Annex 17

Annexure E

OPERATION OF FUNDS AND PROGRESS REPORT

1. **Title of the Project:** Study of construction and performance requirements of 1 kg, 2 kg, and 5kg leno woven sacks	**Project number:** TXD0174
2. Name & Address of Project leader(s): Dr. Anilkumar Lalchand Yadav (PI), Dr. Mukesh Bajya (Co-PI), and Dr. Priyanka Gupta (Co-PI) Department of Textile Technology, Dr. B. R. Ambedkar National Institute of Technology Jalandhar, Punjab - 144008, India.	**Date of commencement:** 25/06/2024

3. **Details of Equipment Purchased (if any):**

Name of equipment	Cost	Supplier	Date of purchase/ placing order for each item of equipment
Nil	Nil	Nil	Nil
Note: The equipment fund once fixed cannot be enhanced. Project leaders are advised to give authenticated estimates of the cost of equipment. Equipment should invariably be purchased within 1 month from the date of receipt of the fund and/or sanction letter.			

4. Total project cost: **Rs. 969600.0**

5. Fund received: **Rs. 261792.0 (30% of total project cost – 10% TDS)**

6. Expenditure made: **Rs. 37087.0**

Expenditure	Amount	Taxes (as applicable)	Total
Manpower cost	36167.0	-	36167.0
Consumables	420.0	-	420.0
Equipment	-	-	-
Travel	500.0	-	500.0
Others	-	-	-
Grand Total	**37087.0**	-	**37087.0**

7. Amount saved (if any) from the last installment: **Rs. 224705**

8. Date on which scheme will complete its normal tenure of months **December 2024**

9. Whether extension beyond normal tenure has been requested: **Yes**

An extension of two months is required to complete the work due to the following reasons.

a. Delay in hiring of manpower.
b. The poor response of industry personnel resulted into delay in procurement of samples and this is also not allowing us to visit to small /medium/ large scale industry to observe the manufacturing process.

10. **Constraints (if any) faced in the progress of work and suggestions to overcome them.**

The present research project is facing following constrains.

a. No response from industry to provide the 5 kg, 2 kg, and 1 kg samples
b. Industry is not responding for the industrial visit
c. The procured samples are obtained locally
d. The information obtained from the local supplier on 2 kg and 1 kg samples, that the same 5 kg samples is reduced to smaller capacity by stitching.

11. **Any deviation from original plan with its nature and cause.**

So, far we are adhering to the exact plant which we had proposed in the research project. However, it seems the unavailability 2 kg and 1 kg samples will lead to some modifications in the proposed plan. for which the suggestions from BIS authority is highly appreciated.

12. **List of publication giving full bibliographic details accrued from this project (copies of the paper (s) should be enclosed): Nil**

13. **Summary of work done (200 words).**

The progress of research project comprises of following. Recruitment of a manpower (Joint the project since August 16, 2024). Contacted to several industries through India Mart and contacts supplied by the BIS authority for supply of the 1 kg, 2 kg, and 5 kg leno wove bags. Procurement of 5 kg capacity leno woven bags available locally. In-house testing of procured leno woven bags. Requested for industrial visit (through email and telephonic conversation) to explore manufacturing process of leno woven sacks

14. **Proposed programme of work for the next month (1000 words).**

Presently we are searching for the suppliers of leno woven bags of different capacity and of different varieties. We are contacting to several industries for visit to explore the manufacturing

process. Further, procurement of supporting consumables is under progress. Testing of samples through two different national level laboratories and in-house testing of samples are also the part of further activities.

15. Detailed progress report enlisting the objectives in beginning briefly (up to five pages maximum): **Attached separately.**

Signature of Project leader

Date: 24/09/2024

PROJECT PROGRESS REPORT

STUDY OF CONSTRUCTION AND PERFORMANCE REQUIREMENTS OF 1 KG, 2 KG, AND 5 KG LENO WOVEN SACKS

PROJECT CODE: TXD0174

FUNDED BY BUREAU OF INDIAN STANDARDS (BIS)

Project title: Study of construction and performance requirements of 1 kg, 2 kg, and 5 kg leno woven sacks.

