A PROJECT REPORT

ON

"DESIGN AND DEVELOPMENT OF HIGH STRENGTH PAPER BAG USING NON–RECYCLED PAPER"

Submitted by

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KHAN MOHD. SHAAHID

SHAIKH MOHD. RAFI

In partial fulfillment for the award of the Degree

Of

BACHELOR OF ENGINEERING

IN

MECHANICAL ENGINEERING

UNDER THE GUIDANCE

Of

PROF. ZAKIR ANSARI

DEPARTMENT OF MECHANICAL ENGINEERING

ANJUMAN-I-ISLAM'S

KALSEKAR TECHNICAL CAMPUS NEW PANVEL,

NAVI MUMBAI – 410206

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ANJUMAN-I-ISLAM

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CERTIFICATE

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To the Kalsekar Technical Campus, New Panvel is a record of bonafide work carried out by him under our supervision and guidance, for partial fulfillment of the requirements for the award of the Degree of Bachelor of Engineering in Mechanical Engineering as prescribed by **University Of Mumbai**, is approved.

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(Prof. Zakir Ansari)	(Prof.____________)
Head of Department	**Principle**
(Prof. ____________)	(Dr._______________)

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APPROVAL OF DISSERTATION

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(Internal Examiner) **(External Examiner)**

___________________ ___________________

Date: ___________

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THAKUR ALTAMASH ALIMIYAN

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Abstract

The detrimental effects of plastic bags on the environment are well known. It is now appropriate to use alternative materials for manufacturing bags and in packaging industries. While biodegradable plastics research has gained steam in the first world countries, countries like India are still dependent upon cheaper alternatives such as Kraft paper/ old newspaper (ONP) as packaging materials for transport.

Recycling of paper to produce bags is very common but it has its own disadvantages. The best option is to reuse. Every year lacs of papers are collected in academic Institutes in the form of assignment and practical papers with which paper bags can be produced. This option is very good in terms of economic viability. Further, the cost of these bags can be reduced by adopting appropriate materials in manufacturing. The design of the bag conforms and is much more than the expected load carrying capacity of a bag whether plastic or paper of the same size. Striking a balance between the strength and cost of the bags requires extensive experimentation using different designs and materials used for gluing and handle. Design of experiment using software Minitab helped to optimize the experiment results and deduce the best combination therefrom. The design of machine for manufacturing these paper bags is based on the design selected from this analysis.

In order to reduce the dependence on plastic bags in our day-to-day life, it is very important to achieve desirable factors such as strength, durability and affordability in paper bags. In future mass production by establishing a centralized unit for our as well as nearby Institutes can help to further reduce and provide sponsorship to this project.

Table of Content

List of Figures

List of Tables

Chapter 1

Introduction

The hazards associated with the usage of single-use plastic bags, which are often distributed (for no additional cost) along with purchases in a local grocery store, for instance; are well known. Being a strong, cost-effective, hygienic and overall efficient method of transporting articles; such lightweight plastic bags have come into acceptance and use since the early 1980s in India – substituting their modest paper bag predecessors.

Predominantly fabricated from high-density polyethylene (HDPE), the employment of plastic bags poses some serious problems on the frontiers of consumption of non-renewable sources (crude oil, gas, petrol etc.), disposal and overall environmental impact. According to an estimate by the World Wide Fund for Nature, the consumption of plastic bags has jeopardized aquatic life; with about 100,000 whales, seals and turtles perishing globally every year. The blockage of drains and sewer systems, the geographical issues associated with mass-scale plastic bag dumping, the non-biodegradability of HDPE plastic bags resulting in the release of several toxic substances into the environment has ensued in the coinage of a relatively new term associated with the environmental implications of discarded plastic bags: *white pollution*.

One of the reasons why paper bags are popular is because of safety. Another reason why shoppers prefer paper bags is because they are easily disposable. Paper bags are light, safe and can be easily discarded after they are used.

Chapter 2

Literature Review

In today's highly competitive bag making industry, businesses across the globe face unprecedented and volatile changes. Manufacturers, material suppliers, and machine builders (OEMs), are affected by shifting customer demands, globalization, industry consolidation, technology innovations, safety requirements, government regulations and the demand for lower customer prices. Bag manufacturers must reap the most productivity from every stage of their manufacturing process. At the same time, they must ensure the Bags produced meet their customers' specifications and overall quality standards. Bags/Pouches come in various materials, shapes, sizes and designs based on the product packed or the end user industry. Products typically in solid, liquid form are packed for Food & Beverage, Pharmaceutical and Consumer Product industries.

To get high quality output product to meet the customer's requirement good quality raw material should be used at lower possible cost. Therefore paper bag manufacturer use recycled paper sheets instead of virgin paper to get raw material at favorable price.

The following are shape and size of paper bag available in the market produced by paper bag manufacturers with their specification:

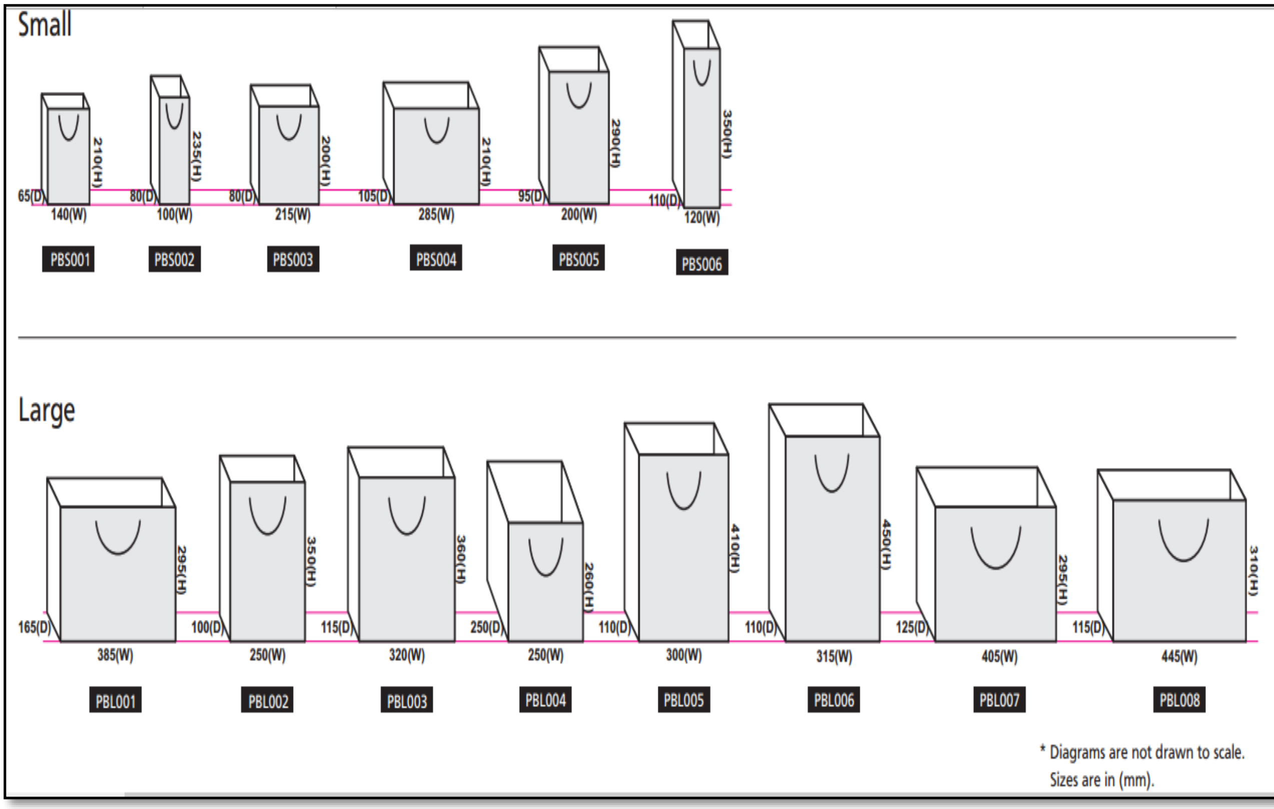

Fig.2.A.Paper Bags Available In Market

Model		Size (mm) H(height) x W(width) x D(depth)	Paper Type		Rope (• recommended rope)		Print Side	Print Colour (Front + Back)	Finishing	
			Gloss Art Paper 157gsm	Gloss Art Card 200gsm (1 side coated)	350mm (Black/Blue Red/White)	750mm (Black/Red)			Compulsory	Optional
Small	PBS 001	210 x 140 x 65	✓	-	•		1 side (Outer)	- 4C + 0	Standard	- Spot UV (Applicable ONLY with Matte Lamination) (Applicable for Gloss Art Card only)
	PBS 002	235 x 100 x 80	✓	-	•					
	PBS 003	200 x 215 x 80	✓	✓	•				- Die-cutting - Folding	
	PBS 004	210 x 285 x 105	✓	✓	•				- Gluing	
	PBS 005	290 x 200 x 95	✓	✓	•				- Hole Punching	
	PBS 006	350 x 120 x 110	✓	✓	•				- Roping	
Large	PBL 001	295 x 385 x 165	-	✓	•	•				
	PBL 002	350 x 250 x 100	✓	✓	•				Colour Protective Finishing (Choose either one)	
	PBL 003	360 x 320 x 115	✓	✓	•					
	PBL 004	260 x 250 x 250	✓	✓	•				- Matte Lamination	
	PBL 005	410 x 300 x 110	-	✓	•				- Gloss Lamination	
	PBL 006	450 x 315 x 110	-	✓	•				- Overprint Varnish	
	PBL 007	295 x 405 x 125	-	✓	•	•			(Not available for Gloss Art Paper 157gsm)	
	PBL 008	310 x 445 x 115	-	✓	•	•				

Fig.2.B. Specification of Paper Bag Available In Market

2.1 RECYCLING OF PAPER

The paper bags available in the market are made up of recycled paper. To recycle paper, it is passed through many process to get recycled paper sheet. These numerous process increases the cost of recycled paper sheet which ultimately results in overall increase in cost of paper bag. Therefore the cost of paper bag available in the market ranges from Rs.4 to Rs.10 per bag depending on the quality of recycled paper and load carrying capacity.

