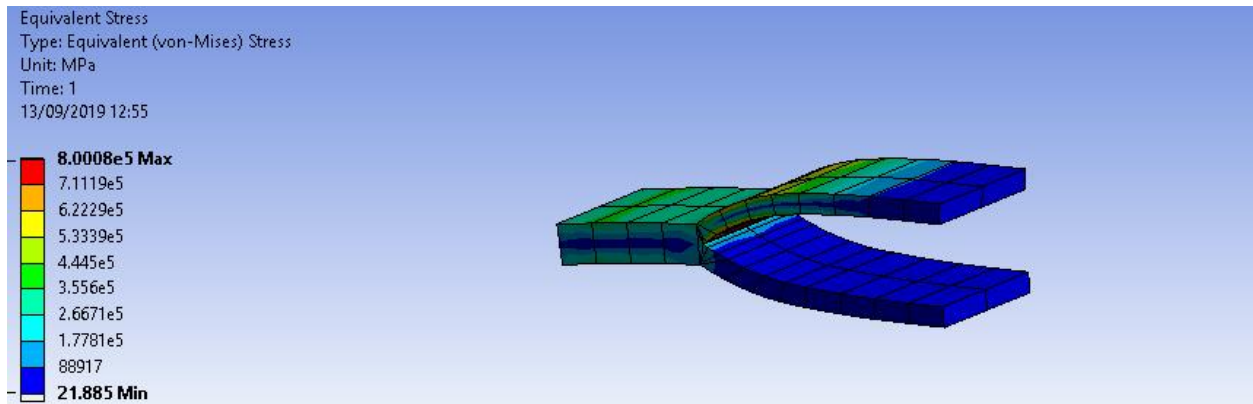


Figure 9.8 Equivalent Stress (von Mises) for Connector

Maximum equivalent von Mises stress = 8.0008×10^5 MPa

Minimum equivalent von Mises stress = 21.885 MPa

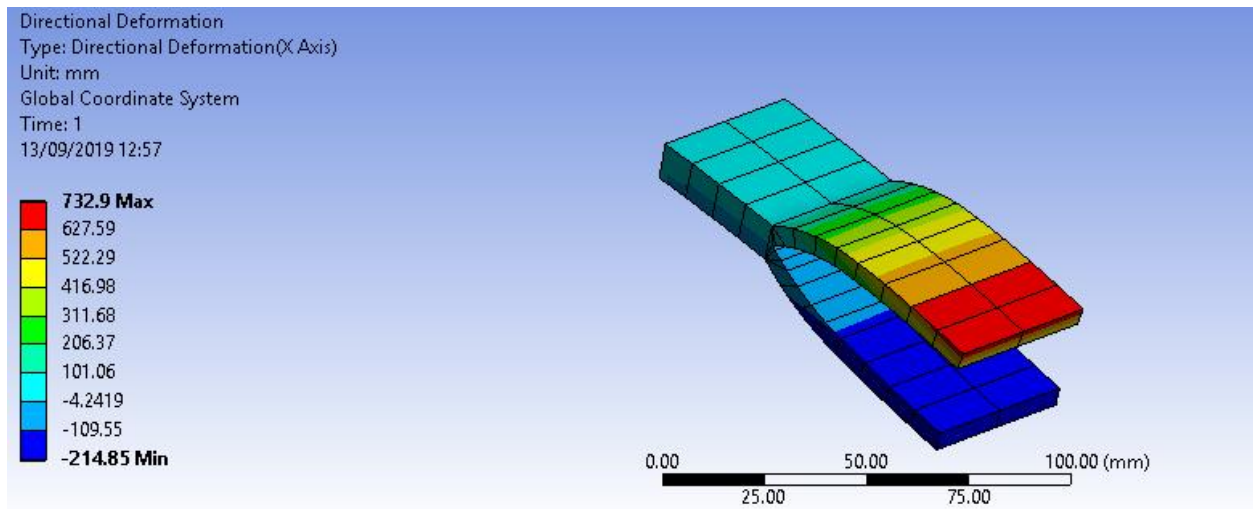


Figure 9.9 Directional Deformation for Connector

Maximum directional deformation = 732 mm

Minimum directional deformation = -214.85

9.1.5 Analysis of Punch Machine and Spiral Binder Frame

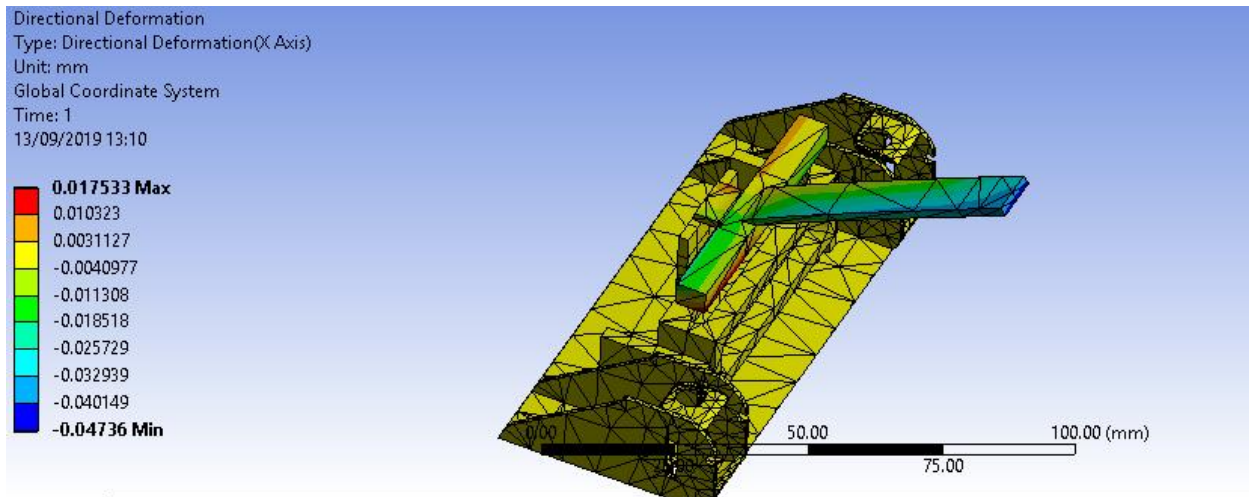


Figure 9.10 Directional Deformation of Punch Machine and Spiral Binder Frame