Project code: TXD0174

Proposers:

Dr. Anilkumar Lalchand Yadav (PI, Department of Textile Technology, Dr. B. R. Ambedkar National Institute of Technology Jalandhar, Punjab - 144008, India. yadaval@nitj.ac.in)

Dr. Mukesh Bajya (Co-PI, Assistant Professor, Department of Textile Technology, Dr. B. R. Ambedkar National Institute of Technology Jalandhar, Punjab - 144008, India. bajyam@nitj.ac.in)

Dr. Priyanka Gupta (Co-PI, Assistant Professor, Department of Textile Technology, Dr. B. R. Ambedkar National Institute of Technology Jalandhar, Punjab - 144008, India. guptap@nitj.ac.in)

Approved project cost: Rs. 9,69,600.0

Amount sanctioned in first installment: Rs. 261792 (30% of total project cost – 10% TDS)

Project start date: June 25, 2024

Objective:

- Collect and analyze the relevant technical data and scientific evidence for constructional and performance specifications of 1 kg, 2 kg, and 5 kg leno woven sacks from both primary and secondary sources (such as small and medium scale industries, etc.).
- To define the terminology used for the leno woven sacks for the said applications.
- To specify the essential and desirable product requirements of leno woven sacks for packaging application and revised the existing BIS standard IS16187:2014.

MILESTONE I: Literature review, desktop study, sample collection, and in-house testing

Introduction

Leno weave sacks have progressed over the years to become a prime source of packaging solutions to various industries. Among the materials used, High-density Polypropylene (HDPP) sacks are very popular around manufactures due to its low production cost and its reusable nature by being able to maintain shape and strength even after multiple uses. The design parameters of these sacks are such that they are a dependable source to transport and store a wide variety of agricultural products especially fruits and vegetables as well as other industrial commodities including cement and other construction materials. Here, the only difference would be in mesh designs, where the Leno sacks for cement world would require a coarser mesh made with stronger and more durable materials, and on the other hand food produce would require Leno sacks with finer mesh, providing good ventilation and avoiding any moisture buildup. Leno woven bags are often noted for their distinctive weave architecture providing them with superior strength and structural stability making them a suitable choice for carrying heavy loads and abrasive products.

Leno weaving is a unique technique where the two warp yarns are criss-crossed and interlocked over the weft yarn, thereby resulting in a *helix-like structure* with a distinctive yarn geometry and crimp. This weaving method assures that the sacks possess a light weight construction, with high breathability and durability that can withstand mechanical and tearing stresses and strains. These qualities are very pivotal for preserving perishable produce that require proper ventilation. Additionally, Leno bags also provide the necessary tenacity for these bags to endure challenging transit and storage conditions, including harsh environmental situations.

Although Leno woven bags has a widespread market, there is a need for a detailed exploration of the constructional parameters and their subsequent performance stats for these woven sacks, and also a need to focus mainly on the lighter versions Leno woven sacks in the category of 1kg, 2kg and 5kg capacities and not only that, each weight category of Leno sacks possesses its own definite set of structural characteristics (such as material composition, yarn count, weave pattern, etc) and functional (such as tenacity, load-bearing properties etc) dynamics so as to meet performance criteria. The primary objective of this study is to thoroughly analyze the above mentioned aspects including material selection, structure-property relationships and testing standards which are relevant to each weight classes, and be able to explain the complex construction of Leno woven sacks and how they perform when designed to hold 1kg, 2 kg and 5 kg of goods. In addition this research will study properties like tensile strength, abrasion resistance, puncture resistance, bursting strength, impact resistance, stiffness and bagging behaviour while also assessing environmental exposure such as UV, moisture and temperature fluctuations.

An essential component of this study entails conduction standardized testing of Leno sacks according to standards and evaluating them using industry-specified procedures to determine accurate results under controlled conditions of testing. These evaluations of different weight Leno bags will give valuable insights into

the structure-property influence during real-time application. The assessment will check whether the quality control processes used to make the sacks meet international standards like ISO and ASTM, making sure that the sacks are reliable and safe to use.

This research seeks to provide valuable learning to researchers and manufacturers in the packing technology for the agro-based industries through systematic and thorough analysis of the above specified elements. The finding of this research will aid in the creation of improved versions of Leno woven sacks that are efficient and long lasting, which will help to meet the changing requirements of different industries and contribute to the evolving packaging technology.

