Final Technical Report

on

DEVELOPMENT OF SUITABLE PRODUCTION SYSTEM FOR NATURAL RUBBER COATED JUTE FABRIC FOR NOVEL END USES (RCJ)

FINAL PROJECT REPORT

ON

The Project: DEVELOPMENT OF SUITABLE PRODUCTION SYSTEM FOR NATURAL RUBBER COATED JUTE FABRIC FOR NOVEL END USES (RCJ)

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SECTION A

General introduction

A.1. Introduction

The exploitation of coated textiles/fabrics for protective clothing, shelters, covers, liquid containers, etc., dates back to antiquity. From ancient history it is recorded that the use of coated textiles was by the natives of Central and South America, who applied latex to a fabric to modify it as waterproof substance. Other materials, viz., tar, rosin and wax emulsions have been used over the years to prepare water-resistant fabrics. For their broad spectrum of properties, rubber and other polymeric materials have become the preferred coatings and now polymer is the essential coating material. Coated fabrics are now in an important place in technical textiles and its manufacturing processes are one of the important technological innovations in modern industry. The properties of a coated fabric depend on the type of polymer used and its formulation, the nature of the textile substrate, and the coating method employed. The approach for natural rubber coating on jute fabric pays attention because both are from natural resource, thereby good ecological balance and no additional carbon footprint. But, there is no exploratory research on ultra-thin coating. Most of the reported works are based on thick coating and lamination which varies from 30 to 50 wt percent polymer content. Fabric coating technology has passed long runway. Due to the versatility of the design of the substrate fabric and coated polymer and subsequent end uses, fabric coating technology exhibits interest in long way in research and industry.

Chronological history of fabric coating:

1742: Germany began art of coating with oil.
1754: U.S. established the first commercial factory for producing oil-coated fabrics.
1791: British patent granted for applying natural rubber to fabric.
1832: Charles Macintosh builds factory in Glasgow, Scotland to produce rubber-coated cloth and started the worldwide Macintosh concept of rainwear.
1838: The Frenchman, Regnault, prepared first vinyl chloride.
1855: British patent granted for fabric coating with pyroxylin.
1890: U.S. produced commercial coating of cellulose nitrate.
1897: American patent rights for coating fabric with pyroxylin granted to Pegamoid Company of Hohokus, NJ (moved to Newburg in 1902 and was purchased by DuPont in 1910).
1927: Union Carbide Corporation manufactured first vinyl in U.S.A.
1931: BF Goodrich Company became second producer of vinyl in U.S.A.
1938-1939: Germany produces first plasticized PVC coated fabrics.
World War II Period: Vinyls used for a multitude of military uses because of rubber shortage.
Post World War II: The research and emergency applications of vinyl products during World War II gains them almost immediate acceptance in major consumer markets, such as automotive and furniture upholstery, wall covering, footwear and apparel and eventual acceptance in many other fields.

The incidence of coating is explained by the science of adhesion bonding. Adhesion of the polymer to the textile substrate is an important aspect of coating technology, especially when the articles are put to dynamic applications. The reported mechanisms of adhesion are as follows:

1. Mechanical interlocking: this mechanism operates when the adhesive interlocks around the irregularities or pores of the substrate, forming a mechanical anchor. A rough surface has a higher bonding area.
2. Adsorption: the attractive forces may be physical, i.e., physical adsorption by van der Waals forces, H-bonding, or chemical bonding (chemisorptions).
3. Diffusion: the adhesive macromolecules diffuse into the substrate, i.e., interpenetration occur at the molecular level. It requires that the macro-molecules of the adhesive and the adherents have sufficient chain mobility and are mutually compatible.

The mostly used man-made fibers for coating are polyester, nylon, rayon, aramid, rayon etc. and natural fibers are cotton and jute. By choosing the right fabric substrate and coating material, the fabric can exhibit desired mechanical properties, such as flexibility over a wide temperature range, good formability without loss of barrier properties, and good tear and tensile strength without significant weight increase. NR has a very uniform microstructure that provides the material with very unique and important characteristics, viz., the ability to crystallize under strain, a phenomenon known as “strain-induced crystallization”, and very low hysteresis. Over the last few years, a number of researchers have been involved in investigating the exploitation of natural fibers as load bearing constituents in composite materials. The use of such lignocellulosic materials has increased due to their relative cheapness, ability to recycle and they can compete well in terms of strength per weight of material. The structure, microfibrillar angle, cell dimensions, defects and the chemical composition of fibers are the most important variables that determine the overall properties of the fibers and polymer-fiber composites. There is a wide spectrum of application for coated fabrics, viz., foul weather protection (clothing comfort, impermeable coating, breathable fabrics), non-apparel coating (synthetic leather, architectural textile, fluid container, tarpaulin, automotive air bag fabric, carpet backing, textile foam laminates for automotive interior, flocking) and hi-tech applications like fabrics for chemical protection, thermochromic fabric, temperature adaptable fabric, camouflage net and metal and conducting polymer coated fabric. This investigation is exclusively for ultra-thin natural rubber latex coating on jute hessian cloth (burlap) suitable for modern eco-friendly packaging, food grain packaging, fashion materials, multipurpose bags, etc. Packaging industry plays an important role in almost all domains of business because of its uniqueness in material, design and texture.

Depending upon the product, the mode of transportation and logistics requirement there are various types of fabrics among which jute based woven fabrics are in an increased rate of demand due to its abundance and as a green resource. However, rigidity and high hydrophilic nature of jute restrict its applications. Effort has been done to modify the overall properties of conventional jute fabrics by an ultra-thin coating with natural rubber (NR) latex by a suitable production system. The key advantages of these novel NR coated fabrics are biocompatibility, minimizing hairiness of fabric surface, smooth surface finish and no rubbery odour.

A.2. Background

Jute is an agricultural crop, which contains basically a lignocellulosic fiber with a complex internal structure and considerable amount of free volume. The specific gravity of jute is ~1.2 and its tensile strength is found in the range 600-900 MPa. Since it is a natural fiber, its properties vary widely and biodegrade over a period of months to year. Its resistance to moisture/humidity is also low. Before the development of synthetic fibers, jute was the only natural fiber for composite products in domestic as well as in industrial sectors apart from its wide usage in packaging sector for food grains, fertilizer, cement, etc. The major reason for switching over from jute to synthetic fiber was ascribed to its brittleness, low resistance to moisture and environmental degradation. To overcome such shortcomings jute was used to be treated/coated with bituminous products which provided a partial success. On the contrary other textile fibers showed good adhesion to both natural and synthetic polymers and such coating caused tremendous improvement of their mechanical and durability properties. For example, nylon and polyester chords coated with resorcinol-formaldehyde resin are excellent materials as carcass in heavy duty rubber tyres and conveyor belts. Such coating makes the chord stronger and provides good adhesion to hydrophobic rubber as well as producing a strong reinforced composite. Natural rubber is a high molecular weight strong hydrophobic viscoelastic polymer, which can be ideally exploited for reinforcing as well as increasing durability of natural fiber like jute. Rubberized fabric is an example for various water proofing applications. Being a potentially strong fiber, if coated with rubber all the shortcomings of jute can be removed and a range of excellent strong and durable products can be made. If coated in a fabric form depending on the coating thickness jute can regain its lost market in flexible packaging of cement, fertilizer as well as food grains. So, this needs an optimized process development for coating of jute fabric by rubber.

A.3. Deliverable

a) Process deliverables

i) Optimized rubber coating composition
ii) Optimized process development for natural rubber coating on jute fabric
iii) Optimized process parameters

b) Product deliverables

Water/moisture resistant, durable, strong and user friendly thin NR coated jute fabric for packaging and fancy goods.