In conventional method following processes are used to recycle the used papers before using it for the manufacturing of paper bags.

Sorting:

Successful recycling requires clean recovered paper, so you must keep your paper free from contaminants, such as food, plastic, metal, and other trash, which make paper difficult to recycle. Contaminated paper which cannot be recycled must be composted, burned for energy, or land filled. Recycling centers usually ask that you sort your paper by grade, or type of paper. Your local recycling center can tell you how to sort paper for recycling in your community. To locate your nearest dealer, look in the yellow pages of your phone book under “waste paper” or “recycling.”

Collection and Transportation:

You may take your sorted paper to a local recycling center or recycling bin. Often, a paper stock dealer or recycling center will collect recovered paper from your home or office. Your local dealer can tell you the options available in your community. At the recycling center, the collected paper is wrapped in tight bales and transported to a paper mill, where it will be recycled into new paper.

Storage:

Paper mill workers unload the recovered paper and put it into warehouses, where it is stored until needed. The various paper grades, such as newspapers and corrugated boxes, are kept separate, because the paper mill uses different grades of recovered paper to make different types of recycled paper products. When the paper mill is ready to use the paper, forklifts move the paper from the warehouse to large conveyors.

Re-pulping and Screening:

The paper moves by conveyor to a big vat called a pulper, which contains water and chemicals. The pulper chops the recovered paper into small pieces. Heating the mixture breaks the paper down more quickly into tiny strands of cellulose (organic plant material) called fibers. Eventually, the old paper turns into a mushy mixture called pulp. The pulp is forced through screens containing holes and slots of various shapes and sizes. The screens remove small contaminants such as bits of plastic and globs of glue. This process is called screening.

Cleaning:

Mills also clean pulp by spinning it around in large cone-shaped cylinders. Heavy contaminants like staples are thrown to the outside of the cone and fall through the bottom of the cylinder. Lighter contaminants collect in the center of the cone and are removed. This process is called cleaning.

Deinking:

Sometimes the pulp must undergo a "pulp laundering" operation called deinking (de-inking) to remove printing ink and "stickies" (sticky materials like glue residue and adhesives). Papermakers often use a combination of two deinking processes. Small particles of ink are rinsed from the pulp with water in a process called washing. Larger particles and stickies are removed with air bubbles in another process called flotation. During flotation deinking, pulp is fed into a large vat called a flotation cell, where air and soap like chemicals call surfactants are injected into the pulp. The surfactants cause ink and stickies to loosen from the pulp and stick to the air bubbles as they float to the top of the mixture. The inky air bubbles create foam or froth which is removed from the top, leaving the clean pulp behind.

Refining, Bleaching and Color Stripping:

During refining, the pulp is beaten to make the recycled fibers swell, making them ideal for papermaking. If the pulp contains any large bundles of fibers, refining separates them into individual fibers. If the recovered paper is colored, color stripping chemicals remove the dyes from the paper. Then, if white recycled paper is being made, the pulp may need to be bleached with hydrogen peroxide, chlorine dioxide, or oxygen to make it whiter and brighter. If brown recycled paper is being made, such as that used for industrial paper towels, the pulp does no need to be bleached.

Paper Making:

Now the clean pulp is ready to be made into paper. The recycled fiber can be used alone, or blended with new wood fiber (called virgin fiber) to give it extra strength or smoothness. The pulp is mixed with water and chemicals to make it 99.5% water. This watery pulp mixture enters the head box, a giant metal box at the beginning of the paper machine, and then is sprayed in a continuous wide jet onto a huge flat wire screen which is moving very quickly through the paper machine. On the screen, water starts to drain from the pulp, and the recycled fibers quickly begin to bond together to form a watery sheet. The sheet moves rapidly through a series of felt-covered press rollers which squeeze out more water. The sheet, which now resembles paper, passes through a series of heated metal rollers which dry the paper. If coated paper is being made, a coating mixture can be applied near the end of the process, or in a separate process after the paper making is completed. Coating gives paper a smooth, glossy surface for printing. Finally, the finished paper is wound into a giant roll and removed from the paper machine. One roll can be as wide as 30 feet and weigh as much as 20 tons! The roll of paper is cut into smaller rolls, or sometimes into sheets, before being shipped to a converting plant where it will be printed or made into products such as envelopes, paper bags, or boxes.

2.2 DRAWBACKS ASSOCIATED WITH RECYCLING

Despite recycled papers are preferred over virgin paper because of their lower environmental impact, some of the drawbacks of paper recycling are listed as follows -

- **High Initial Cost**:

Setting up new recycling unit involves high cost. This huge cost can come up as a part of acquiring different utility vehicles, upgrading the processing facility, educating residents by organizing seminars and other programs, disposing of existing waste and chemicals etc.

- **Energy Use:**

Although recycling paper saves 28 to 70 percent--depending on the facility--of the energy used for making virgin paper, this savings is controversial because of the type of energy used in these two processes. Paper recycling uses fossil fuels while the production process for virgin paper fiber employs waste products from timber to supply a high percentage of its energy requirements. Moreover, recycled paper is less energy-friendly than plastic. The paper bag recycling process uses 98 percent more energy than that for recycled plastic bags.

- **Water Pollution:**

When recycling facilities remove inks from paper, the waste makes its way into the water stream. Metals from printing inks, including copper, lead, zinc, chromium and cadmium, enter the water stream. Waste water from paper recycling often contains dioxins as well, though experts are unable to determine their precise origin.

- **Solid Waste:**

Waste paper reprocessing produces a sludge that contains solids including small fibers, ink from the de-inking process and fillers. This waste, including the heavy metals from the inks, is often sent to landfills. Incineration is an alternative, but this process releases dangerous emissions, including dioxins and hydrocarbons, as well as the heavy metals from the inks. The ash that remains after incineration also is consigned to landfills.

- **Encouraging Consumption:**

Recycling programs use effective advertising to convince consumers they can help the planet by recycling their waste. This advertising, perhaps inadvertently, sends the message that consumption doesn't matter so long as you recycle what you don't use. Because recycling does create pollution, reducing consumption is the most effective way to help the environment.

2.3. DESIGN OF EXPERIMENTS (DOE)

Design of experiments (DOE) is a systematic method to determine the relationship between factors affecting a process and the output of that process. In other words, it is used to find cause-and-effect relationships. This information is needed to manage process inputs in order to optimize the output.

Also, design of experiments is a series of tests in which purposeful changes are made to the input variables of a system or process and the effects on response variables are measured. Design of experiments is applicable to both physical processes and computer simulation models. Experimental design is an effective tool for maximizing the amount of information gained from a study while minimizing the amount of data to be collected. Factorial experimental designs investigate the effects of many different factors by varying them simultaneously instead of changing only one factor at a time. Factorial designs allow estimation of the sensitivity to each factor and also to the combined effect of two or more factors. Experimental design methods have been successfully applied to several Ballistic

Missile Defense sensitivity studies to maximize the amount of information with a minimum number of computer simulation runs. In a highly competitive world of testing and evaluation, an efficient method for testing many factors is needed

Design of experiments (DOE) is a systematic, rigorous approach to engineering problem-solving that applies principles and techniques at the data collection stage so as to ensure the generation of valid, defensible, and supportable engineering conclusions. In addition, all of this is carried out under the constraint of a minimal expenditure of engineering runs, time, and money.

A) DOE Problem Areas

There are four general engineering problem areas in which DOE may be applied:

1. Comparative
2. Screening/Characterizing
3. Modeling
4. Optimizing

1. Comparative:

In the first case, the engineer is interested in assessing whether a change in a single factor has in fact resulted in a change/improvement to the process as a whole.

2.Screening/Characterizing

In the second case, the engineer is interested in "understanding" the process as a whole in the sense that he/she wishes (after design and analysis) to have in hand a ranked list of important through unimportant factors (most important to least important) that affect the process.

3.Modeling:

In the third case, the engineer is interested in functionally modeling the process with the output being a good-fitting (= high predictive power) mathematical function, and to have well (= maximal accuracy) estimates of the coefficients in that function.