Directional deformation of punch machine is as follows:

Maximum deformation=0.017533 mm

Minimum deformation = -.04736 mm

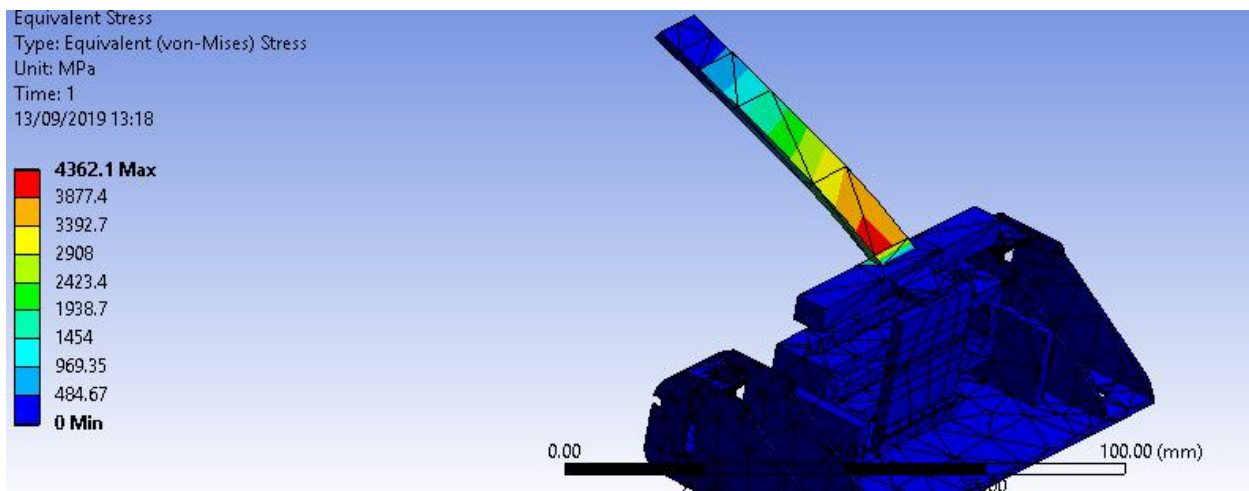


Figure 9.11 Equivalent Von Mises Stress of Punch Machine and Spiral Binder Frame

Equivalent von Mises stress of punch machine is as follows:

Maximum von Mises stress = 4362.1 MPa

Minimum von Mises stress = 0 MPa

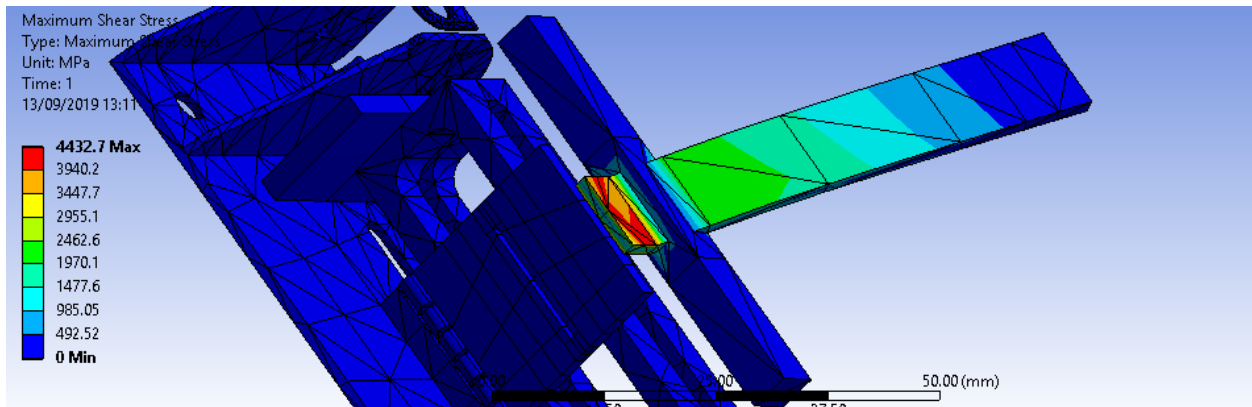


Figure 9.12 Maximum Shear Stress of Punch Machine and Spiral Binder Frame

Maximum shear stress of punch machine is as follows:

Maximum shear stress = 4432.7 MPa

Minimum shear stress = 0 MPa

9.1.6 Analysis of Base Frame

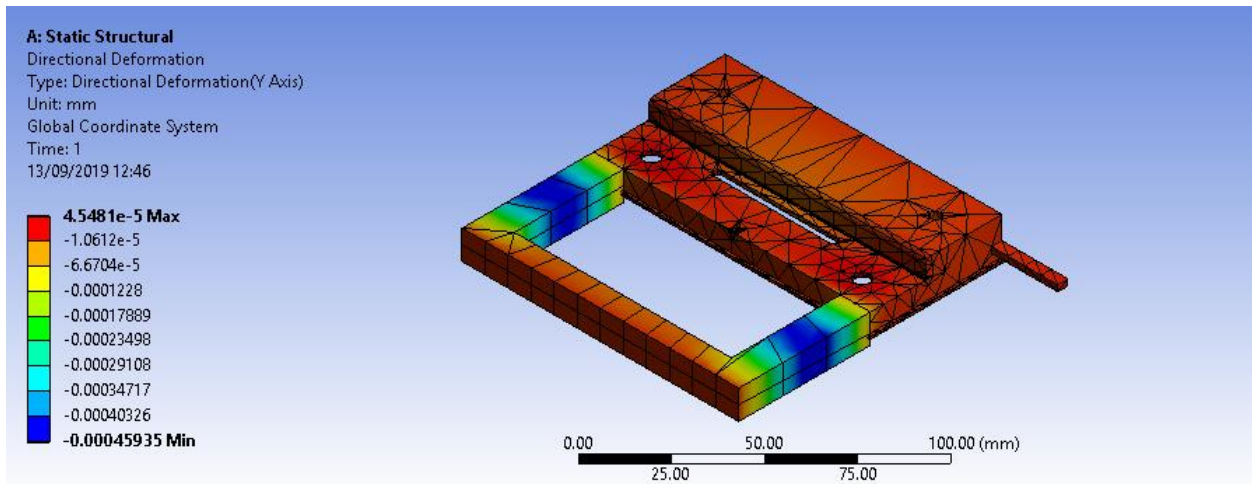


Figure 9.13 Directional Deformation of Base

Directional deformation of Base is as follows:

Maximum directional deformation = $4.548e^{-5}$ mm

Minimum directional deformation = -0.00045935 mm

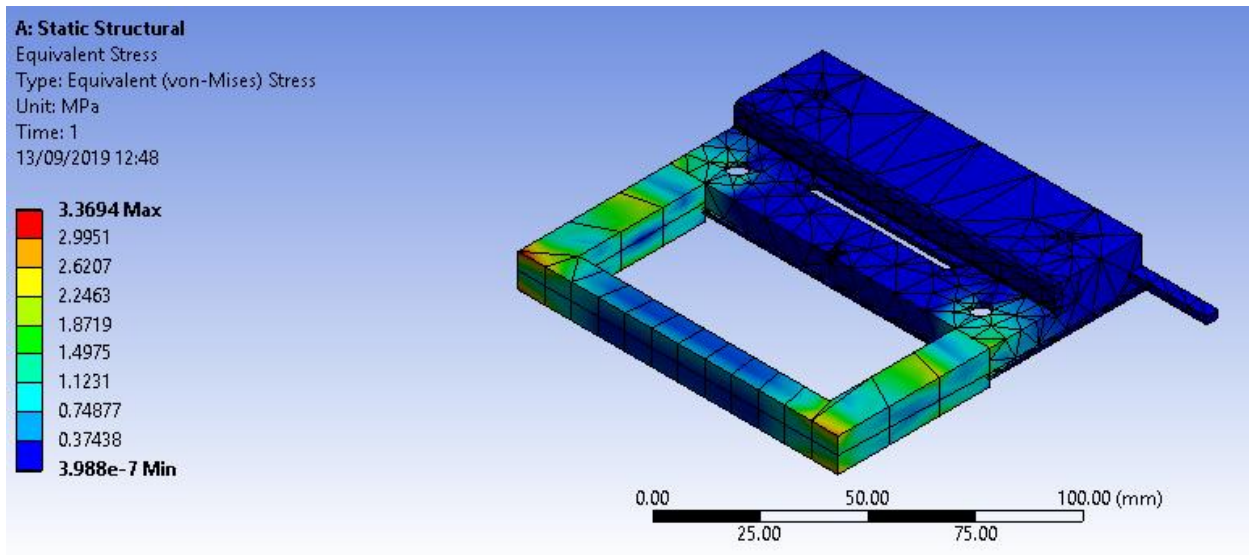


Figure 9.14 Equivalent Von Mises Stress for Base

Equivalent von Mises Stress for Base is as follows:

Maximum von Mises stress = 3.3694 MPa

Minimum von Mises stress = 3.988×10^{-7} MPa

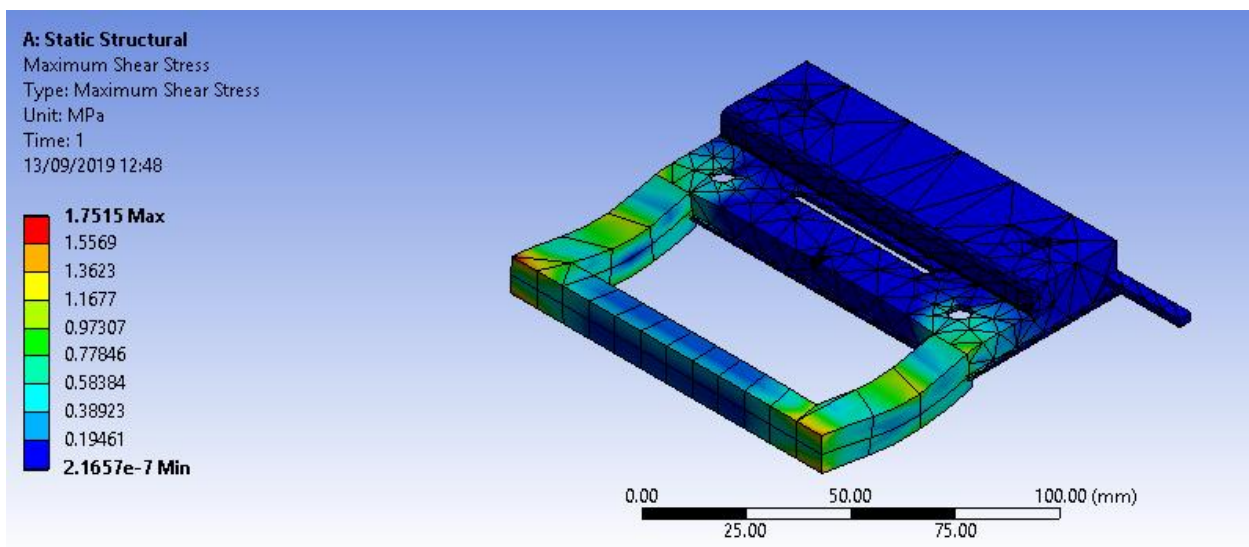


Figure 9.15 Shear Stress for Base

Shear stress for Base part is as follows:

Maximum shear stress = 1.7515 MPa

Minimum shear stress = 2.1657×10^{-7} MPa

Chapter 10

Cost and Sensitivity Analysis

Cost and revenue are the main parameters of measuring a products economic aspect. The focus is always on reducing costs and increasing profits. Cost analysis presents a product's credibility to attain a desired level of output with desired amount of profit. It shows how much capable a product is to reach its break-even point. Along with this, sensitivity analysis is also very important to determine the production system's economic stability. Sensitivity analysis gives a insight of the ratio of change in break-even with change in any cost parameter. In this chapter, a brief discussion on the cost and sensitivity analysis for the manufacturing of Super Binder has been drawn.

10.1 Demand Forecast

Forecasted Number of Products Per Year: 20,000 Pcs.

10.2 Manufacturing Costs

Manufacturing cost is the cost of production that is directly incurred during the production process. It includes direct labor, direct material and manufacturing overhead costs.

10.2.1 Cost of Machineries

1. Name: Shearing machine (Brand Name: Bhavya, Ahmedabad, India)
Buying cost: 3, 25,000 Tk.
Effective working life: 20 year
Salvage value: 25,000 Tk.
Quantity: 1
2. Name: Lathe machine (Brand Name: WMT CNC Industrial Co., China)
Buying cost: 6, 00,000 Tk.
Effective working life: 22 years
Salvage value: 50,000 Tk.
Quantity: 1

3. Name: Shaper machine (Brand Name: Bhavya, Ahmedabad, India)
Buying cost: 3, 82,500 Tk.
Effective working life: 15
Salvage value: 30,000 Tk.
Quantity: 1
4. Name: Vertical drilling machine (Brand Name: Bhavya, Ahmedabad, India)
Buying cost: 4, 25,000 Tk.
Effective working life: 20 years
Salvage value: 25,000 Tk.
Quantity: 1
5. Name: Grinding machine (Brand Name: WMT CNC Industrial Co., China)
Buying cost: 4, 55,000 Tk.
Effective working life: 17 years
Salvage value: 50,000 Tk.
Quantity: 1
6. Name: TIG welding setup (Brand Name: ESAB, United Kingdom)
Buying cost: 2, 40,000 Tk.
Effective working life: 20 years
Salvage value: 35,000 Tk.
Quantity: 2
7. Name: furnace (Brand Name: Zhzhou Chenxin Equipment Co., China)
Buying cost: 4, 00,000 Tk.
Effective working life: 20 years
Salvage value: 25,000 Tk.
Quantity: 1
8. Name: Casting setup (Supply by Local Agent)
Buying cost: 10,000 Tk.
Effective working life: 5 years
Salvage value: 500 Tk.
Quantity: 3
9. Name: Injection molding machine (Brand Name: Bhavya, Ahmedabad, India)
Buying cost: 8, 00,000 Tk.
Effective working life: 25 years
Salvage value: 80,000 Tk.