A.4. Scope and objectives

1) Development of production system for NR coated jute products, viz., fabrics for fancy carry bags for shopping, bags for water/wine bottles, packaging material for consumable items, and packaging of agricultural products satisfying different environmental requirements. The rubber coated jute fabric should be adequately flexible and strong enough to meet respective service demands.
2) Preparation of suitable natural rubber coating compositions with functional chemical additives, which can help adhesion bonding with jute fabric as well as increase mechanical and durability properties after curing of the NR coated jute fabric.
3) Evaluation of the properties of NR-coated jute fabrics for improving the functional properties for shopping/carry bags and other applications.
4) Standardization of quality and process parameters for NR coating of jute fabric under industrial conditions.
5) The proposed product should be manufactured either in a rubber-coating unit or in a suitable set-up installed within the premises of a jute mill/JDP unit.
6) To optimize cost of NR compound as well as the NR coated jute fabric so that the development can meet the specialized needs of products at a low cost.
7) To prepare a compendium on industrial trials containing process details as well as a cost analysis for guiding the potential entrepreneurs.

A.5. Work plan

a) Milestones planned for first year
   i) Manpower Recruitment
   ii) Materials Procurement
   iii) Market Survey
   iv) Pretreatment of jute fabric for surface activation and standardization of treatment compositions
   v) Formulation of natural rubber (NR) latex compound
b) Milestones planned for second year
   i) NR latex compounding with additives as per the developed formulation
   ii) NR latex coating of jute fabric, curing, properties evaluation and optimization
c) Milestones planned for third year
   i) Prototype product development and market testing
   ii) Report preparation and dissemination of project findings

SECTION B

Formulation of natural rubber (NR) latex compound

B.1. Formulation of natural rubber (NR) latex compound

Development of suitable NR compound formulation was the initial challenge in this project. Considering the coating requirements and performance, fabric construction, in-situ fabric treatment and commercial stage uninterrupted production, a suitable NR latex formulation has been developed. This comprises of a suitable grade of NR latex, a natural polymer, dispersion aid, curing agent, accelerator and accelerator activator. Details ratio of compounding ingredients is described in Table B1.

Table B1: Formulation of NR latex compound

Compounding Ingredients	Weight (phr)
NR latex	100
Natural polymer	0.2-0.5
Dispersion aid	1.0-2.0
Curing agent	1.0-1.5
Accelerator	1.0-2.5
Accelerator activator	2.0-4.0

This formulation is subject to minor variation depending upon the product category.

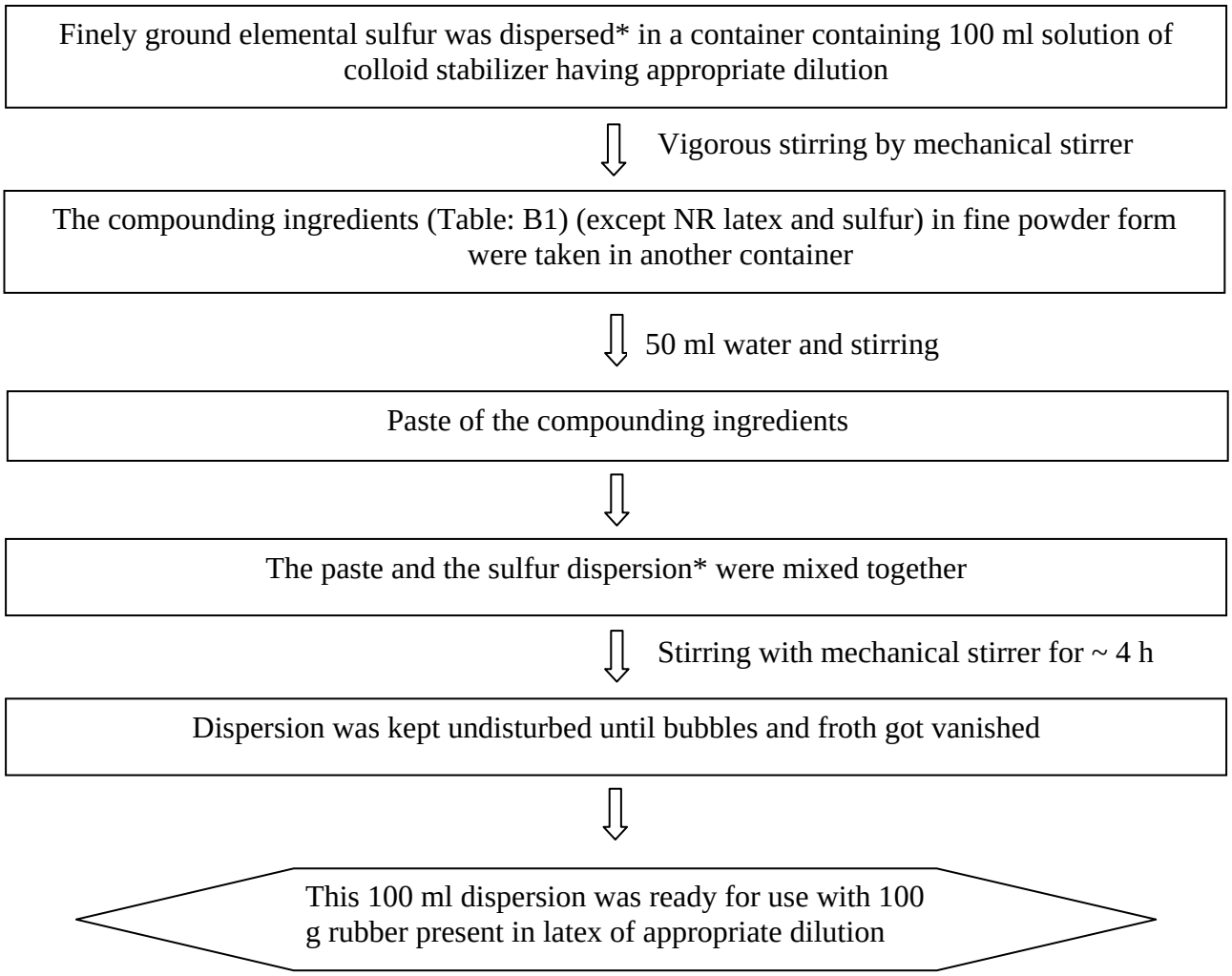
Achievement

- ✓ Formulation of natural rubber compound

SECTION C

NR latex compounding with additives as per the developed formulation

C.1. NR latex compounding with additives as per the developed formulation
Preparation of compound dispersion:



Scheme C1: Preparation of compound dispersion

The above 100 ml dispersion was then compounded with 167 ml NR latex (containing 100 g rubber) using magnetic stirrer.

Achievement

- ✓ Compounding as per developed formulation
- ✓ Monitoring appropriate dilution of NR compound to achieve the target rubber content in coated jute fabric

SECTION D

NR latex coating of jute fabric, curing, prototype product development, characterization, properties evaluation and optimization of rubber coated jute fabric

D.1. NR latex coating of jute fabric and curing

D.1.1. Materials, coating and curing of natural rubber compound on jute fabric

Brown jute Hessian cloth (15X13 construction, 250 GSM) has been used for NR coating purpose.

NR latex: Solid content is 60% (m/m).