4.Optimizing:

In the fourth case, the engineer is interested in determining optimal settings of the process factors; that is, to determine for each factor the level of the factor that optimizes the process response.

B) Methods for designing experiments:

- Taguchi method.
- Full factorial design.
- Mixed level design.

C) Full Factorial Design

In this project the implementation of design of experiments is by full factorial method. Factorial design, are often used to find the "vital few" significant factors out of a large group of potential factors. This is also known as a screening experiment. It is also used to determine curvature of the response surface. In this method the experiment output is obtained by using combinations of different factor levels as input parameters as explained below.

- In 2^k design = k factors, each with 2 levels, 2^k total runs
- 3^3 design = 3 factors, each with 3 levels, $3^3 = 27$ total runs

2k designs are the most popular ones as compared to 3^k designs.

Some of the software available for performing design of experiment are:

1. ReliaSoft's DOE++
2. JMP
3. Minitab
4. Design- Expert

Fig2.3.1. Logos of DOE Analysis Software

2.4. REUSED PAPER

Paper is widely used for a variety of purposes, and much of it gets tossed into trash and ends up in landfills. We can reduce our footprint by reusing the paper accumulate in our daily life. The papers are widely used in corporate offices, schools, colleges, stationaries, printing press, and other sectors.
Most of the paper remains in good condition after use. The advantage of Reused paper is that they have more strength than recycled paper.

Fig.2.4.1. Used Paper

2.5. VIRGIN PAPER VS. RECYCLE PAPER VS. REUSE PAPER

The **Environmental Paper Network** (EPN) is an organization, accelerates environmental transformation in the pulp and paper industry through coordination and collaboration of a strong and diverse coalition of nonprofit non-governmental organizations.

The **Environmental Paper Network's (EPN's)** Paper Calculator shows environmental impact of virgin paper, recycle paper and reuse paper. The following example shows the environmental benefits of using reuse copy paper rather than virgin copy paper.

Virgin Paper vs. Recycle Paper vs. Reuse Paper				
Parameters	**1 ton virgin fiber paper**	**1 ton 100% recycled paper**	**1 ton 100% Reuse Paper**	**Environmental Savings from Reused Content**
Trees	**24** trees	**0** trees	**0** trees	**100%**
Energy	**33** million BTUs	**22** million BTUs	**0** BTUs	**67%**
Greenhouse Gases Released CO_2 equivalent	**5,601** pounds	**3,533** pounds	**0** pounds	**63%**
Wastewater	**22,853** gallons	**11,635** gallons	**0** gallons	**51%**
Solid waste	**1,922** pounds	**1,171** pounds	**0** pounds	**61%**

Table.2.5.1- Comparison between Virgin, Recycled and Reused Paper

The above comparison shows, paper that provides the most environmental benefits, that saves the most resources, that avoids the most toxics and pollution, is paper with reused content.
The pollution caused by a bag made up of recycled paper is more than that of plastic bag because in recycling a paper large amount of energy is utilized and also large amount of greenhouse gases liberates for running a paper recycling plant. So making a paper bag with the help of non-recycled paper is a great idea.

2.6. AN INNOVATIVE IDEA

Getting a good quality used paper as raw material for making paper bag at cheapest rate is a tough job. Because to get good quality used paper it is firstly needed to sort out from other contaminants and the papers obtained is not necessary to have uniform or standard size. But some organizations like educational institutes' produces large number of used pages in form of assignment pages. And these assignment pages are available in standard A4 (standard) size of 217mm x 288 mm dimensions. We can utilized those used pages to make paper bag.

Each year around 2,50,000 assignment pages (used ones) are produced by our college alone each year. By using 10 pages per bag we have approximated the number of paper bags that can be made using these papers to be about 50000 per year.

The benefits of using these used assignment papers are:

- The biggest advantage is that the basic raw material for our project i.e. Paper for making bags is available at cheap cost.
- The paper is of good quality.
- The used paper available is having standard size that will facilitate the paper bag making.
- The disadvantages related to recycling of paper have been eliminated. Also the strength of paper has not been affected as much to account for (recycling reduces the strength of paper considerably.
- In order to reduce the prevalence of plastic bags, the paper bags produced should be at a price which is competitive to that of plastic bag.
- Thus our aim is to introduce mass manufacturing of paper bags at competitive rates in order to compete with the existing paper bags in the market.

Fig.2.6.1.Paper Bags

Chapter 3

Problem Definition

To combat the detrimental effects of plastic bag usage, one of the major alternatives as a solution to the problems posed by plastic bag usage in India has manifested in a resurgence in the employment of traditional paper bags. Ranging from local grocery shops to branded stores in supermarkets, a reversal trend has been observed, with a steady increase in the usage of paper bags.

Fig.3.1 - Paper Bags - Green Alternative to Plastic Bags

Chapter 4

Methodology

4.1. MARKET SURVEY AND COST ANALYSIS:

Market survey was the primary stage to get the material which are required to make paper bag at lowest possible cost. Firstly price quotation of the each material is obtained from local shops. Then to get heavy discount on material to be purchased wholesaler and distributor were approached.

The materials which were used for making bag other than paper were surveyed for their optimum cost are as follows:

Sr. No	Type	Quantity	Cost (in Rupees)
1	Fevicol	700 ml	163
2	Camel	700 ml	85
3	Puppy(Joker)	700 ml	35

Table 4.1 - Cost of Various Glues Surveyed

Sr. No	Type	Quantity	Cost (in Rupees)
1	Jute	14 meters	₹.45
2	Cotton lace (6mm diameter)	5 meters	₹.40
3	Cotton lace (3mm diameter)	50 gram	₹.30
4	Assignment Thread	100 meters	₹.35

Table4 .2 - Handle Material Specifications

4.2. STATIC TEST SETUP AND ANALYSIS OF PAPER BAGS

A) Experiment Setup:

The testing setup for the paper bags was designed in order to test the load carrying capacity of the bags. Test setup was designed to check static load carrying capacity of the paper bag.

The experimental setup consisted of:

1) An iron rod
2) Weighing Machine
3) Two chairs
4) Gravel
5) Weights

Fig.4.2.1.Experiment Setup

B) Experiment Procedure:

The testing of bags was carried as explained follows:

a) Two same chairs (for maintaining equal balance) were kept adjacent to each other and the rod was placed above them.

b) The bag was hanged by the rod and it was filled by gravel.

c) When extra load was required additional weights of measured capacity were kept above it.

d) The gravel was filled very slowly when the bag was nearing its fatigue point in order to determine precise capacity of bag.

e) The fractured bag was collected in a large pan along with the gravel and weights and its weight was measured on a digital weighing machine.

f) At least three bags of same dimensions and design were tested and the average results of them was taken.

g) The fractured bag was preserved to analyze the failure pattern observed.

h) The experimental results were tabulated as shown in subsequent section.

i) The bag with the highest load carrying capacity was selected subsequently for production.

4.3. PAPER BAG DESIGN AND DEVELOPMENT

Paper bags which are available in the market are generally made by cutting large sheets into smaller desired size. Biggest challenge was size of paper bag. It was very difficult to make a bag from pieces of assignment paper. To get rid of this problem five assignment pages was joint together by glue and final page sheet is shown below:

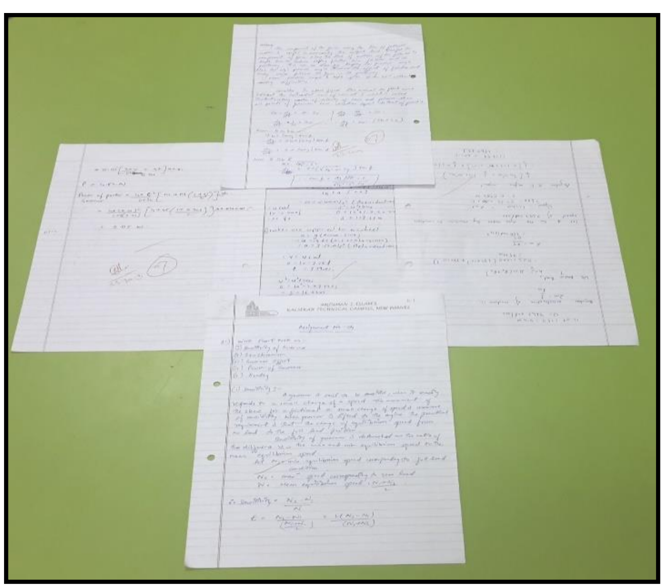

Fig.4.3.1. Plus Shaped Process Sheet made from 5 pages

After this two plus shape sheet was used to make final process sheet to make paper bag. The time-line sequence of design development of bags is explained as follows:

First Design:

Dimensions - 13cm x 5cm x 11cm (W x B x H)

No of pages - 1

Handle material - No handle

Design Limitations:

- Absent of handle makes difficult to hold the bag.
- Overall small dimension of bag
- Very low load carrying capacity about 2 kg.

Fig.4.3.2. First Paper Bag without Handle

Second Design:

Dimensions - 24cm x 17cm x 21cm (W x B x H)

No of pages - 5

Handle material - no handle

Design Features:

- Easy to make.