Literature Review

Historical Development and Evolution of Leno sacks

In the ancient times, before the advent of Leno sacks and other modern pack tech, humans used woven baskets, wooden crates, cloth sacks, leather pouches and sometimes huge leafs like banana leaf for carrying food produce. Polypropylene (PP) Leno mesh sacks have evolved significantly over the years to become an essential packaging solution in various industries around the globe. The Leno bags market had a stagnant market from the year 2019 to 2023, with an average growth rate of 3.0% per year, and this was mainly due to the supply chain disruptions, shift in consumer needs and increased competition from alternative packaging solutions. But this trend has experienced a major shift, due to the increased demand in the food industry. Prominently the Asian countries are the largest and fastest growing markets for Leno bags, where countries like India, Thailand, China, Vietnam and Indonesia are the major exporters for fresh produce hence the huge market for Leno bags.

Leno weave

A Leno weave structure is shown in Fig.1, where a set warp thread is made to overlap one another after interlacing with the weft yarn. This crossing of the warp threads gives the fabric a very firm and durable structure, resulting in a fabric with higher strength compared to other types consisting of similar yarn counts and pick per inch. (Shinn and Mckenna, 1930)

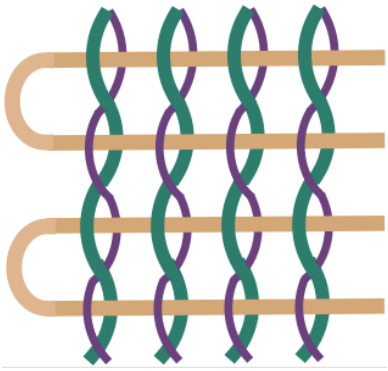


Figure 1: Leno weave structure.

Types of leno weave

There are mainly two types of Leno weave structures, namely half Leno and full Leno. Fundamentally, both half and full Leno weaves are distinguished by their method of interlacement that involves 'doup' ends around the ground as shown in Fig 2; Doup is nothing but a loop or string which is used in the Leno weaving process to twist the warp threads around each other, interlocking the weft yarn. This method of construction creates a stable, open weave structure that prevents the warp yarns from slippage.

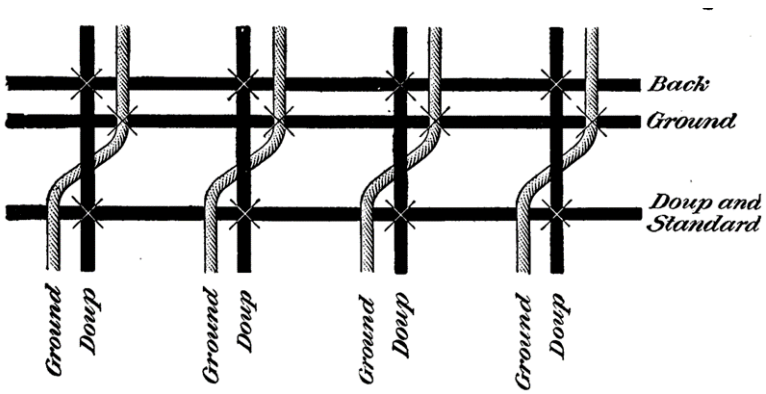


Figure 2: Representation of doup and ground ends (Shinn and Mckenna, 1930).

Half leno

In a half Leno weave, only one doup end is involved in the interlacing with the ground ends of the fabric. The second end is stationary in position while the doup end is twisted around it as shown in Fig. 3, resulting in a structure having a subtle openness due to the lack of complete interlacing of all warp threads and not dense as in case of traditional weaves.