Process of rubber coating on jute fabric:

Untreated jute Hessian cloth of 20 cm width and 60 cm length was taken

⇩

The cloth was then dried in an oven at 70°C until it got dried completely

⇩

The cloth was then preserved in a desiccator

⇩

Weight of the dry cloth was taken

⇩

Dipping of dried jute fabric was done in compounded NR latex and the fabric was drawn from another side

⇩

The latex dipped fabric was dried into a hot air circulated oven at 70ºC till moisture content of the fabric was found to be 10 to 15wt %

⇩

The latex dipped jute cloth was then cut into three equal pieces and was placed within a two plate flat mold and the mold was placed between the platens of a hot hydraulic press for simultaneous heating and pressing

⇩

The rubber coated jute cloth was thus cured under pressure (500 psi) at a convenient temperature (100ºC) for 1 min

⇩

The above process was repeated for the remaining two pieces

Scheme D1: Process of rubber coating on jute fabric

The final product was odourless, water repellent and non sticky.
The product texture is as follows:

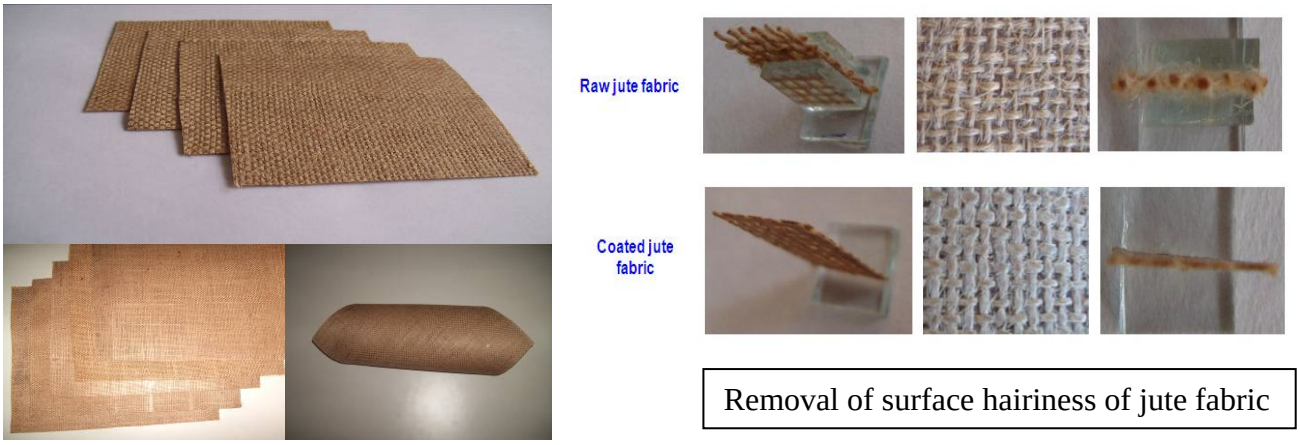


Fig. D1. Texture of rubber coated jute Hessian

Rubber coating compositions were varied to obtain different level of rubber coating on jute fabric. NR coating on jute fabric was done in a wide range, i.e., 0.4 to 15%. Characterization and testing were done for 1-5% rubber coated jute fabrics.

A sample calculation of the rubber content up-taking by the jute fabric during coating is given below:

Table D1: Weight chart of rubber content up-taking by the jute fabric

Description	**Wt. (g)**
Wt. of uncoated jute fabric (after drying)	4.71
Wt. of jute fabric (after NR coating)	4.73

Wt. of only NR coating (4.73-4.71) g. = 0.02 g.

Rubber content in the fabric is 0.42%.

D.2. Properties evaluation and optimization of uncoated and NR coated jute fabric

D.2.1. Moisture absorption

Moisture absorption experiment for NR coated jute fabric was performed according to ASTM D1909. The results are in Table D2:

Table D2: Moisture absorption of NR coated jute fabric

Percent (w/w) NR content	**0**	**1**	**2**	**3**	**4**	**5**
Equilibrium moisture absorption (%)	19	18	14	13	12	11

Equilibrium moisture absorption is decreasing in trend with increasing NR coating percentage. For uncoated (0) jute fabric this value was found to be 19%. In 5% coating, equilibrium moisture absorption is 11%. So, NR coating decreases the tendency to absorb moisture from environment.

D.2.2. Water absorption

Water absorption test on NR coated fabric at equilibrium condition was determined according to ASTM D 751. The results are shown in Table D3:

Table D3: Water absorption of NR coated jute fabric

Percent (w/w) NR content	**0**	**1**	**2**	**3**	**4**	**5**
Equilibrium water absorption (%)	365	281	279	262	254	247

Water absorption of uncoated jute fabric was found to be 365%. From Table D3, it is clear that water absorption is decreasing continuously with increase in NR coating percentage. This study indicates that NR coated jute fabric has better water repellent property compared to that of the uncoated jute fabric.

D.2.3. Tensile strength (TS) and elongation at break (EB)

Tensile strength and elongation at break were measured by universal testing machine, model: H10KS, made by Hounsfield according to ASTM D 638. The results are given in the Table D4.

Table D4: Tensile strength and elongation at break

Percent (w/w) NR content	**0**	**1**	**2**	**3**	**4**	**5**
Tensile strength (MPa)	9.2	12.6	19.9	24.5	26.6	31.3
Elongation at break (%)	7.3	8.5	8.7	11.1	12.8	13.2

Tensile strength and elongation at break of uncoated jute fabric was found to be 9.2 MPa and 7.3%. So, increasing trend of tensile strength and elongation of coated jute fabric with increase in rubber content indicates the better mechanical performance due to better coating adhesion.

D.2.4. Bursting strength

Test for measurement of bursting strength of NR coated fabric was done with diaphragm bursting tester according to ASTM D 751. The test results are shown in Table D5.

Table D5: Bursting strength

Percent (w/w) NR content	**0**	**1**	**2**	**3**	**4**	**5**
Bursting strength (kPa)	1210	1225	1254	1264	1284	1431

Bursting strength test is a good performance test of a fabric when it is under three dimensional load. This value is 1210 kPa for uncoated jute fabric. So, with increase in NR content the fabric becomes more and more strong.

D.2.5. Abrasion resistance

Abrasion resistance test is the excellent experiment on coated fabric to justify the abrasion behaviour of coated fabric during use (especially for bags and packaging materials) either by calculating the weight change or by peeling behavior of the fabric. This study was done using Martindale method according to ISO 12947-3: 1999 by calculating percent mass loss in the range 5000 to 25000 rubs. The results are shown in Table D6.

Table D6: Abrasion resistance

Percent (w/w) NR content	**0**	**1**	**2**	**3**	**4**	**5**
Abrasion resistance (percent wt loss)	4.66-13.69	2.30-12.60	3.82-9.03	3.60-8.20	1.90-6.60	0.90-5.40

Wt loss in the uncoated fabric was found to be 4.66-13.69. From the Table D6 it is clear that gradual wt loss occurred with increase in NR content in the fabric. This is the indication of good adhesion bonding of NR with jute fibrils.

D.2.6. Tear strength

Trapezoidal tear test was performed in accordance with ASTM D 751 to evaluate the uneven tearing behaviour of the NR coated fabric. Table D7 shows the results of tear strength.

Table D7: Trapezoidal tear strength

Percent (w/w) NR content	**0**	**1**	**2**	**3**	**4**	**5**
Trapezoidal tear strength (N)	80	100	102	133	137	150

For uncoated jute fabric tear strength was found to be 80 N. A gradual increasing trend of tear strength with the NR content signifies better performance of NR coated fabric.

D.2.7. Accelerated weathering test

Accelerated weathering test was performed using Atlas Suntest weatherometer instrument according to ASTM D 4355 with an exposure of 25186 kJ/m^2 in a total duration of 120 h. The results are shown in Table D8.

Table D8: Wt loss, TS and EB after accelerated weathering

Percent (w/w) NR content	**0**	**1**	**2**	**3**	**4**	**5**
Wt loss (%)	17.44	11.70	5.94	2.63	2.04	1.98
Tensile strength (TS) (MPa)	6.7	8.1	9.7	10.1	13.9	14.8
Elongation at break (EB) (%)	7.1	8.1	8.5	8.8	9.2	9.4

For uncoated fabric, wt loss, TS and EB are 17.44%, 6.7 MPa and 7.1% respectively. These results indicate that coating of NR improves the stability of the jute fabrics against degradation under UV exposure. Again, more is the NR coating, less is the loss of TS and EB. So, the durability of the NR coated fabric is enhanced by increasing the percentage of NR coating.