Quantity: 1

10. Name: Coloring sprayer (Brand Name: Yangzhou Coating Machinery Co., China)

Buying cost: 5, 00,000 Tk.

Effective working life: 18 years

Quantity: 1

11. Name: Forging Die (Supply by Local Agent)

Buying cost: 1, 00, 000 Tk.

Effective working life: 10 years

Quantity: 20

Total Cost of Machineries: 42, 57,000 Tk.

10.2.2 Cost of Raw Materials

1. Stainless Steel Sheet (2 mm)

Required Quantity: 0.5 sq ft

Market price: 90 Tk./sq ft

Total Cost Per Product: 45 Tk.

2. Stainless Steel Rod (2 mm diameter)

Required Quantity: 0.1 kg

Market price: 220 Tk./ kg

Total Cost Per Product: 44 Tk.

3. Stainless Steel Rod (6 mm diameter)

Required Quantity: 0.05 kg

Market price: 240 Tk./ kg

Total Cost Per Product: 12 Tk.

4. Mild Steel Sheet

Required Quantity: 0.75 sq ft

Market price: 55 Tk./ sq ft

Total Cost Per Product: 42 Tk.

5. Silicone Rubber

Required Quantity: 25 gm

Market price: 500 Tk./ kg

Total Cost Per Product: 13 Tk.

6. PVC

Required Quantity: 35 gm

Market price: 440 Tk./ kg

Total Cost Per Product: 16 Tk.

7. Nylon Plastic

Required Quantity: 80 gm

Market price: 400 Tk./ kg

Total Cost Per Product: 32 Tk.

8. Epoxy Adhesive

Market price: 800 Tk./ container

Total Cost Per Product: 5 Tk.

9. Color

Required Quantity: 100 gm

Market price: 150 Tk./ kg

Total Cost Per Product: 15 Tk.

10. Casting Sand

Market price: 3 Tk./ kg

Total Cost Per Product: 1 Tk.

11. Lubricating Oil

Required Quantity: 5 ml

Market price: 200 Tk./ liter

Total Cost Per Product: 1 Tk.

Total Cost of Raw Materials Per Product: 226 Tk.

Total Cost of Raw Materials Per Year: 45, 20,000 Tk.

10.2.3 Cost of Labor

1. Name of job: lathe machine operator

Number of workers: 1

Wage rate: 9000 Tk.

Total labor cost: 9000 Tk.

2. Name of job: Shaper machine operator
Number of workers: 1
Wage rate: 8000 Tk.
Total labor cost: 8000 Tk.

3. Name of job: Drilling and grinding machine operator
Number of workers: 1
Wage rate: 8000 Tk.
Total labor cost: 8000 Tk.

4. Name of job: TIG welder
Number of workers: 1
Wage rate: 10000 Tk.
Total labor cost: 10000 Tk.

5. Name of job: Casting operator
Number of workers: 2
Wage rate: 7000 Tk.
Total labor cost: 14000 Tk.

6. Name of job: Injection molding operator
Number of workers: 1
Wage rate: 7000 Tk.
Total labor cost: 7000 Tk.

7. Name of job: Color operator
Number of workers: 1
Wage rate: 7000 Tk.
Total labor cost: 7000 Tk.

Total Cost of Labor Per Month: 63,000 Tk.

Total Cost of Labor Per Year: 7, 56,000 Tk.

10.2.4 Purchasing Cost per Unit of Product

Table 10.1 Purchasing cost per unit

Parts	Price Per Unit (Tk.)	Quantity	Total Cost (Tk.)
6 mm diameter spring	5	3	15
2 mm diameter spring	2	1	2
2 mm hard spring with two end extension	4	2	8
4 mm diameter rivet	2	2	4
Total Purchasing Cost Per Unit (Tk.)			29

10.2.5 Manufacturing Overhead Cost

Table 10.2 Manufacturing overhead cost of personnel per month

Post	No. of post	Monthly salary/ person (Tk.)	Total(Tk.)
Production Manager	1	30,000	30,000
Manufacturing and Assembly Engineer	1	30,000	30,000
Supply Chain and Quality Control Manager	1	30,000	30,000
Guard	2	5,000	10,000
Manufacturing overhead cost per month			1, 00,000

Power Consumption: 1, 20, 000 Tk./year

Factory Space required: 2,000 sq ft.

Rent of factory space per year: 90 Tk. / sq ft.

Total rent of factory space: 1, 80,000 Tk./ year

Factory insurance: 20,000 Tk./ year

Material handling cost: 15,000 Tk./year

Packaging Cost: 35,000 Tk./year

Total Manufacturing Overhead Cost per year: 15, 70,000 TK.