Design Limitations:

- Load carrying capacity was significantly improved but difficult to hold the bag due to absence of handle material.

Fig.4.3.3.Handle-free Paper Bag

Third Design:

Dimensions - 24cm x 17cm x 21cm (W x B x H)

No of pages - 10
Handle material - paper strips

Design Features:

- Ease of handling due to incorporated handle.

Design Limitation:

- Low strength of paper strip handle material.
- Lesser load carrying capacity abut 2-3 kg

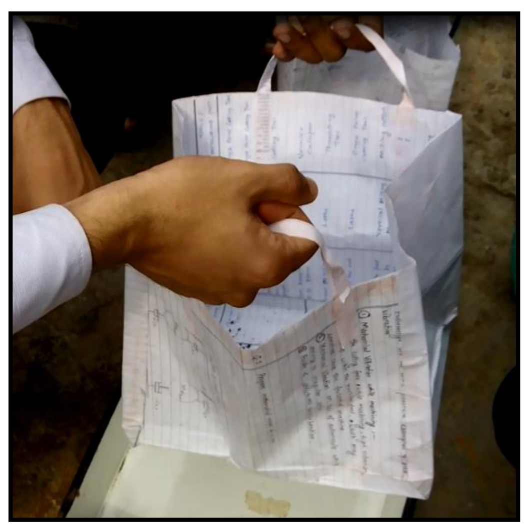

Fig.4.3.4.Paper Strip Handle Paper Bag

Third Design:

Dimensions - 18cm x 18cm x 21cm (W x B x H)

No of pages - 7

Handle material - Jute Thread

Design Features:

- High strength of handle material.

Design Limitation:

- Jute fibers were sticking to hand while holding bag.
- Speeded jute fibers resulted in poor esthetics of bag.
- High costs of Jute thread.

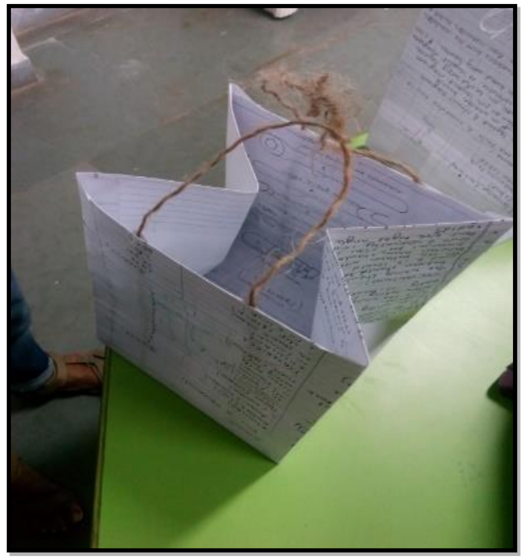

Fig.4.3.5.Jute Thread Handle Paper Bag

Fifth Design:

Dimensions - 16cm x 16cm x 20cm (W x B x H)
No of pages - 7
Handle material - 3 turns of cotton thread

Design Features:

- Less cost of paper bag due to low cost handle material.

Design Limitation:

- Small diameter of cotton thread resulted in quickly sheared off of paper bag.
- Lower load carrying capacity as compared to jute thread bag.

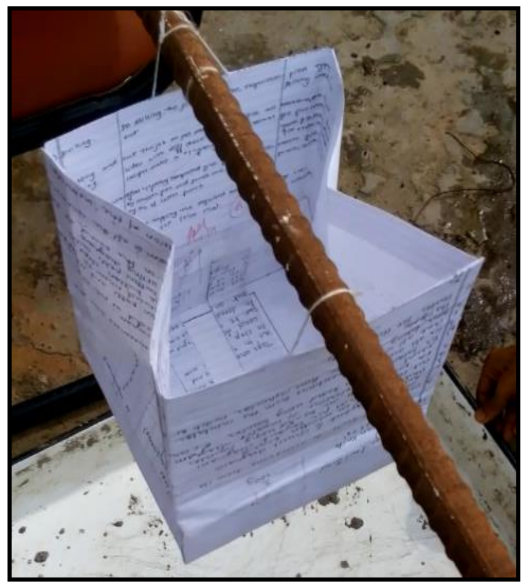

Fig.4.3.6.Cotton Thread Handle Paper Bag

Sixth Design:

Dimensions - 22cm x 18cm x 22cm (W x B x H)
No of pages -10
(2 paper strip reinforcement at the base)
Handle material – Thick Cotton Thread

Design Limitations:

- Small diameter of rope make uncomfortable handling of loaded bag.

Fig.4.3.7.Thick Cotton Thread Handle Paper Bag

Seventh Design:

Dimensions - 22cm x 18cm x 22cm

No of pages - 8 Nos.

Handle material - Jute Rope

Design Features:

- High strength of paper bag

Design Limitations:

- Bulky & poor Aesthetics.
- High cost of handle material
- Deformation at the base under application of loading.

Fig.4.3.8.Jute Thread Handle Paper Bag

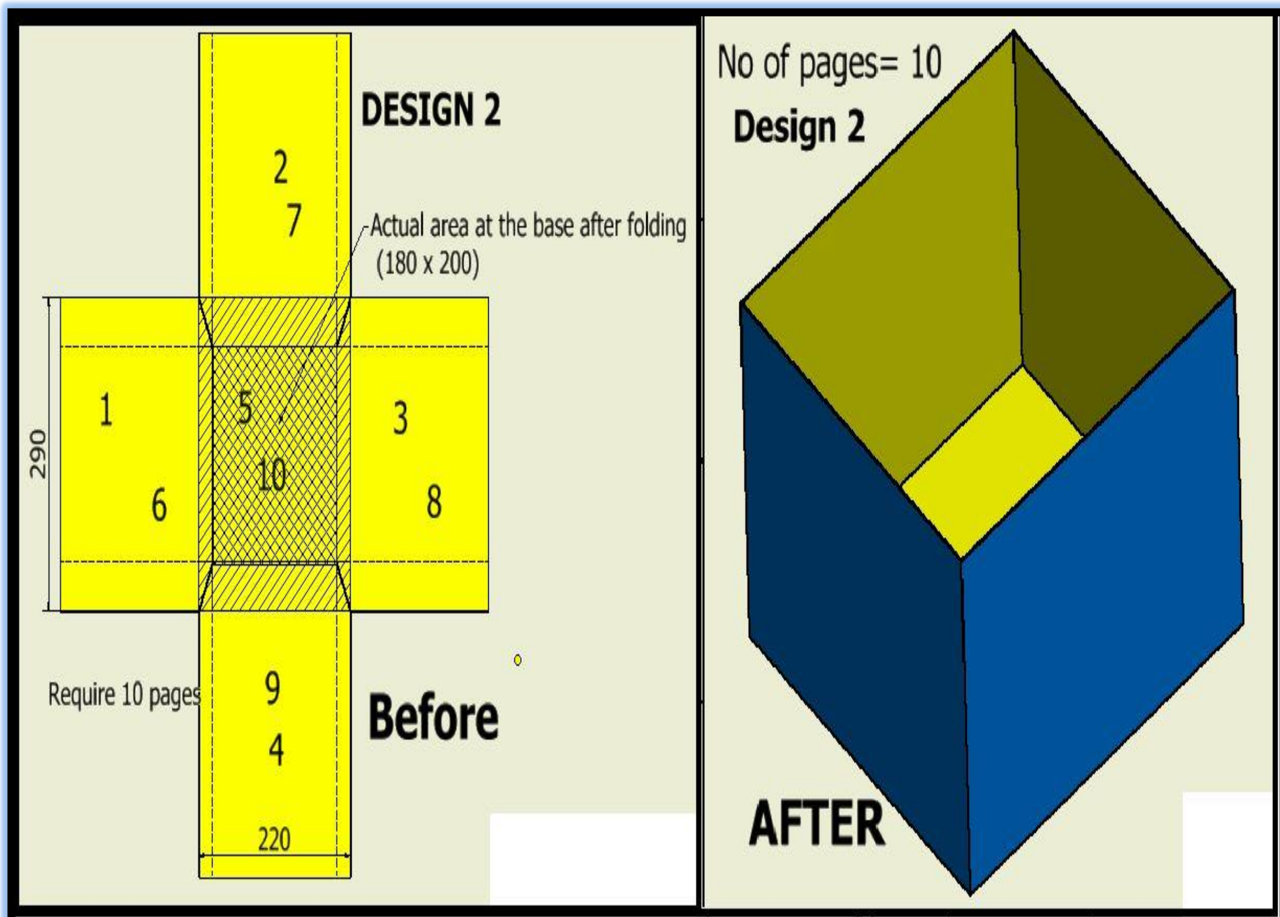

Fig.4.3.9. Initial Design & Dimension of Paper Bag

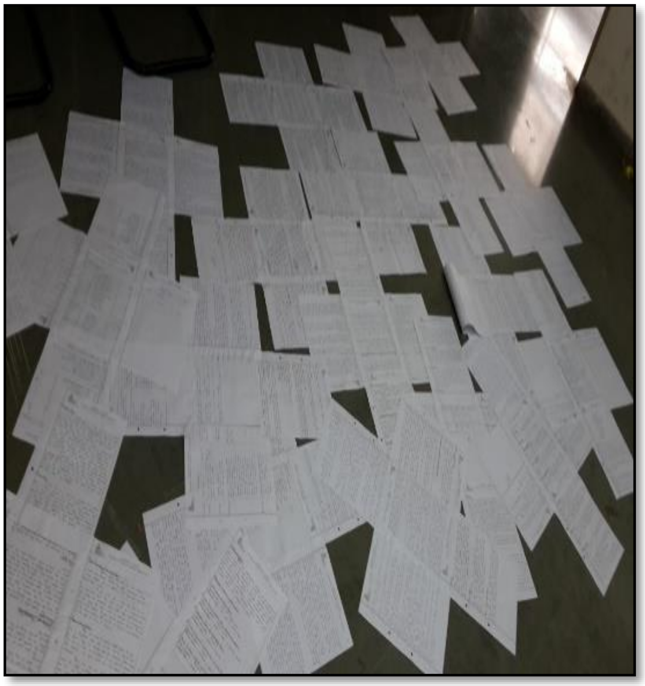

Fig.4.3.10.Plus Shape Paper Process Sheet *Fig.4.3.11. Paper Bag of Different Combination*