D.2.8. Test for microbial degradation

Microbial biodegradation test was performed in a combination of standards G 160 and IS 1623: 1992 with respect to time. Jute fabrics are liable to deterioration by the action of microorganisms. Since they are often stored, transported and used under conditions favorable for the growth of microorganism, various preservative treatments have been developed and their number is constantly increasing.

Two methods for testing jute fabrics for resistance to attack by microorganisms have been prescribed in this standard, namely, mixed culture method and soil burial method. We have performed the second one using a thoroughly compost mix of fertile garden soil, cow dung manure and sand in the proportion of 2:1:1. The test results are reported as percent wt loss with time in Table D9.

Table D9: Biodegradation test

Percent (w/w) NR content		**0**	**1**	**2**	**3**	**4**	**5**
Wt loss (%) in biodegradation test	20 days	57	54	52	50	45	42
	40 days	73	63	60	59	57	55
	60 days	80	75	73	68	66	64
	80 days	84	78	74	73	72	70
	100 days	88	81	77	75	73	71

Biodegradation test in soil burial method shows that the rate of biodegradation is decreased with increase in NR coating percentage. In turn, this test is an indication of eco-friendliness of the natural rubber coated jute fabric.

Physical Change of sample after biodegradation:

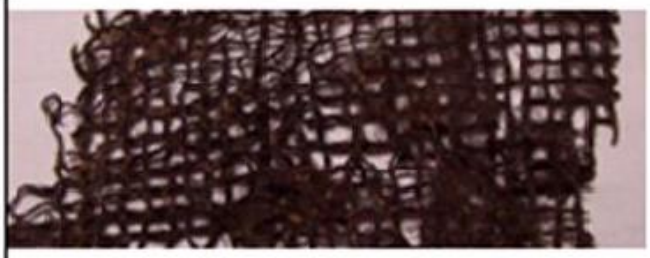
Before biodegradation	**After biodegradation**
 COATED	
 COATED	
 UNCOATED	

Fig. D5. Physical change of rubber coated samples after biodegradation

Observations after partial degradation:

i) Colour	Blackish
ii) Physical Change	Partially brittle in 20 days and almost fully brittle in 40 days
iii) Smell	Compost like

Table D10: Optimized properties of NR coated jute fabric at a glance:

PROPERTIES		Raw jute fabric	Product type-I	Product type-II	Product type-III	Product type-IV	Product type-V
NR content (Wt%)		0.0	0.8	1.8	2.6	3.9	4.7
Equilibrium moisture absorption (%)		19	18.2	13.8	12.6	12.5	11.6
Equilibrium water absorption (%)		365	281	279	262	254	247
Water permeability (%)		206	192	173	168	150	117
Tensile strength (MPa)		9.2	12.6	19.9	24.5	26.6	31.3
Elongation at break (%)		7.3	8.5	8.7	11.1	12.8	13.2
Abrasion loss (wt%) Number of rubs: 5000-25000		4.66-13.69	2.30-12.60	3.82-9.03	3.60-8.20	1.90-6.60	0.90-5.40
Bursting strength (kPa)		1210	1225	1254	1264	1284	1431
Trapezoidal tear (N)		80	100	102	133	137	150
Accelerated weathering Exposure: 25186 kj/m² (120 h)	Wt loss (%)	17.44	11.70	5.94	2.63	2.04	1.98
	TS (MPa)	6.7	8.1	9.7	10.1	13.9	14.8
	EB (%)	7.1	8.1	8.5	8.8	9.2	9.4
Wt loss (%) biodegradation test	20 Days	57	54	52	50	45	42
	40 Days	73	63	60	59	57	55
	60 Days	80	75	73	68	66	64
	80 Days	84	78	74	73	72	70
	100 Days	88	81	77	75	73	71
Limiting oxygen index (LOI of raw NR is 17.15)		18.75	18.19	18.02	17.44	17.05	16.48

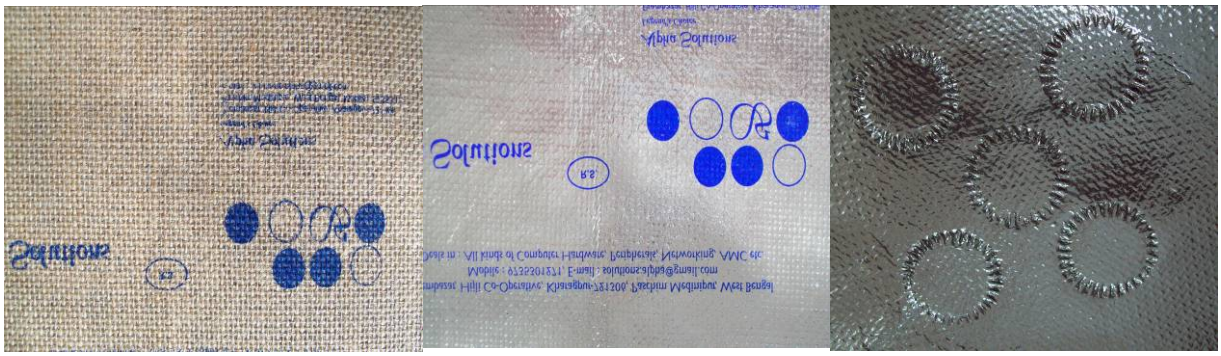
Table D11: Comparative physical property analysis of different polymer laminated /rubber coated jute fabric.

Physical features	One side PP/ PE lamination	One side thick rubber coating	Thin NR coating	Remarks on thin NR coating
Weight increase	15 – 20%	30% and above	1-5%	Thin rubber coating is lighter than other polymer coating
Hairiness	Hairiness remains	Hairiness remains	No hairiness	Non hairy fabrics on rubber coating
Environmental impact	Does not degrade	Does not degrade	85% degradation	Less solid waste and bio safe
Feel	Rough feel	Moderate feel	Smooth feel	Acceptable for fashion goods
Texture	Differ in both sides	Differ in both sides	Evenly textured	Attractive
Smell	Polyolefinic smell	Foul smell	Negligible smell	Removable by processing
Water repellency	One side repellent	One side repellent	Bulk repellent	Repellency depends on amount of rubber coating
Moisture absorbance	One side absorbent	One side absorbent	Bulk resistance	Coating resists moisture
Flammability	High	High	Less than others	Safe to use
Printability	One side printable	One side printable	Both side printable	Flexibility in printing
De-lamination property	Chance of delamination	Chance of delamination	No scope for delamination	Longer life
Aesthetics	Low priority	Low priority	High aesthetic value	Suitable for fashion goods
Flexibility	Low	Low	More	Suitable for flexible goods
Stretch ability	Low	Low	More	Suitable for flexible goods
Drapability	Low	Very low	High	Drapable into various patterns
Stitchability	Moderate	Low	Very good	Trouble free assembling
Abrasiveness	One side as abrasive as plain fabric	One side as abrasive as plain fabric	Less abrasive due to uniform coating	Look of fabric remains good for longer period

Printability, lamination, stitching and hot stamping:

The final product is user friendly in the way of good printability, capability of lamination, outstanding stitching behaviour and excellent capability of hot stamping on laminated NR coated jute fabric.