10.2.6 Total Manufacturing Cost

Total Cost of Raw Materials Per Year : 45, 20,000 Tk.

Total Cost of Purchasing Per Year : 5, 80,000 Tk.

Total Cost of Labor Per Year : 7, 56,000 Tk.

Total Manufacturing Overhead Cost per year : 15, 70,000 Tk.

Total Manufacturing Cost Per Year : 73, 46,000 Tk.

10.3 Non-manufacturing Costs

Non-manufacturing costs are the costs that are not directly related with manufacturing, but these are needed to maintain the supply chain properly. Generally these include selling and administrative cost. Non-manufacturing costs are generally incurred at the later portion of the supply chain.

10.3.1 Administrative cost

Table 10.3 Administrative cost of administrative personnel per month

Post	No. of post	Monthly salary/person	Total(Tk.)
Chief Executive Officer (CEO)	1	55,000	55,000
HR Manager	1	40,000	40,000
Accountant	1	25,000	25,000
Secretary	1	20,000	20,000
Clerk	2	5,000	10,000
Guard(G4S)	2	5,000	10,000
Total administrative cost of administrative personnel per month			1, 60,000

Office Rent: 2, 20,000 Tk./ year

Maintenance: 50,000 Tk./ year

Office Furniture and Equipment = 1, 00,000 Tk./ year

Electricity Bill: 24,000 Tk./ year

Total Administrative Cost Per Year: 23, 14,000 Tk.

10.3.2 Selling Expenses

Table 10.4 Selling expense of sales personnel per month

Post	No. of post	Monthly salary/person	Total(Tk.)
Marketing Executive	1	15,000	15,000

Advertising cost: 90,000 Tk./ year

Selling Expenses: 1, 50,000 Tk./year

Total Selling Cost Per Year: 4, 20,000 Tk.

10.3.3 Total Non-manufacturing Cost

Total Administrative Cost Per Year : 23, 14,000 Tk.

Total Selling Cost Per Year : 4, 20,000 Tk.

Total Non-manufacturing Cost Per Year : 27, 34,000 Tk.

10.4 Bank Loan & Interest

Total bank loan= 43, 00,000 Tk.

Interest rate, $i= 14\%$

Repayment periods, $n= 20$ years.

Amount to be paid to the bank annually, $A= P (^{A/P, 14, 20})$
 $= 6, 50,400$ Tk.

10.5 Total Cost

Total Manufacturing Cost Per Year	:	73, 46,000 Tk.
Total Non-manufacturing Cost Per Year	:	27, 34,000 Tk.
Total Bank Loan Repayment Per Year	:	6, 50,000 Tk.
Total Cost Per Year	:	1, 07, 30,000 Tk.

10.6 Break-even Analysis

Fixed Cost for First Year

Bank payment: 6, 50,000 Tk.

Factory Rent: 1, 80,000 Tk.

Factory insurance: 20,000 Tk.

Material handling cost: 30,000 Tk.

Factory utilities: 20,000 Tk.

Fixed overhead cost: 39, 34,000 Tk.

Power consumption: 1, 20,000 Tk.

Total amount of fixed cost: 49, 54,000 Tk. per year.

Fixed cost per unit production: 247. 7 Tk. per year.

Variable Cost for First Year

Raw material cost: 45, 20,000 Tk.

Purchasing Cost: 5, 80,000 Tk.

Labor cost: 7, 56,000 Tk. per year.

Total variable cost per year: 58, 56,000 Tk.

Total variable cost per unit production: 292.8 Tk.

Total production cost per unit: $(247.7 + 292.8)$ Tk. = 540.5 Tk.

Selling price: 550 Tk.

Profit per unit: $(550 - 540.5)$ Tk. = 9.5 Tk.

At Break Even Point,

$\text{Selling price} \times Q_{\text{bep}} = \text{Total Fixed cost} + \text{variable cost} \times Q_{\text{bep}}$

Or, $550 \times Q_{\text{bep}} = 49,54,000 + (292.8 \times Q_{\text{bep}})$

Or, $Q_{\text{bep}} = 19,262$ units.