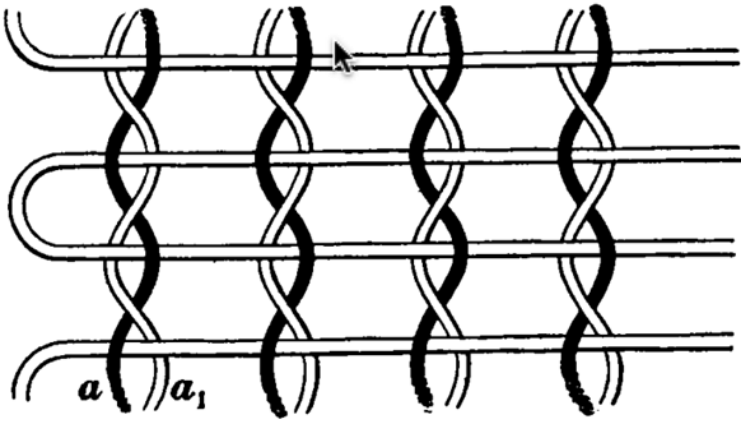


Figure 3: Half Leno weave, 'a' represents warp (or doup) end and 'a1' represents ground (stationary) end (Shinn and Mckenna, 1930).

Full leno

In a full Leno weave also known as double Leno weave, both doup ends (a left-hand doup and a right-hand doup) are used, which are twisted around the ground ends on both sides, creating a more intricate interlacing pattern with larger and more defined open spaces with better stability. (Leno weaves, The University of Arizona)

In simple words, a full Leno involves two warp yarns crossing over each other on both sides (left and right) of the weft yarns as shown in Figure 4, thereby creating a robust fabric.

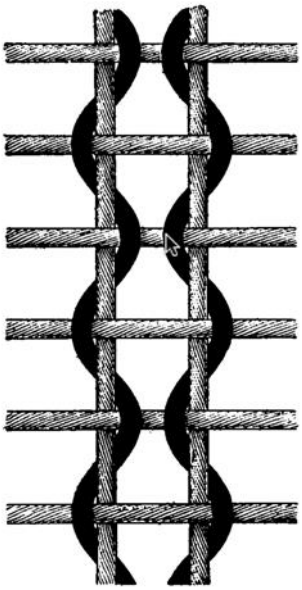
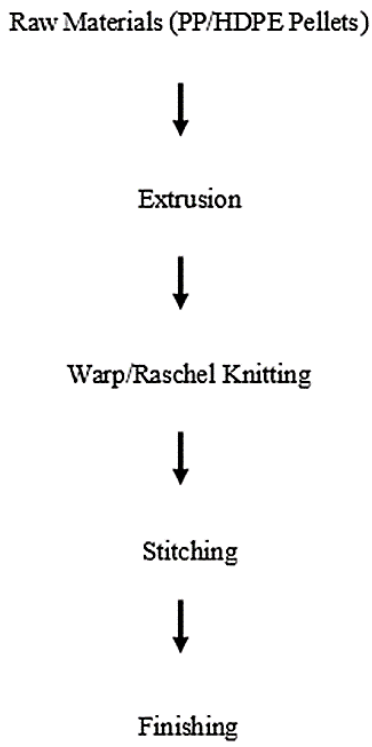


Figure 4: Full Leno weave structure showing alternating interlacement of doup ends (Shinn and Mckenna, 1930).

Leno Bag Manufacturing

The main processes involved in the manufacture of leno woven bags are provided in the flowchart, initially suitable raw materials are fed to the feed hopper of the tape plant, extrusion takes place and the PP/HDPE tapes are then fed into the warp knitting machine for Turing into leno fabric. This fabric is then stitched , printed on and finished to make the final product. [12]



Market size

The global leno woven bag ad sack market is estimated at US 4.46B in 2024, with an estimated expansion up to 6.67 B, with key growth drivers being cost effectiveness, increased demand in the agriculture and constructional sector. The recyclable nature of these bags also adds to its sustainability factor and play an important role in its adoption. [11]

Varieties of Leno Woven Sacks

Leno woven sacks are mainly made from full leno or half leno as the name suggests, and varieties can be in their weight/ capacity, colour availability, UV or anti-slip finishing and biodegradable sack types.

i) **Standard leno bags:** These sacks are the common variety sacks used for agricultural produce, where proper ventilation is required to allow air circulation preventing any spoilages.

ii) **High-density leno bags:** Useful for heavier products, the increased density makes it more resistant to wear and tear.

iii) **Coloured leno bags**: In order to make the sacks aesthetically pleasing, different colours and prints are used by brands to make their product more identifiable and attractive.

iv) **UV stabilized/anti-slip finished leno bags:** UV shield is provided to protect the products from sunlight, this feature is important for contents that would be stored outside and hence help from spoilage or damage

from prolonged UV exposure. Anti-slip treatment done to reduce slipping of products when stacked, ensuring safe storage and transport.

v) **Biodegradable leno bags**: To combat sustainability concerns related to plastic leno bags, biodegradable leno bags made from materials that break down easily upon disposal, materials like PLA (Polylactic acid), Cellulose-based films etc.