Fig. D6: Lamination and stitching of NR coated fabric



NR coated jute Hessian | **Metallized film coated jute Hessian** | **Hot stamping**

Fig. D7. Printability and Hot stamping of rubber coated fabric

Achievement

- ✓ Compounded NR latex coating of jute fabric
- ✓ Latex curing at soaked condition in the fabric
- ✓ Prototype NR coated jute hessian development
- ✓ Characterization, properties evaluation and optimization of rubber coated jute fabric
- ✓ Development of the excellent user friendly properties

SECTION E

Cost analysis

Cost analysis based on laboratory R&D:

Table E1: Composition of one sq. m. (250 GSM) coated jute fabric having different NR percent

NR coating wt%	Jute (g)	NR compound requirement (g) for respective coating
1	250	2.53
2	250	5.10
3	250	7.73
4	250	10.42
5	250	13.16
6	250	15.96
7	250	18.82
8	250	21.74
9	250	24.73
10	250	27.78

Table E2: Cost break up of NR latex compound on 100 g dry rubber basis

Compounding ingredient	Price/Kg (Rs)	Price/g (Rs)	Qty reqd (g) for a batch	Price per one batch of compound (Rs)
Dry Natural rubber (NR)	**170**	**0.17**	**100**	**17.00**
Natural polymer	**170**	**0.17**	**0.30**	**5.10**
Dispersion aid	**350**	**0.35**	**1.5**	**0.53**
Curing agent	**25**	**0.03**	**1.5**	**0.05**
Accelerator	**200**	**0.20**	**2.0**	**0.40**
Accelerator activator	**90**	**0.09**	**2.5**	**0.25**
TOTAL			**107.8 g (single batch of compound)**	**23.00**

Table E3: Process cost analysis of one sq. m. rubber coated jute fabrics (250 GSM)

Column I	Column II	Column III	Column IV	Column V	Column VI
***Market price of Hessian (Rs) per m^2**	**Rubber coating (%)**	**Compound qty in g**	**Compound cost (Rs) (@ Rs 230/kg)**	**Compound cost + cost of coating process (Rs)****	**Final cost of rubber coated fabrics: column (I + V)**
22	1	2.53	0.60	0.90	22.90
22	2	5.10	1.20	1.80	23.80
22	3	7.73	1.80	2.70	24.70
22	4	10.42	2.40	3.60	25.60
22	5	13.16	3.02	4.50	26.50
22	6	15.96	3.70	5.50	27.50
22	7	18.82	4.35	6.50	28.50
22	8	21.75	5.00	7.50	29.50
22	9	24.73	5.70	8.50	30.50
22	10	27.80	6.40	9.60	31.60

***Ex-factory price as on August, 2010**
****Process cost is 50% of the compound cost, taking higher side of costing**

Achievement

- ✓ Technically feasible and economically viable NR compound and coating process development

SECTION F

Pilot scale trial

Pilot scale trial of natural rubber (NR) coated jute hessian fabric at M/S KE Technical Textiles Pvt. Ltd., Rupnarayanpur, Kharagpur

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Trial 1. **Date:** 06.02.2011

Name of industry: M/s KE-Technical Textiles Pvt. Ltd., Rupnarayanpur, Kharagpur, West Bengal.

The process of latex dipping comprises of the following steps:

1. Preparation of natural rubber (NR) latex compound
2. Latex dipping and curing unit comprise a combination of the following equipments:

   i) Latex bath (Capacity: 70 liter)

   ii) Roller for raw fabric

   iii) Squeeze rollers

   iv) Hot air blowing oven

   This is the most important component in the total unit. There is a temperature controllable gas fired heating source. Fan is used for circulating hot air inside the oven. There are six guiding rollers, three are at top and three are at the bottom part. The oven is enclosed with heat insulating wall having the bottom part naked and an opening at the top for exiting hot air. There are two different temperature zones, one is close to dipping bath and another is close to the winding roller.
3. Drawing rollers
4. Metering device
5. Winding roller

NR latex compounding was made according to the predefined formulation. This latex with appropriate dilution was kept in the latex bath and used for coating purpose. The hessian cloth was dipped into the latex and was drawn with the help of a guiding fabric through the oven at a speed of 3 m/min and cured at 90°C before the exit zone of the oven. Total length of the coated fabric was measured with a metering device attached with the rolling coated fabric. Finally the finished coated fabric (8 wt% rubber content) was winded on a card board bobbin.

Cost of 5 wt% NR coating of 100 m x 1.3 m, i.e., 130 sq m jute hessian fabric (15 x 13)

Production rate: 180 meter (width: 1.3 meter)/h (i.e., 234 sq m) (variable)
Cost of electricity and LPG consumption per hour for a production rate of 180 m/h:

a) **Electricity consumption** : 6 kWh (2 HP motors: 4 nos)
   Electricity cost: Rs. 45.00/h (Electricity charges: Rs. 7.50/kWh)
b) **LPG consumption**: @6.5 kg/h
   Cost of LPG: Rs. 423.00/h (LPG Price: Rs. 65.00/kg)
   Total energy (electricity + LPG) cost per hour: Rs. 468.00

Total energy cost for coating of 234 sq m jute fabric: Rs. 468.00

Cost of NR coating of 100 meter x 1.3 meter jute fabric, i.e., 130 sq m

Cost of raw materials (NR compound) (A): Rs. 650.00 (@ Rs. 5/sq m)
Cost of energy consumption (B) : Rs. 260.00 (@ Rs. 2/sq m)
Labour (C) : Rs. 26.00 (@Rs. 0.20/sq m)
Total (A + B + C) : Rs. 936.00
Overhead @ 20% of (A + B + C) : Rs. 187.00
Total cost of NR coating of 130 Sq. m. of jute hessian of 250 gsm (15x13): Rs. 1123.00.

Total cost of NR coating of 100 Sq. m. of jute hessian 250 gsm (15x13): Rs. 864.00.

So, cost of NR coating for one square meter is Rs. 8.64.

Comment:

Cost of coating will be further reduced by:

a) Increasing the speed of coating by a more efficient machine

b) Bulk procurement of raw material

Sequential views of pilot trial of NR coating on jute hessian fabric

RAW JUTE FABRIC

JUTE FABRIC DIPPING IN NR LATEX

CONTINUOUS DRAWING OF JUTE FABRIC TROUGH COMPOUNDED NR LATEX

SQUEEZING OFF NR DIPPED FABRIC

DRAWING OF FABRIC THROUGH OVEN

INSIDE VIEW OF OVEN

COATED AND CURED FABRIC FROM OVEN

FABRIC METERING

FINAL NR COATED JUTE FABRIC

Trial 2. **Date:** 27.06.2011

Second trial was carried out on different categories of jute fabrics on 27.06.2011 in the same factory in presence of the delegates came from National Jute Board, Kolkata.

Photographs on field trial held on dated 27.06.2011








Achievement

- ✓ Pilot scale trial of NR coating of jute fabric is successful
- ✓ The rubber coating process appears to be viable

SECTION G

Summary and achievement

Summary:

Thin coating of rubber on a particular grade of jute fabric has been done by varying the rubber concentration. All the performance tests of coated fabric have been carried out. The following findings have been drawn at the end of this project:

A) Process development (Batch process) and product testing

- For this particular project 250 GSM jute Hessian fabric was procured from market and used for the development of rubber coating process.
- Commercial grade of natural rubber (NR) latex (having 60% solid content) and laboratory grade compounding ingredients were used for coating on jute fabric.
- Optimized the NR latex compound formulation varying the proportion of different ingredients in the batch.
- NR latex compounding with different auxiliary chemical ingredients was done as per the optimum compound formulation.
- Jute fabric was dip coated with the compounded latex for a specific duration in a laboratory scale.
- This dipped fabric was dried in an oven at a temperature below the rubber curing temperature.
- The dried rubber coated fabric was cured in a hot press applying light pressure.
- Finally very thin layer coating of natural rubber on jute fabric has been achieved.
- Upto 5 wt% NR coating has been done with optimized process parameters and optimized compounding formulation.
- Mechanical, weathering, biological, thermal and other performance tests of NR coated jute fabric have been done. Few of these tests were carried out in National Test House (NTH), Indian Institute of Packaging (IIP), Regional Laboratory of Textile Committee (Ministry of Textiles).
- Foul odor of rubber coating on jute fabric has been removed by using a suitable additive during latex compounding.
- Jute fabric samples having varied rubber coating were developed and shown to different traders and manufactures through M/S Roots and Yards, Kolkata for market awareness.
- Few industries approached for a field trial.
- Two times field trial have been done in M/s KE Technical Textiles Pvt. Ltd., Rupnarayanpur, Kharagpur.