4.4. MATERIAL USED FOR MAKING PAPER BAG

Following are the images of materials which were selected for making paper bag of different combinations for experimentations.

Fig.4.4.1.Jute Thread (For Handle Material) *Fig 4.4.2.Cotton thread for handle material*

Fig.4.4.3.Glue (Puppy Gum)

Fig 4.4.4.Cotton Lace for Handle Material

Other materials and equipment used during experimentation are as follows:

- Sand and Gravel
- Bucket
- Weighting machine
- Metal rod- for holding bag during experimentation
- Scoop
- Side Supports- for holding rod
- Tray

4.5 EXPERIMENT RESULTS (PRIMARY TEST RESULTS)

Various designs of bags were made (as shown in above images) and tested for their load carrying capacity and analyzed for failure patterns. At least three bags of each type were made and the average of the three results was noted as shown below:

Sr. No	Type of Bag	Dimensions (LxBxH) in cm	Specifications	Failure Location	Maximum Load
01	Plastic Bag	10x14	20 microns	Failure at bottom	4 kg
02	Paper bag without handle	13x5x11	No of pages-1	At base	1.8 kg
03	Paper bag	24x17x21	No of pages-10 Handle made of paper strips	Failure of paper strip	3.95 kg
04	Paper bag with jute thread	18x18x21	No of pages-7 (Used Jute Thread)	At the Handle (At Rope itself)	6.7 kg
05	Paper bag without handle	24x17x21	No of pages-5	Shear failure from side face	6.81kg
06	Paper bag with cotton thread	16x16x20	No of pages-7 (3 turns of cotton thread)	Shear failure of bottom due to thread	7.5 kg
07	Paper bag with thick thread	22x18x22	No of pages-10 (2 paper strip re inforcement at the base)	Failure at the side of handle	27.039 kg
08	Paper bag with jute thread	22x18x22	No of pages-8	Failure at side face of bag	26.59 kg

Table.4.5.1. Experiment Results (Observations)

At this stage the design was selected considering only its load carrying capacity temporarily. Following are the images captured at the time of primary experiments.

4.6. EXPERIMENT FIGURES

Fig.4.6.1.Gravel Used for Testing

Fig.4.6.2.Hanging the Bag for Testing

Fig.4.6.4.Static Load Capacity Testing

Fig.4.6.3.Gravel Filling For Testing

Fig.4.6.5.Collection of Gravel Carried By Bag

Fig.4.6.6.Weighing Machine

4.7. CONCLUSIONS FROM PRIMARY TESTS

- Although the selected paper bag had very high load carrying capacity (25-28 kg) which is nearly 400% of that carried by plastic bag, its cost came out to be nearly Rs. 3.98 which was much higher than our target (less than that of carry bag of same size).

Cost of Glue - ₹.1.41 Per Bag
Cost of Handle Material - ₹. 2.57 Per Bag
Cost of One Bag - ₹. 3.98

- In order to select a paper bag with maximum load carrying capacity with minimum cost possible, bags with varying combinations of material handle, no. of papers and adhesive had to be made and tested for their strength.
- Due to large number of combinations, it was seemingly impossible to produce and test such a large number of bags due to time constraints.
- A systematic approach had to be followed instead of random experiments to achieve concrete results.
- Thus an approach which would help track the change in results by changing various parameters and which gives desired results had to be taken which is explained in following section.

4.8 EXPERIMENT EXECUTION BY D.O.E TECHNIQUE

- The experiments were again performed in similar manner as explained previously.
- But the difference was that this time the combinations of various factors were used which was suggested by Minitab (DOE) software, to make paper bags in a systematic way in order to feed input parameters as factor levels for software analysis.
- For reducing the cost of the bag, the type 2 glue used earlier was replaced by type 3 which decreased the cost considerably without much change in its strength. Also Jute thread was replaced by soft cotton lace to get more comfort and better aesthetics of paper bag.

A) Factors and Levels in Paper Bag Experiment

To get output combinations factors and levels need to be entered in the software. The factors (variables) which were selected for experimentations to obtain bags of different combinations are:

A. No. of Papers
B. Bonding material
C. Handle material

Each factor consists of various levels as follows:

- For the factor named *"No. of Paper"* there are 3 levels based on number of papers used in making the paper bag.
  1. 8 pages
  2. 9 pages
  3. 10 pages

- For the factor named *"Bonding Material"* there are 2 levels based on the type of bonding material used.
  1. Glue
  2. Hybrid(Combination of glue and stitching)

- For the factor named *"Handle Material"* there are 3 levels based on the type of handle material used
  1. Thread
  2. Cotton
  3. Jute

B) Design of Experiments by Minitab

There are many software available but Minitab software was used for Design of Experiment (DOE) because of its simple Graphical User Interface (GUI).Whenever large number of possible combinations are available in any given experiment, it becomes a very tedious and time consuming process to perform such a large number of experiments arising due to several variable and parameters. In such a case, software for experimental analysis are very useful and they help in analyzing the relationship between various input parameters and thus determining the most optimum combination of variable factors.

As there were three factors and variable levels under each factor so based on those factors and levels the maximum possible combination were 81. But Minitab has suggested us 18 combinations.
The various factors and the experimental results are fed as shown below:

↓	C1	C2	C3	C4	C5	C6-T	C7-T
	StdOrder	RunOrder	PtType	Blocks	Paper	Bonding Material	Handle Material
1	1	1	1	1	8	Glue	Cotton Lace
2	2	2	1	1	8	Glue	Jute
3	3	3	1	1	8	Glue	Thread
4	4	4	1	1	8	Hybrid	Cotton Lace
5	5	5	1	1	8	Hybrid	Jute
6	6	6	1	1	8	Hybrid	Thread
7	7	7	1	1	9	Glue	Cotton Lace
8	8	8	1	1	9	Glue	Jute
9	9	9	1	1	9	Glue	Thread
10	10	10	1	1	9	Hybrid	Cotton Lace
11	11	11	1	1	9	Hybrid	Jute
12	12	12	1	1	9	Hybrid	Thread
13	13	13	1	1	10	Glue	Cotton Lace
14	14	14	1	1	10	Glue	Jute
15	15	15	1	1	10	Glue	Thread
16	16	16	1	1	10	Hybrid	Cotton Lace
17	17	17	1	1	10	Hybrid	Jute
18	18	18	1	1	10	Hybrid	Thread
19							

Fig.4.8.1.Experiment Combinations Suggested By Minitab

The three different designs made by changing the number of papers are shown below:

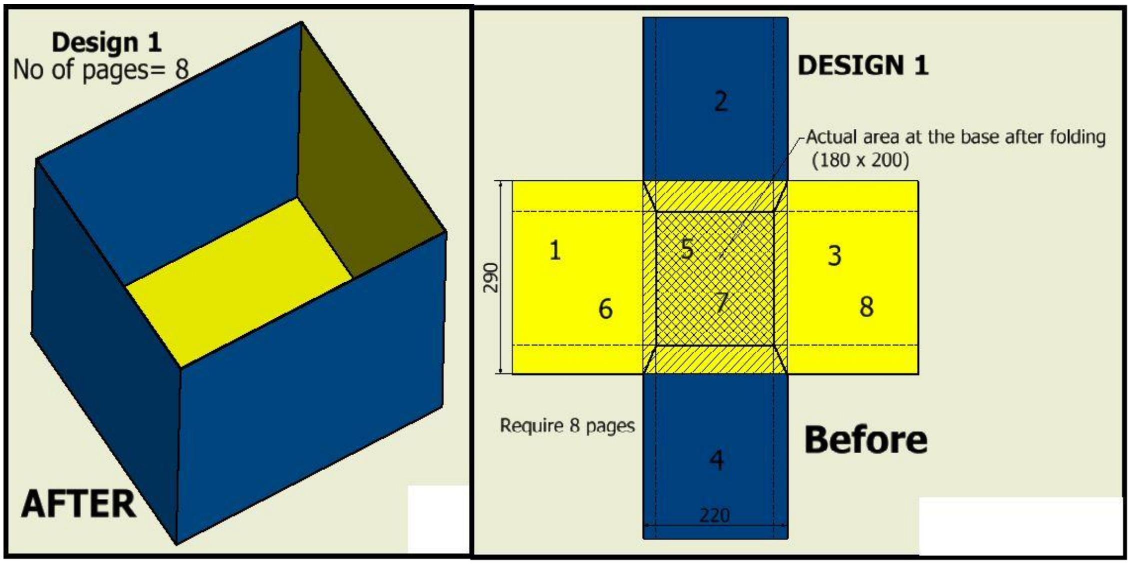

Fig 4.8.2. Design of 8 Page Paper Bag

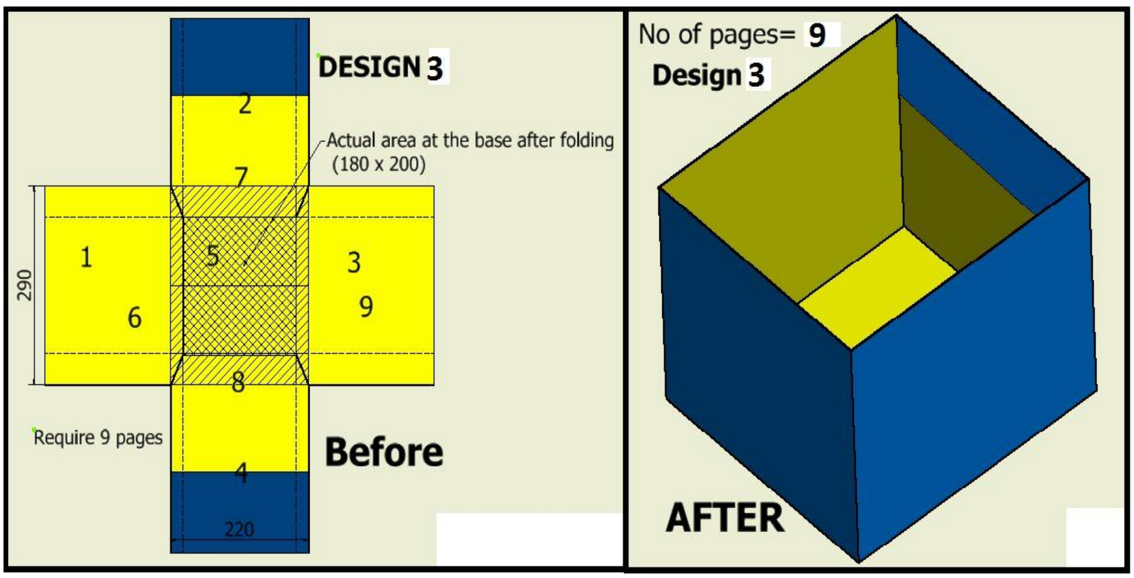

Fig.4.8.3. Design of 9 Page Bag

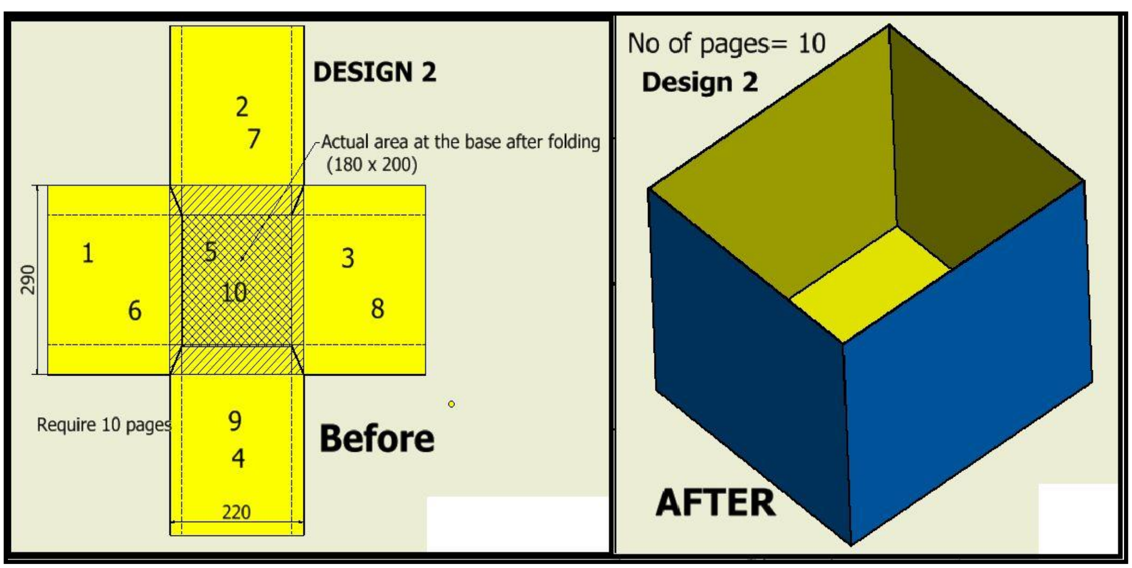

Fig.4.8.4.Design of 10 Page Bag

After putting all the factors and levels in the software paper bags were made as per Minitab suggested combinations and experiment tests was carried out on each bag to get the ultimate load carrying capacity of each type of bag on prepared paper bag static test setup. The variables and the test results data was fed into the Minitab software for software analysis as shown below:

↓	C1	C2	C3	C4	C5	C6-T	C7-T	C8
	StdOrder	RunOrder	PtType	Blocks	Paper	Bonding Material	Handle Material	Weight(kg)
1	1	1	1	1	8	Glue	Cotton Lace	10.9
2	2	2	1	1	8	Glue	Jute	12.5
3	3	3	1	1	8	Glue	Thread	10.7
4	4	4	1	1	8	Hybrid	Cotton Lace	6.5
5	5	5	1	1	8	Hybrid	Jute	5.0
6	6	6	1	1	8	Hybrid	Thread	6.0
7	7	7	1	1	9	Glue	Cotton Lace	12.0
8	8	8	1	1	9	Glue	Jute	13.4
9	9	9	1	1	9	Glue	Thread	12.4
10	10	10	1	1	9	Hybrid	Cotton Lace	6.0
11	11	11	1	1	9	Hybrid	Jute	6.5
12	12	12	1	1	9	Hybrid	Thread	5.0
13	13	13	1	1	10	Glue	Cotton Lace	11.6
14	14	14	1	1	10	Glue	Jute	14.5
15	15	15	1	1	10	Glue	Thread	10.7
16	16	16	1	1	10	Hybrid	Cotton Lace	9.0
17	17	17	1	1	10	Hybrid	Jute	9.5
18	18	18	1	1	10	Hybrid	Thread	10.5
19								

Fig.4.8.5. Experimental combinations with corresponding load carrying capacity in Minitab

Plot 1) Relationship between Weight Carried and No. Of Pages (Interaction Plot):