Previous research studies and findings

There are quite a few research studies based on done Leno bags so far, highlighting key properties, modified manufacturing processes and important applications. The below mentioned summary critically analyzes significant findings and contributions to the understanding of Leno weave structures and their optimization for lightweight applications.

Chaudhary and Rakshit (2009) concluded that HDPE woven sacks showed superior properties compared to traditional gunny bags made of jute. HDPE sacks portrayed superior properties including slower fire propagation, lighter weight, higher tenacity, even structure, better moisture resistance and improved protection against pest infestation, and these properties help in enhancing the storage and transit efficiency of produce; thereby making HDPE woven sacks a preferable choice in different applications.

Saha et al. (2017) modified the method of Leno fabric production without the need of a dobby shedding mechanism with a benefit of making it accessible and cost-effective. The resulting Leno fabric exhibited properties like high tear and bursting resistance, meeting the required optimum strength levels with lower GSM than anticipated.

Sharma and Alagh (2021) focused on using Polypropylene granules as raw material for the analysis of various steps and examining the key factors which influence the production process of PP mesh bags. Major properties influencing quality and performance were found out to be high strength, durability and resistance to chemicals. And these Leno bags are mentioned as being suitable for packaging various products such as fruits, vegetables, cement, fertilizer, polymer granules, chemicals, grains, animal feed, seeds, and tarpaulins.

Saifullah et al. (2023) used a Leno design where cotton and jute yarns were used for warp and weft. An important observation was that the tensile strength in the weft direction was higher compared to the warp direction due to the coarser weft yarn used; applications included upholstery, curtains, car set cover and garments. The study highlighted the need for pilot runs and development of such jute Leno designs in order to encourage a widespread market for jute union products. But the problem with combining different yarns is its recyclability after its lifecycle.

Shaker et al. (2018) combined various structures to study the properties of Leno woven fabric using multifilament polyester yarn as the warp and weft material. The result showed that both hybrid and pure Leno

structures showed similar tensile properties with a lower puncture resistance for the hybrid weave. This difference in behaviour can be attributed to different interlacement patterns between warp and weft which might have altered the overall fabric stability and resistance to puncture.

Purnima et al. (2016) study proved that Leno bags were inefficient as bunch covers for fruits and a similar study done by Brar et al. (2019) which also proved that Leno bags were inefficient and non-woven bags performed better at preventing pest infestation.

Indraneel and John (2024) used Leno fabric for composite reinforcement purpose, and was later found that it was unsuitable due to low fiber volume fraction. The tensile strength of the reinforcement is also revealed to be low due to the yarn geometry and degree of crimp compared to other types of woven fabric reinforcement; these reinforcement can offer potential resistance to delamination. The paper further discusses damage initiation and different failure modes in woven fabric composited in general, which can also be applied to Leno woven composites as well.

There are many standards available for analyzing the structure-property relationship of Leno fabric specifically for assessing the behaviour Leno woven bags, there are mainly two key standards frequently followed. The first one being, IS 16187 : 2014, prescribed by the Bureau of Indian Standards, which outlines the essential specifications, design and property tolerance limits for HDPE woven sacks in 25 kg and 50 kg capacities, specifically designed for packaging and storing food produce. Similarly, the International standard ISO 23560 : 2015 provides guidelines on the requirement and general characteristics of Leno woven sacks, also intended for carrying agro-based products in 25 kg and 50 kg quantities. Therefor, these two standards play a critical role in ensuring the reliability and performance of Leno woven bags under practical applications.