B) Market survey

Detail market survey/need assessment on this project has been accomplished by M/s Roots and Yards, Kolkata, a professional organization in this domain.

Achievement:

a) Achieved a very thin layered natural rubber coating on jute fabric in a cost effective manner
b) Improvement in the weather resistance properties of coated jute fabric
c) Removal of hairiness of jute fabric
d) Substantial reduction in abrasion loss of jute fabric
e) Good drape property of jute fabric
f) Improvement of mechanical properties (tensile, bursting strength, tear strength)
g) Removal of foul smell of rubber
h) NR coated jute fabric became printable and stitchable
i) Lamination can also be done on NR coated jute fabric
j) Biodegradation rate of NR coated jute fabric was almost unaffected compared to uncoated jute fabric

The process of coating is feasible at industrial level with minor modifications of machineries and techniques which will depend upon the area of application.

SECTION H

Market survey & Need Assessment By M/S Roots & Yards, Kolkata

H.1. Background

Jute and Jute Textiles

The Jute industry occupies an important place in the national economy. It is one of the major industries in the eastern region, particularly in West Bengal. Jute, the golden fiber, meets all the standards for 'safe' packaging in view of being a natural, renewable, biodegradable and eco-friendly product.

The total area under jute cultivation in India varies between 6.38 lakh hectares to 10 lakh hectares, which is the highest in the world. This constitutes 0.6 per cent of the total area sown during the Kharif crop season. There is no significant change in area under jute cultivation since 1992-93 onwards.

Jute is an important cash crop, which is as an intercrop before paddy transplantation in most parts of the country. This has significant contribution to the income of a large section of rural households. Production of raw jute and mesta has witnessed a steady increase since 1951-52. It was 13.2 lakh M.T. in Jute year 1990-91 (July-June), which rose to 14.76 lakh M.T. in the Jute year 2008-09.

Globally, India is the largest producer and second largest exporter of jute goods and this sector supports the livelihood of about 40 lakh farm families, and provides direct and indirect employment to 4 lakh workers. There are 78 Jute mills in the country. Of these 61 are in West Bengal, 3 each in Bihar and Uttar Pradesh, 7 in Andhra Pradesh, and one each in Assam, Orissa, Tripura and Chhattisgarh.

Exports

The exports of jute and jute products during current financial year 2009-10 (upto October 2009) are estimated at US$ 1 billion. Cumulative exports during April-October 2009 are of the order of 75,999 M.T.

The use of coated textile for protective clothing, shelters, covers, liquid containers, etc., dates back to antiquity. Historically, the earliest recorded use of coated textiles was by the natives of Central and South America, who used to apply latex to a fabric to render it waterproof. Other materials such as tar, resin and wax emulsions have been used for the years to prepare water resistant fabrics. Due to their vast superior properties, rubber and other polymeric materials have become the preferred coatings. Today coated fabrics are essentially polymer coated textiles. Advances in polymer and textile technologies have led to phenomenal growth in the application of coated fabrics for many diverse end uses.

Textiles are made impermeable to fluids by two processes, coating and laminating. Coating is a process of applying a viscous liquid (fluid) or formulated compound on a textile substrate. Lamination consists of bonding of pre-prepared polymer film or membrane with one or more textile substrates using adhesive, heat or pressure.

Several methods of production are used to manufacture a wide range of coated or laminated fabrics. Broadly they are spread coating, dip coating, melt coating and lamination. Paste or

solutions are required for spread coating, solutions are required for dip coating and solid polymers such as powders, granules and films are required for melt coating and lamination.

H.2. Use of rubber in jute textile application

H.2.1. Uses

The use of rubber is widespread, ranging from household to industrial products, entering the production stream at the intermediate stage or as final products. Tires and tubes are the largest consumers of rubber. The remaining 44% are taken up by the general rubber goods (GRG) sector, which includes all products except tires and tubes.

Uses of latex coated fabric

- Latex is usually blended with other fibers and it is used as foundation garments
- Latex mattress pads
- Latex gloves
- Latex wrist cuffs and integral socks
- Latex armor
- Latex soles
- High fashion bags

H.2.2. Coating jute fabrics with natural rubber latex

Latex coated fabric has high waterproofing and dry cleaning property. It is resistant to heat and light.

H.2.3. Characteristics of latex coated fabric

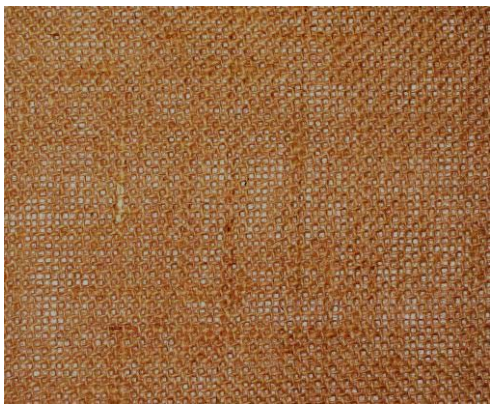
- It is waterproof.
- It has dry cleaning property.
- It is heat and light resistant.

H.2.4. Physical properties of coated fabrics

General Characteristics: Tensile strength, elongation, adhesion, tear resistance, weathering behaviour, microbial degradation, yellowing.

H.2.5. Coating methods

Roll coating, dip coating, transfer coating, rotary screen printing, calendaring, hot melt coating.



H.3. Current approaches to natural rubber coated jute fabrics

The novel approach of coating involves

a) Use of natural rubber in latex form
b) Very thin invisible NR coating maintaining the original texture of jute fabric
c) Homogeneous coating of each individual jute fibrils
d) Production process using a combination of conventional machineries with few modifications so that the final manufacturing process becomes cost effective at the industry level.

H.4. Natural rubber latex/dry natural rubber suppliers

1. Harsukhram & Son

Contact	Status of organization
101/15, Thakkar Bappa Colony, S.G. Barve Marg, Chembur, Mumbai, Maharashtra-400071 Phone: 91-22-25223869/25273376, Fax: 91 22-25223869 Mobile: 91-9821006949/9321730999	Supplying and exporting of latex that includes natural latex, industrial natural latex and footwear natural latex.

2. Gurumurthy

Contact	Status of organization
No:54/27, Amman Koil Street, Athipet Kuppam, Chennai Phone: 91-44-26250820, Fax: 91-44-26247722	--

3. Alpha Elastomer

Contact	Status of organization
65/2, Rama Mandir Road, Magadi Main Road, Kaveripura, Kamakshipalya, Bangalore 560079. Phone: +91-80-23480715, Fax: +91-80-23480715 Website: http://www.alphaelastomer.com/	--

4. Industrial Rubber Products

Contact	Status of organization
No. 13, New No. 25, Mooker Nallamuthu Street, Chennai 600001 Phone: 91-44-25266834, Fax: 91-44-25266834 Contact Person: Taher Z Habib, Mobile: 09840068634	--

5. Innovative Sleep Systems Private Limited

Contact	Status of organization
23 Banaswadi Main Road, Bengaluru, Karnataka - 560 039 Phone: 91-80-25450952, Mobile: 91-9448289791	Retailer of natural latex including natural latex sheets.

6. Sperry Plast Limited

Contact	Status of organization
B. M. House, H-88 A, Kirti Nagar, New Delhi 110 015 Phone: 91-11-41424379, Fax: 91-11-41424375	Engaged in manufacturing all types of transparent natural latex.