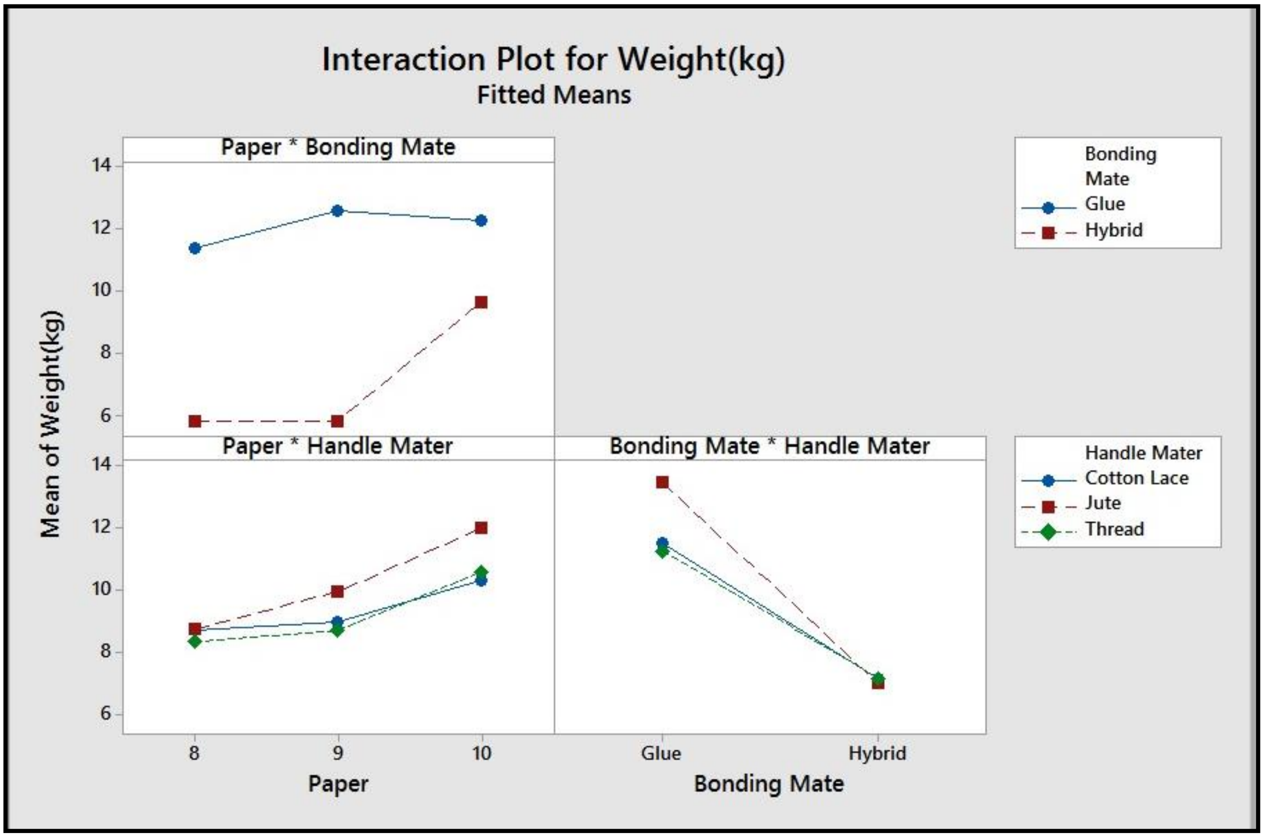

Fig.4.8.6. Interaction Plot for Weight Carried By Bag

When two or more independent variables are involved in a research design, there is more to consider than simply the "main effect" of each of the independent variables (also termed "factors"). That is, the effect of one independent variable on the dependent variable of interest may not be the same at all levels of the other independent variable. Another way to put this is that the effect of one independent variable may depend on the level of the other independent variable.

In order to find an interaction, we must have a factorial design, in which the two (or more) independent variables are "crossed" with one another so that there are observations at every combination of levels of the two independent variables.

The line graph shows the relationship between no. of pages and the weight carried by the bag considering the effect of handle material and type of paper bag (made by using glue or partial stitching).

Outcome from above Interaction Plot1:

1. Graph for Paper Vs Bonding Material- Glue as a bonding material provides more strength than Hybrid type of bonding for all type of bag (8 page bag, 9page bag, 10 page bag).

2. Graph for Paper Vs Handle Material- Jute thread provide slightly better strength as compared to cotton lace and cotton thread. Whereas cotton lace and cotton thread paper bag has same strength.

3. Graph for Bonding Material Vs Handle Material- Jute as a handle material is more stable (does not move from its position) than other handle material.

Plot 2) Effect of Weight on Number of Papers, Type of Bonding and Handle Material (Main Effects Plot):

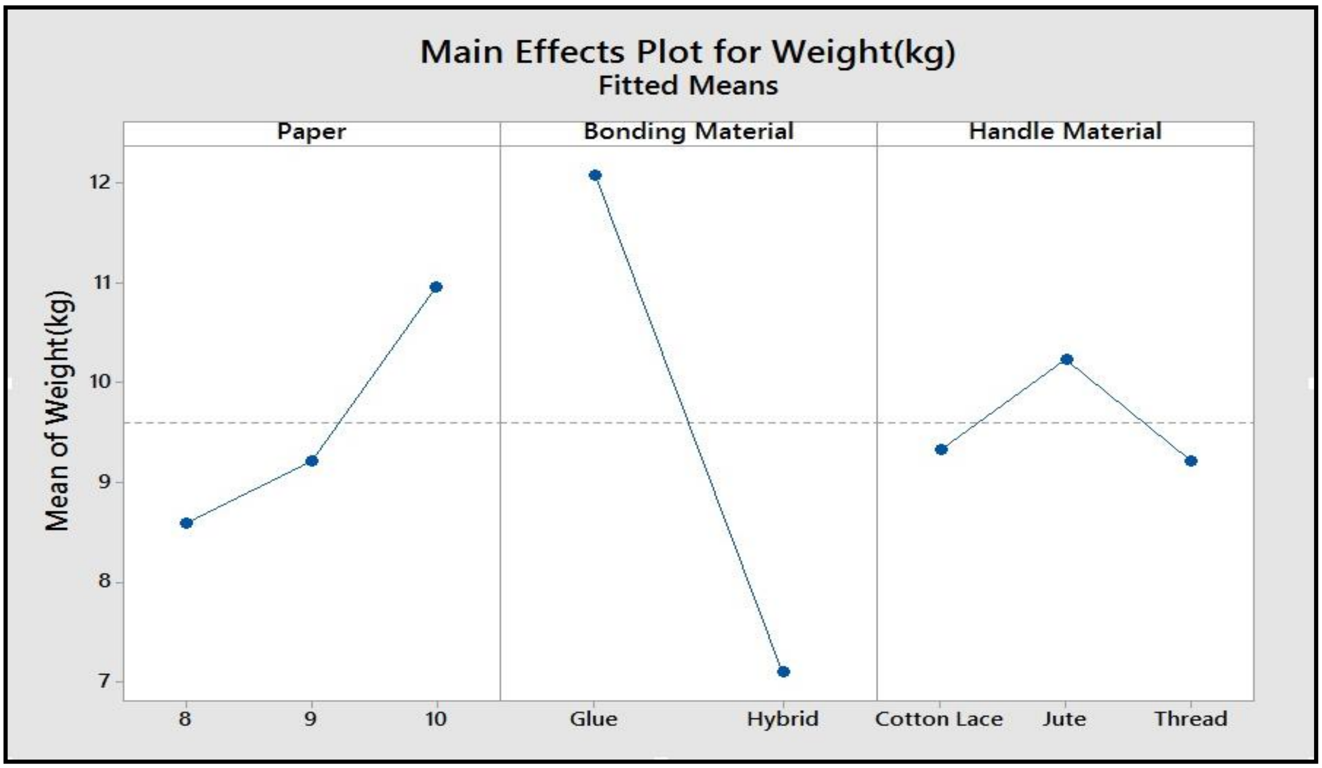

Fig.4.8.7. Main Effects Plot for Weight Carried By Paper Bag

In the design of experiments and analysis of variance, a main effect is the effect of an independent variable on a dependent variable averaging across the levels of any other independent variables. The term is frequently used in the context of factorial designs and regression models to distinguish main effects from interaction effects.

Relative to a factorial design, under an analysis of variance, a main effect test will test the hypotheses expected such as H0, the null hypothesis. Running a hypothesis for a main effect will test whether there is evidence of an effect of different treatments. However a main effect test is nonspecific and will not allow for a localization of specific mean pairwise comparisons (simple effects). A main effect test will merely look at whether overall there is something about a particular factor that is making a difference. In other words a test examining differences amongst the levels of a single factor (averaging over the other factor and/or factors). Main effects are essentially the overall effect of a factor.

Outcome from Main Effects Plot for Weight:

1. Graph for Paper Vs weight- The paper bag made up of 10 pages has got more strength (12 to 15kg) than 8 and 9 page paper bag.
2. Graph for Weight Vs Bonding Material- glue as a bonding material gives more strength to paper bags than hybrid bonding.
3. Graph for Weight Vs Handle Material- Paper bag of jute as a handle material has higher strength than paper bag of other type of handle material.

Chapter 5

Results

Following are the results of paper bag that were made according to the suggested combinations by the Minitab software:

Sr.No	No. Of Pages	Handle Material	Bonding Material	Weight Lifted (Kg)
1	9	3 Twisted Thread	Full Glue	12.39
2	10	Cotton Lace	Stitch and Glue	9
3	10	Jute	Stitch and Glue	9.5
4	10	Twisted Thread	Stitch and Glue	10.5
5	8	Jute	Full Glue	12.5
6	**10**	**Cotton Lace**	**Full Glue**	**11.6**
7	8	Thread	Full Glue	10.7
8	10	Jute	Full Glue	14.5
9	9	Jute	Full Glue	13.4
10	9	Thread	Full Glue	12.7
11	8	Cotton Lace	Full Glue	10.9
12	9	Cotton Lace	Full Glue	12

Table.5.1.1.Final Results

Based on the above experiments and the following conclusions can be made:

1) From the design of experiments using Minitab software, it can be concluded that the best paper Bag for production is of the combination –

Final Selected Design

Number of pages - 10

Handle Material - Cotton lace

Dimensions - 125cm x 240cm x 200cm (W x B x H)

Weight lifted - 11.6 Kgs

Fig.5.1.1 - Lace Handle Bag

Paper bag design selection was done based on following factors:

a) Load carried by bag
b) Durability
c) Availability of material
d) Economic feasibility of materials used
e) Aesthetics
f) Ease of manufacturing and machine constraints

Comparing the design of bag in the first and second experiments, the modification of design has been done in following areas:

PARAMETERS	EXPERIMENT STAGE 1	EXPERIMENT STAGE 2
Dimensions	210×175×221	240×125×221
Handle Material	Jute Rope	Cotton Lace
Glue	Camel	Puppy gum
Cost(approx.)	3.98	0.75
Load carried (kg)	26.59	11.6