Problem statement

There is an increased demand for Leno woven sacks globally due to their efficiency in preserving agro-products and its cost-effectiveness, so there is a need to understand the impact of design parameters, materials selection and other factors on Leno sack performance. Although there are established standards, and quite a few research done on heavy-duty Leno sacks (25 kg and 50 kg), the smaller capacity sacks haven't been properly explored. This knowledge gap impedes the development of optimized Leno sacks that meet the specific needs of the agro-based packaging industry, potentially leading to inefficiencies in the supply chain and increased post-harvest losses.

Research Gap

This study aims to fill the gaps by conducting a comprehensive study on lightweight Leno woven sacks, some of the main gaps are mentioned below,

Gap 1: Insufficient work done under low capacity Leno sacks

The present literature predominantly focuses on heavy duty Leno sacks, there were two research works done on bunch covers which had mentioned the use of lower weight Leno woven sacks. Yet there is a lack of real-time testing data on their performance characteristics, which hampers the ability to optimize these designs and performance for specific agricultural applications.

Gap 2: Impacts on mechanical properties and validate testing standards for light-weight Leno sacks

There is a research shortfall on the impact of the design parameter on the properties of lower weight Leno sacks under standardized conditions. Some key parameters like tensile strength, abrasion resistance, bursting strength, impact resistance, stiffness, and bagging behavior needs to be assessed. Also propose and validate testing standards for lightweight Leno woven sacks to ensure consistency, reliability, and safety in their application.

Gap 3: Study of Environmental effects on Leno sacks

Examination of the effects of environmental factors such as UV exposure, moisture, and temperature fluctuations on the durability and performance of these sacks, as this understanding will help in transporting and storing perishable goods under various climatic conditions.

Gap 4: Leno weave fabric reinforced composites

This application of Leno weave mesh fabrics have the potential to offer superior resistance to delamination and improved impact properties in composite materials. However, their complex geometry and crimped yarn arrangement pose challenges in achieving *optimal fiber-matrix bonding and uniform stress distribution*, hence a further study is required in understanding the micro-structural behaviour and the long term performance of such composites.

Work done so far

1. Recruitment of a manpower (Joint the project since August 16, 2024)
2. Contacted to several industries (Contacts supplied by the BIS Authority and contacts searched on internet) for supply of the 1 kg, 2 kg, and 5 kg leno wove bags
3. Procurement of leno woven bags of 5 kg capacity (100 pieces) available locally
4. In-house testing of procured leno woven bags
5. Requested for industrial visit (through email and telephonic conversation) to explore manufacturing process of leno woven sacks

Industry Contacted

S. No.	Industry name	Contact No.	Call response	Mail Response	Remark
1	Formosa Synthetics Pvt. Ltd.	9606975787	Not Attending	Not Respond	-
2	Shalimar Group	9930009300	Not Attending	Not Respond	-
3	Bharat Plastic Industries	9872758108 9876110997	Not Attending	Not Respond	-
4	Kalyani Polymers Pvt. Ltd.	9886480224	Not Attending	Not Respond	-
5	UMA Group	9829600809	Not Attending	Not Respond	-
6	R L Commercial Private Limited	8910305158	Not Attending	Not Respond	-
7	Singhal Industries Private Limited (BIS Licence)	9090919019	Not Attending	Respond	Send catalogue but not attend call and in mail write my marketing team contact with you soon
8	Balaji Packaging	9330859698	Attend	Not Respond	Not deal in 1-2-5 kg
9	VED Industries	9326616645	Not Attending	Not Respond	-
10	V K Agropack	7038850006 9923366006	Not Attending	Not Respond	-
11	Brightflexi International Pvt Ltd.	8242453344	Attend	Not Respond	Not deal in leno bags
12	Vee Kay Treading Co.	9815139922	Meeting done	NA	Materials received

Yellow color leno woven bag

Red color leno woven bag

Figure: Images of 5 kg leno woven bags procured from the local supplier (Vee Kay Trading Co. Jalandhar)

Results

Sr. No.	Property	Method Reference	Value
i	Capacity	-	5 kg
ii	Dimensions (cm)	-	
	(a) Inside Length (cm)	IS 1954	40.7
	(b) Inside Width (cm)	IS 1954	39.2
iii	GSM ($g/m^{2)}$	IS 1964	36.0
iv	EPI	IS 1963	12
v	PPI	IS 1963	6
vi	Avg Breaking strength of fabric (N) (Cut strip method) - Warp way	IS 1969 (Part 1)	444.6
vii	Avg Breaking strength of fabric (N) (Cut strip method) - Weft Way	IS 1969 (Part 1)	281.9