7. Pameric Exports Inc.

Contact	Status of organization
Pothen Joseph And Sons Building, 5th Cross Road Willingdon Island, Cochin, Kerala - 682 003 Phone: 91-484-2666159, Fax: 91-484-2666643 Mobile: 91-9847050643	Manufacturer and supplier of rubber and synthetic rubber products that includes natural rubber sheet and rubber latex.

8. The Cottanad Plantations Limited

Contact	Status of organization
P.O. Box-1117, Beach Road, Calicut, Kerala - 673 032 Phone: 91-495-2765261, Fax: 91-495-2768687	Exporters and supplier of natural rubber latex and natural latex gum.

H.5. IIT's major work under the project: Development of Suitable Production System for Natural Rubber Coated Jute Fabrics for Novel End Uses.

H.5.1. First stage

a) Development of production system for NR coated jute products, viz., fabrics for fancy carry bags for shopping, bags for water/wine bottles, packaging material for consumable items and packaging of agricultural products are satisfying different environmental requirements. The rubber coated jute fabric should be adequately flexible and strong enough to meet respective service demands.
b) Preparation of suitable NR coating compositions with functional additives, which can help adhesion bonding with jute fabric as well as increase mechanical and durability properties after curing of the NR coated jute fabric.
c) Pretreatment of jute fabric and coating with the developed NR coating composition.
d) Evaluation of the properties of NR-coated jute fabrics for improving the functional properties for shopping/carry bags and other applications.

e) Standardization of quality and process parameters for NR coating of jute fabric under industrial conditions.
f) The proposed product should be manufactured either in a rubber coating unit or in a suitable set-up installed within the premises of a jute mill/JDP unit.
g) To optimize the cost of NR compound as well as the NR coated jute fabric so that the development can meet the specialized needs of products at a low cost.
h) To prepare a compendium on industrial trials containing process details as well as a cost analysis for guiding the potential entrepreneurs.

H.5.2. Study of product specification as per the need of customer

Product specification is depicted in Table H1.

Table H1: Product specification as per the need of customer

Product line	End user	Specification as per the need of customer
Packaging	Agriculture sector, Furniture sector, Linoleum packaging	1. Rigidity (tea packaging) 2. Flexibility 3. Resistance to weather (anti-termite, anti-fungal, less moisture absorbing etc) 4. Food grade packaging for food grain packaging 5. Odorless 6. Cost effective 7. Light weight to reduce transportation
Fancy jute product	Households, swimmers, students, children, corporate & govt. offices, common people	1. Color 2. Texture 3. Luster 4. Look 5. Durable 6. Odorless 7. Comfort to use 8. Cost effective
Upholstery	Households, fancy and decorative product manufacturer	1. Non-toxic 2. Color 3. Design 4. Durable
Automotive	Automobile manufacturer	1. Durable 2. Anti-termite and anti-fungal 3. Water repellent 4. Less water and moisture absorbing 5. Cost-benefit analysis 6. Technical compliance to the end use 7. Light weight
Furniture	Households, offices, hospitals, automobile sector, aviation, railway	1. Durable 2. Anti-termite and anti-fungal 3. Cost-effective 4. Light weight
Building & Construction	Civil engineers, irrigation, forest department, private & public houses	1. Technical compliance to the end use 2. Resistance to weather (anti-termite, anti-fungal, less moisture absorbing etc) 3. Cost effective-comparable with the other fibers
Canvas	All sectors to protect from weather for covering a broad area, mines	1. Durable 2. Light weight 3. Price to volume analysis

H.5.3. Specifications of rubber coated jute fabric based on laboratory investigation

Specifications of rubber coated jute fabric developed at laboratory level are shown in Table H2.

Table H2: Laboratory scale specifications of 4% rubber coated jute fabric

Formed fabric size (cm x cm)	20 x 20
Hessian structure	15 x 13
Rubber application	Dipping process
Cure type	Press cure
Jute rubber ratio (wt/wt)	24/1
Final wt (g)	260.42
Press size (cm x cm)	30 x 30
Press Temp (˚C)	125-135
Pressing time (min)	1
Cure pressure (500 psi)	1

H.5.4. Advantages of thin NR coated jute fabrics

The rubber coated jute fabrics are adequately flexible having required strength for respective demands. The advantages of the thin NR coated jute fabric are:

a) Mechanically strong and flexible

b) Increased resistance to moisture and water absorption

c) Reduced surface hairiness of fibers

d) Increased resistance to environmental deterioration

e) Bacterial and fungal resistance

f) Longer life

g) Multidimensional uses

h) Green resource with a strong focus on Clean Development Mechanism (CDM).

H.5.5. SWOT Analysis

SWOT Analysis done for the NR coated Jute fabric with thin layer shown in Table H3.

Table H3: SWOT Matrix of Rubber Coated Jute Fabric

Strength (S)	**Weakness (W)**
1. Eco-friend technology 2. Govt. subsidy on agro-business 3. Substantial weather, abrasion and termite resistance properties 4. Exclusive availability of jute and natural rubber	1. Initial high R & D cost 2. Improper market access 3. Improper training in design and value addition 4. Improper governmental interventions & information sharing.
Opportunities (O)	**Threats (T)**
1. Global consciousness of eco-friend technology 2. Continuous growth of packaging and garment sector	1. Synthetic fiber 2. Threat from Plastics & Petrochemical sector

H.6. Rubber laminating machines suppliers

1. Tunik Products

Contact	Status of organization
108, Shanti Industrial Estate, S N Road, Mulund, Mumbai - 400 080, Phone: 91-22-25684887, Fax: 91-22-25684887.	Manufacturers of all kinds of laminating machines.

2. Janta Paper Mart

Contact	Status of organization
2573, Chawri Bazar, New Delhi - 110 006 Phone: 011-23265832, Fax: 011-27136431	Deals in lamination machine, smartcard making machines and smartcard laminating machines.

3. Web Flex Machines

Contact	Status of organization
202, Apollo Chambers, Mogra Lane, Old Nagardas Road, Andheri (East), Mumbai Phone: 91-2228352813, Fax: 91-2228224767.	Manufacturers of machineries for printing, rotogravure printing machine, flexographic machines and laminating machines.

4. Rhine Polymers

Contact	Status of organization
5/1 2nd Cross, Lalbagh Road, Bangalore Phone: 080-22133206, Fax: 080-41496767.	The importers and distributors of Graphtec cutting plotters, cold laminating machines.

5. Partap Machine Tools Private Limited

Contact	Status of organization
72, Virwani Industrial Estate, W.T. Highway, Goregaon East, Mumbai - 400063 Phone: 91-22-28728766 Fax: 91-22-28750931.	Exporters of automatic packaging machines, corrugated packaging machines, fully automatic & semi automatic paper cutting machine, multi-laminating machines and sheet pasting machines.

6. Expert Industries Pvt. Ltd.

Contact	Status of organization
274-C, Kiadb Industrial. Area, Bommasandra, Anekal Taluk, Bangalore 560099, Karnataka Phone: 91-80-7832690/7833177/7833259.	Paper, film and foil converting machinery. Rotogravure printing machines - for flexible packaging, decorative & speciality applications. Laminating machines.

7. New Empire Industries

Contact	Status of organization
196, Focal Point, Amritsar Phone:911832701609/2588991/2582927/2511 241(R), Fax: 911835098337/2582927.	Manufacturers of paper varnishing, UV coating machine, plain laminating machine, UV curing machines.