Break-even quantity for the first year, $Q_{\text{bep}} = 19,262$ units

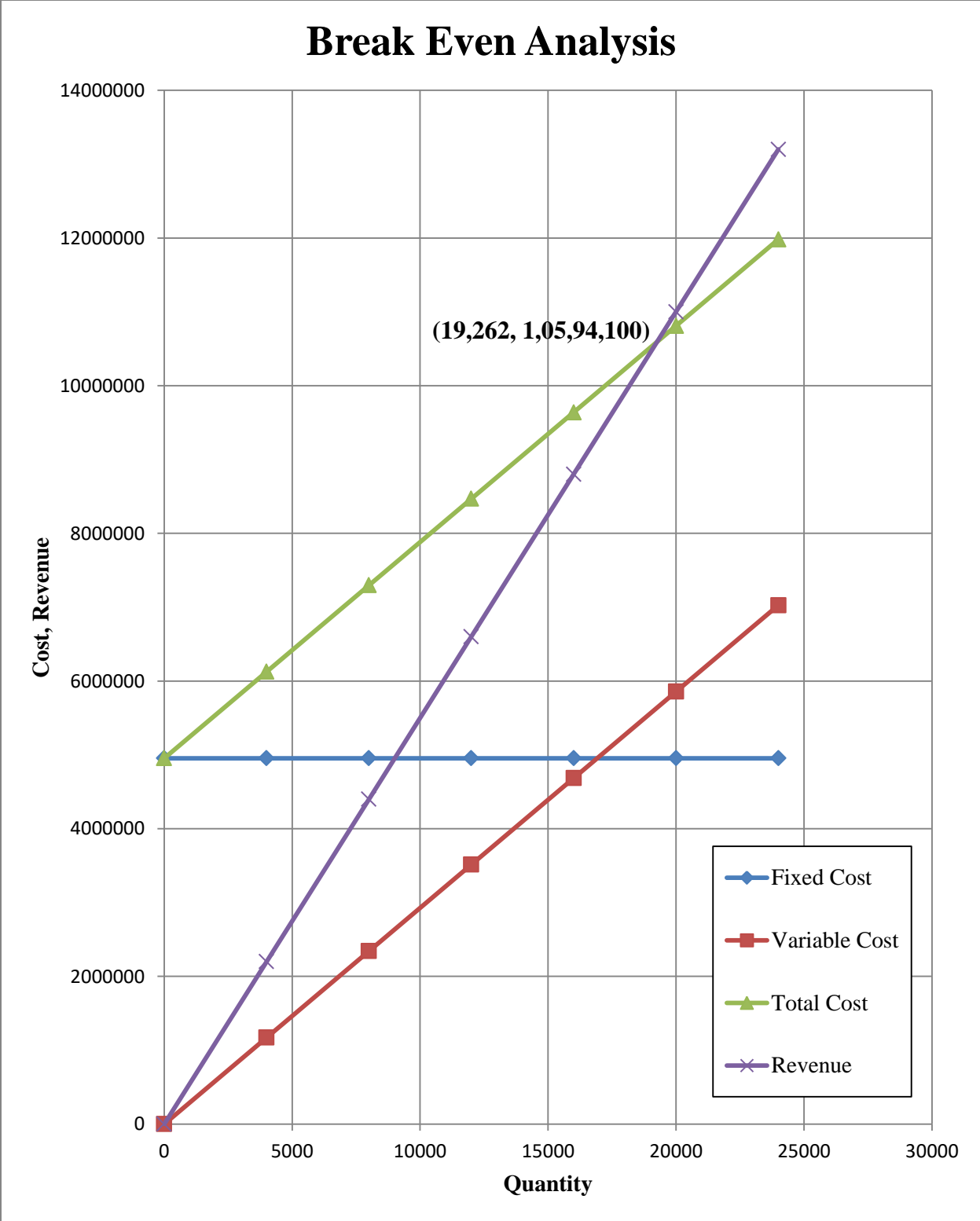


Figure 10.1 Break Even Analysis Graph for Super Binder

10.7 Sensitivity Analysis

Sensitivity analysis gives an insight about how sensitive the break-even point is with respect to a particular cost or revenue parameter. In this sensitivity analysis, a change of 8% is made for each cost parameter separately and then break-even point is computed. This analysis will provide the list of sensitive parameters.

10.7.1 Sensitivity of Demand

At Break Even Point,

$$\text{Selling price} \times Q_{\text{bep}} = \text{Total Fixed cost} + (\text{variable cost} \times Q_{\text{bep}})$$

$$\text{Or, } 550 \times Q_{\text{bep}} \times 1.08 = 49,54,000 + (292.8 \times Q_{\text{bep}} \times 1.08)$$

$$\therefore Q_{\text{bep}} = 17,835$$

$$\Delta Q_{\text{bep}} = ((19,262 - 17,835) / 19,262) \times 100\%$$

$$= 7.41\%$$

So, Demand is very sensitive. The break-even point changes almost proportionally with change in demand. So any change in demand will have a direct impact on the break-even quantity.

10.7.2 Sensitivity of Direct Material

At Break Even Point,

$$\text{Selling price} \times Q_{\text{bep}} = \text{Total Fixed cost} + \text{variable cost} \times Q_{\text{bep}}$$

$$\text{Or, } 550 \times Q_{\text{bep}} = 49,54,000 + ((37.8 + ((51,00,000 \times 1.08) / 20,000)) \times Q_{\text{bep}})$$

$$\therefore Q_{\text{bep}} = 18,040$$

$$\Delta Q_{\text{bep}} = ((19,262 - 18,040) / 19,262) \times 100\%$$

$$= 6.34\%$$

So, Direct Material is also very sensitive. The cost of direct material can significantly dominate on the break-even quantity.