Table.5.1.2. Comparison between Bags Selected From 1st And 2nd Stage Experiments

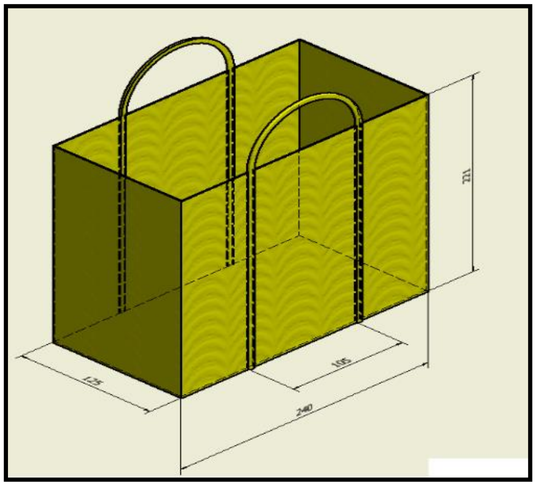

Fig.5.1.2. Modified design

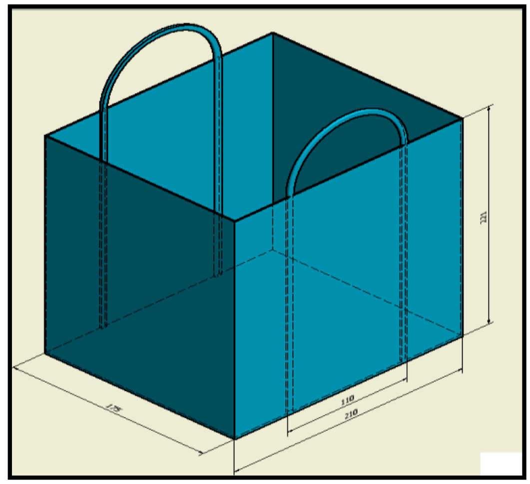

Fig.5.1.3. Older Design

5.2. PROJECT FEATURES

Fig.5.2.1 Features of Paper Bag

Chapter 6

Designed & Fabricated Manufacturing Setup

Generally there are two different methods of making paper bags and are listed as follows:

Manual 1) Manually by Hand:

The first is manual method in which labors are employed to make paper bags. But this method is time consuming. The productivity of this method is low and the quality of paper bag produced is not uniform. This method is suitable for small scale business. Also profit margin is less.

Method 2) By Paper bag Manufacturing Setup:

In this method papers bag are made by paper bag manufacturing unit. Paper bags can be made with higher speed by using manufacturing setup. Also the labor cost get reduced. Which results in higher profit.

6.1. Designed of Non-Recycled Paper Bag Manufacturing Setup

The conventional paper bag manufacturing machine uses recycled paper to make paper bag. The recycled paper comes in the form of long sheet which is reduces the paper bag making process complexity. But paper raw material available for making bag is assignment pages. So a new manufacturing setup has been designed to process assignment pages of A4 size as a raw material to make paper bag.
To simplify the paper making process whole setup is divided into three different substation.
1. Station1- Plus Making Station.
2. Station2-Sandwitching Station
3. Station3- Paper bag Station.
Following is the image of designed paper bag manufacturing setup:

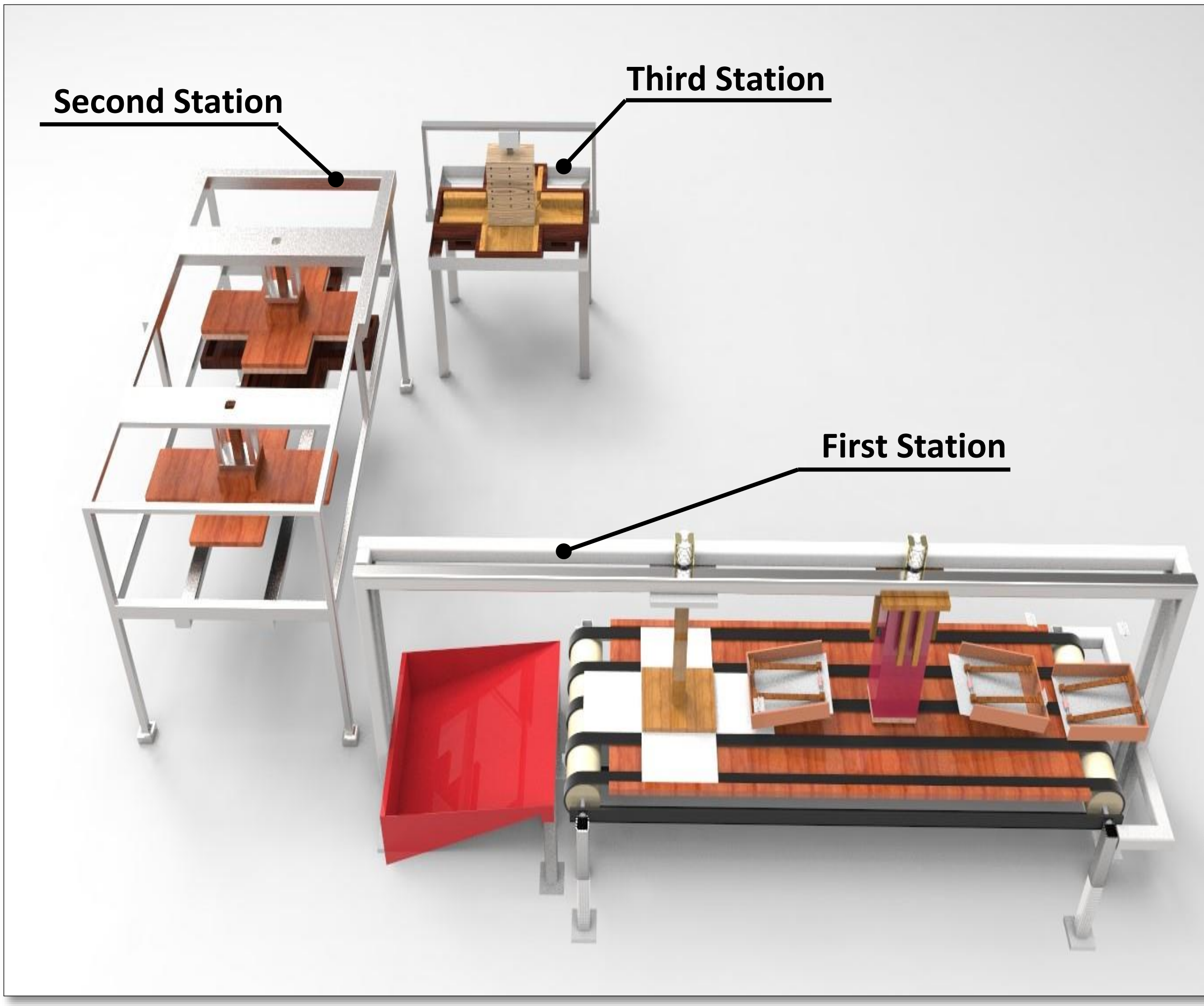

Fig.6.1.Design of Non Recycled paper bag Mfg. Setup

Chapter 7

Conclusion

As decided earlier, paper bag is made using used papers (without recycling it). The strength of the manufactured paper bag is more than the polythene bags used in the market. In fact it gives nearly twice the strength as that of plastic bag.

As per expectations, the load bearing capacity of paper bags which were made of used assignment pages is more than a normal plastic bag. Results showed that the load carrying capacity of paper bags is 2.5 times more than average plastic bag. Following are the features of the project.

- **Low Cost:**
  The paper bag manufacturers mostly purchase raw material in the form of magazines newspapers etc. from scrap vendors. Whereas in the project utilization of used assignment papers are used as raw material which are available in abundance.

- **Material Availability:**
  As far as material availability is considered our Institute alone produces around 5 lac (minimum) assignment papers annually from which around 50 thousand paper bags can be made(10 paper per bag).

- **<u>Strength Effectiveness:</u>**

  After experimentation of paper bag and plastic bag it is concluded that the strength (load carrying capacity) of the manufactured paper bag was nearly 2-3 times as that of plastic bag (20 microns).

- **<u>Environmental Impact:</u>**

  The harmful environmental impacts caused by dumping of plastic bags in environment are many. Paper bags are biodegradable in nature. If implemented, it would reduce the problem of waste plastics to considerable extent in India.

Chapter 8

Future Scope

It is first time that such an initiative has been undertaken in the Mumbai region. The design of paper bag has been constrained to limit manufacturing machine complexity which has been manufactured simultaneously. The amount of paper bags which can be produced is increased by designing and fabricating an automated paper bag manufacturing unit.

In future several centralized production unit can be established in Mumbai region to make paper bag and to meet the customers demand and requirements. The availability of raw material (i.e. Assignment papers) from other nearby colleges can be used as well. Also paper bags of different dimensions and designs can be produced as per demand although it will require some flexibility of the machine.

The paper bag produced are almost of less monetary value than legal plastic bags. If we are able to produce these on a large scale and they find acceptance, it will help in reducing the influence of plastic bags, especially the illegal ones. We hope to provide a plastic free environment (at least to some extent) to the next-generation by initiating this project.

Chapter 9

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