Expenditure Statement

S. No.	Budget Items	Amount (INR)
1	Manpower cost (Salary, 31000.0 per month)	36167.0
2	Consumables: Chemicals, samples, testing glassware, stationery, books, information search from databases	420
3	Equipment	-
4	Travel	500
5	Any other/ Overhead expenses	-
	Total expenditure	37087.0

Reference

1. Brar et al. (2019). Fruit bagging for improving quality of rainy season guava under punjab conditions. *Agricultural Research Journal*, *56*(3), 475-479.
2. Chaudhary, S. N., & Rakshit A. K. (2009) Textiles for packaging, Asian Textile Journal, Vol. 18, No. 5, 64-71
3. Chowdhury, I. R., & Summerscales, J. (2024). Woven Fabrics for Composite Reinforcement: A Review. *Journal of Composites Science*, *8*(7), 280.
4. Leno Weaves, The University of Arizona (1905)
5. Pathak et al. (2016). Influence of bunch covers on appearance and maturity of banana cv. Jahaji under high density planting system. *Research on Crops, 17*(3), 512-516.
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9. Sharma, T., & Alagh, P. (2021). Process and factor analysis in the manufacturing of woven polypropylene packaging textiles. *International Journal of Home Science 7 (2)*, 109-115.
10. Shine W.E and Mckenna A.E. (1930) Leno Weaving and Design, 31-35
11. https://www.factmr.com/report/1203/polypropylene-woven-bags-and-sacks-market
12. https://www.manishflexipack.com/manufacturing-process/index.html

AMAN

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◊ 7206377018aman@gmail.com ◊ +91-7027538416

CAREER OBJECTIVE

To associate myself with an organization where I can learn and grow and obtain enough opportunities to find the practical application of my knowledge and enhance my abilities pertaining to the qualities of an Engineer.

EDUCATION

M.Tech (Textile Engineering and Management) 6.5 SGPA
Dr. B.R. Ambedkar National Institute of Technology, Jalandhar 2022-2024
Research Project- "To Study the mechanical and impact performance of the natural fiber reinforced composites" under the guidance of Dr. Mukesh Bajya

B. Tech (Textile Technology) 77.04 percentage
Panipat Institute of Engineering and Technology Panipat (Haryana) 2019 - 2022

Diploma Engineering 78.00 percentage
Rajeev Gandhi Govt. Polytechnic Narwana Distt-Jind (Haryana) 2016 - 2019

High School 77.80 percentage
Arya Sen. Sec. School Narwana Distt-Jind (Haryana) 2015 - 2016

SKILLS

Advance Knowledge of MS Excel, MS Word and Power Point, Statistical Software Minitab origin and design of experiment, Mathematical Reasoning, Adaptability and leadership, Decision-Making and planning

INTERNSHIP

- One-month Internship in Vardhman Spinning Mill Pvt. Ltd. Baddi (HP) from 10 June 2018 to 10 July 2018
- One-month Internship in Nahar Processing Pvt. Ltd Lalru from 1 July 2021 to 1 Aug 2021
- 10-month work experience as trainee in Anything Skool Pvt. Ltd Karnal as Assistant merchandisers

PROJECTS

- "To Study the Mechanical and Impact Performance of the Natural Fiber Reinforced Composites" under the guidance of Dr. Mukesh Bajya (M. Tech)
- "To Study the Effect of Doubling on Breaker Draw frame" (Internship project)
- "Optimization of Turmeric Dyed Cotton Fabric with Box & Behnken Factorial Design" under the guidance of Ms. Astha Sharma (Assistant Professor) (B. Tech)

ACHIEVEMENTS

- 1st Position in textile department (2016)
- 2nd Position in 1500 mtr (Haryana National Juniors Games 2018)

PERSONAL INFORMATION

- Father's Name- Sh. Sadhu Ram
- Mother's Name- Smt. Parmila
- Date of Birth- 26 Jan 2001
- Languages Known- Hindi, English

DECLARATION

I solemnly declare that the above-mentioned information is true and correct to the best of my knowledge