10.7.3 Sensitivity of Direct Labor

At Break Even Point,

$$\text{Selling price} \times Q_{\text{bep}} = \text{Total Fixed cost} + (\text{variable cost} \times Q_{\text{bep}})$$

$$\text{Or, } 550 \times Q_{\text{bep}} = 49,54,000 + ((255 + ((7,56,000 \times 1.08)/20,000)) \times Q_{\text{bep}})$$

$$\therefore Q_{\text{bep}} = 19,491$$

$$\Delta Q_{\text{bep}} = ((19,491 - 19,262) / 19,262) \times 100\%$$

$$= 1.18\%$$

So, direct labor is not very sensitive. The break-even point changes about 1.17% with a 8% change in direct labor. This indicates that if somehow cost of direct labor goes up and other cost parameters stay stable, then only 1.17% production is to be increased in order to attain break-even point.

10.7.4 Sensitivity of Manufacturing Overhead

At Break Even Point,

$$\text{Selling price} \times Q_{\text{bep}} = \text{Total Fixed cost} + (\text{variable cost} \times Q_{\text{bep}})$$

$$\text{Or, } 550 \times Q_{\text{bep}} = ((33,84,000 + (15,70,000 \times 1.08)) + (292.8 \times Q_{\text{bep}}))$$

$$\therefore Q_{\text{bep}} = 19,750$$

$$\Delta Q_{\text{bep}} = ((19,750 - 19,262) / 19,262) \times 100\%$$

$$= 2.53\%$$

So, manufacturing overhead is not very sensitive. The break-even point changes very slowly with relatively large change in manufacturing overhead. So this parameter does not contribute much in shifting the break-even quantity.

10.7.5 Sensitivity of Administrative Cost

At Break Even Point,

$$\text{Selling price} \times Q_{\text{bep}} = \text{Total Fixed cost} + (\text{variable cost} \times Q_{\text{bep}})$$

$$\text{Or, } 550 \times Q_{\text{bep}} = ((26,40,000 + (23,14,000 \times 1.08)) + (292.8 \times Q_{\text{bep}}))$$

$$\therefore Q_{\text{bep}} = 19,982$$

$$\Delta Q_{\text{bep}} = ((20,503 - 19,794) / 19,794) \times 100\%$$

$$= 3.73\%$$

So, administrative cost is slightly sensitive but it does not influence the break-even quantity. The percentage change in break-even point is almost half of percentage change of administrative cost.

10.7.6 Sensitivity of Selling Cost

At Break Even Point,

$$\text{Selling price} \times Q_{\text{bep}} = \text{Total Fixed cost} + (\text{variable cost} \times Q_{\text{bep}})$$

$$\text{Or, } 550 \times Q_{\text{bep}} = ((45,34,000 + (4,20,000 \times 1.08)) + (292.8 \times Q_{\text{bep}}))$$

$$\therefore Q_{\text{bep}} = 19,392$$

$$\Delta Q_{\text{bep}} = ((19,392 - 19,262) / 19,262) \times 100\%$$

$$= 0.67\%$$

So, selling cost is not sensitive at all. The break-even point changes about 0.64% with a 8% change in selling cost. This indicates that if somehow cost of selling goes up and other cost parameters stay stable, then only 0.64% production is to be increased in order to attain break-even point.

The cost analysis shows that the system developed for the manufacturing of Super Binder is capable of producing units just over the break-even point. This means if any major sources of cost includes in any phase of value addition, the system may lag below the break-even point. Again if the demand decreases under the market influence or the price of Super Binder decreases, then there is possibility of great loss. From this cost analysis, it is clear that it is not feasible to manufacture Super Binder in a factory as a single product because the proportion of administrative cost is much higher than it should be for Super Binder. So if it can be manufactured with similar group of products then it will be more cost effective. From the sensitivity analysis, it is shown that increasing any cost parameter doesn't significantly affect the break-even point. This is a measure of the process stability.

Appendix

A1.Survey Form

Survey Form	
A survey on Super Binder	
Name:.....	Profession:
Question 1: Do you possess a personal stapler?	<input type="checkbox"/> Yes <input type="checkbox"/> No
Question 2: Do you possess a personal puncher machine?	<input type="checkbox"/> Yes <input type="checkbox"/> No
Question 3: Do you have to bind your own books?	<input type="checkbox"/> Yes <input type="checkbox"/> No
Question 4: When you need to bind some loose papers together, which one do you prefer?	<input type="checkbox"/> Yes <input type="checkbox"/> No
Question 5: Do you face any problem in time of using existing stapler or punch machine? If yes, please categorize it	<input type="checkbox"/> Yes <input type="checkbox"/> No
Question 6: Do you think a combination of stapler and punch machine will make tasks easier or user friendly?	<input type="checkbox"/> Yes <input type="checkbox"/> No
Question 7: Having such a machine described in the last question, do you think addition of a portable book binder in it is fine?	<input type="checkbox"/> Yes <input type="checkbox"/> No
Question 8: What is your expected service life from super binder?	<input type="text"/>
Question 9: How much price do you think reasonable for such a product?	<input type="text"/>
Question 10: Are you willing to buy such a product if you find the price reasonable?	<input type="checkbox"/> Yes <input type="checkbox"/> No