H.7. Market survey

H.7.1. Marketing research objective

Industries look for a change and substitution for the plastic lamination on jute fabric for several diversified uses. Those plastic laminated jute fabrics have their own limitation and specific use. Apart from that specific use there could be a novel application area of thin rubber coated jute fabric especially in bags for export market. The plastic laminated bags have specific dimensional stability but it loses the drapability of a fashion bag. Plastic laminated bags have, therefore, captured mid line shopping bag market. On the other hand thin rubber coated bags will enter into the haute couture line of business around the globe. Haute couture bags are draped and stitched in complicated way, as to achieve the designer look. Non-laminated jute fabrics give the required drape but fail to give the necessary fall after stitching.

We found a scope in marketing of thin laminated jute fabric technology and it is a good experience to interact with the companies and exporters in the high fashion line of application of thin coating of natural rubber. A number of exporters have taken interest in this line only.

The goal of market survey is to identify the potential customer/client base for new product and product design accordingly. Correctly prepared surveys can give a comprehensive view of the target market. This information will be of tremendous help to begin to compose the business plan.

Goal of the proposed product:

Conducting the survey to identify the potential customer (end user, manufacturer and trader) of natural rubber coated jute fabric for novel uses, viz.,

i) Designer bags

ii) Shopping bags

ii) Bags for water/wine bottles

iii) Packaging material for consumable items

iv) Packaging sacs for agricultural produce

Potential customer base / demographics:

1. Sea shore
2. Shopping mall
3. Fashion house
4. Agro sector

Meeting of PI with Exporter

H.7.2. Market analysis and assessment

The following companies have been interacted and good amount of feedback has been received. The report of the assessment has been analyzed in three consecutive columns. First column says the first reaction after the presentation given. The rejoinder column signifies the answer of the company towards product and future projects. The third column is consequential to the previous two and comments made by the company.

At the end, most plausible companies are listed in accordance with their wish for Field Trial in bulk scale in their factory premises. Market is assessed as per the demand from the end buyers. The jute bag exporters are interacted with the end buyers in a regular basis. So we interacted with the most innovative jute bag export companies who were willing to hear the new technological advancement towards new product developments.

NR coated jute fabric has a particular demand in the market abroad. It is observed from the laboratory based costing that 1 - 10 % thin NR coat will offer good costing pattern to the exporters, thus it is assumed that the exporters followed by the jute mill owners and the diversified sector in jute business may take interest for the technology developed by IIT Kharagpur under their project "Development of Suitable Production System for Natural Rubber Coated Jute Fabrics for Novel End Uses (RCJ)".

Roots & Yards, Kolkata conducted the survey amongst jute mills and the diversified sectors. It is observed that the companies took interest to see the further development towards implementation in project form. It is hoped that trial run of the product in commercial scale would take place in the interested companies. After the trial run, future prospect could be figured out and future plan could be sorted out by the companies that were surveyed.

List of companies that we visited, their feedbacks and advice are laid below.

1. MNR Exports Pvt. Ltd.

Contact	Assessment of company	Rejoinder	Remarks of Roots & Yards (R & Y)
Doshi Niketan, 1/3A, Ballygunge Place East, Kolkata -700 019. Phone: 91-33-2460 1938, 2460 1940 Contact: Mr. Nilesh Doshi. Mobile: +91 9831095989	Showed interest in rubber coated fabrics	Interested in PP lamination substitute	In regular contact. Showing prototype samples. Sharing thoughts and ideas.

2. National Rubber Works

Contact	Assessment of company	Rejoinder	Remarks of R & Y
171/A, Mahatma Gandhi Road, 1st. Floor, Kolkata - 700 007. Phone: 91-33 2241 0505 Email: info@nationalrubber.net Web: www.nationalrubber.net	Took interest in NR coated fabrics. Demand for NR coated fabrics as substitute of PP lamination.	Samples showed. Concern about the PP. Looking for new things.	In regular contact. Motivating towards. NR coated fabrics. Arranging IIT visit.

3. Glory Polytex

Contact	Assessment of company	Rejoinder	Remarks of R & Y
226, Rabindra Sarani, Kolkata - 700007. Contact: Mr. Arun Kumar Agarwal (Manager) Mobile: 919830028913	Took interest in NR coated fabrics. Demand for NR coated fabrics as substitute of PP lamination.	Concern about the NR's performance and price. Trying for PP's substitute.	In regular contact. Motivating towards rubber coated jute. Sharing ideas for export quality.

4. Richie Bags & Fashions Pvt. Ltd.

Contact	Status	Assessment of company	Rejoinder	Remarks of R & Y
"ARYA MANSION" 10th Floor, Room No.1003, 6A, Raja Subodh Mullick Sq., Kolkata - 700 013. Phone: 91-33 2225 1949 / 1950 Fax: 91-33 2225 1833 Email: richiebags@satyam.net.in Website: www.richiebags.com Contact: Mr. R.B. Lahoti Mobile: 91 98300 57951	Manufacturer & exporter of jute, cotton bags & different fashion accessories.	Have interest in rubber coated fabrics. Rubber has to compete with PP. Concern about bio-degradation	Sharing major issues of rubber coating. Concern about market of NR coated fabrics.	Showing samples. Giving feedback from market.

5. Ashoka Exports

Contact	Assessment of company	Rejoinder	Remarks of R & Y
110, Dharamtalla Road, Ghusuri Howrah-711 107, West Bengal. Phone : 91-33 2655 7059, 3252 5850 (Extn. 22) Fax: 91-33 2655 3908 E-mail: info@ashokaworld.com	NR is their concern. Liked the thin layer coated samples.	Asked the pros and cons of the product. Spoken about the merit of the fabrics.	Company seems responsive. May look for technology. Likes to come into project.

6. Sunil Enterprises

Contact	Status	Assessment of company	Rejoinder	Remarks of R& Y
31 Ganesh Chandra Avenue, 4th floor, Kolkata - 700013. Phone : 91-33-2225 1711/1712 Fax: 91-33-2225 2098 Contact: Mr. Sunil Kumar Goel. Cell: 9198300 – 52386 Email: sunilkbg@vsnl.com	Manufacturing and export of jute, canvas & velvet designer bags having in-house production facility.	Took good interest in the product line.	Like to see more samples to show buyers. Price shall not be major factor.	Interest in trading but not manufacturing. Interest in designer bags. Want bulk samples.

7. AI Champdany Industries

Contact	Status	Assessment of company	Rejoinder	Remarks of R & Y
25, Princep Street, Kolkata - 700 072. Telephone: 91-33-22377880-85 / 2225 1050 /7924 Fax: 91-33-22363754 /22 Email:cil@ho.champdany.co.in Contact: Nirmal Pujara, Executive Director (Marketing), Cell: 9831016405	Wellington Jute Mill is modern to produce diversified jute products aimed at export with a production capacity of 100 tones/day. AI Champdani is in flax, ramie, viscose and wool spinning along with jute.	Concerned about demand of NR coated fabric worldwide. Concerned about eco friendly fabrics.	Wants to see prototype products with proper pricing.	Focused but regular interaction is required. May open room for trial run. Need technology and product service.

8. Birla Corporation Limited (BCL)

Contact	Status	Assessment of company	Rejoinder	Remarks of R & Y
Birla Building 9/1, R. N. Mukherjee Road, Kolkata-700 001. Phone : 91-33-2213 0379/1680, 2248 0135, 3022 7200 Fax: 91-33-22482872/ 7988 E-mail : coordinator@birlacorp.com Contact: D C Patni, Vice President (Export), Cell: 093314 31287.	BCL have modern spinning technology, skilled workforce. Their product range is jute yarn, floor & wall covering, Leno Hessian, decorative fabrics, nursery cloth, scrim, jute carpets, non-woven jute felt, hydrocarbon-free bags/cloth, D.W. canvas carpet backing cloth, hessian cloth/bags, sacking bags/cloth.	Liked technological development. Have quality thoughts for modifications. There is export demand.	Shall go into diversification. Shall enjoy getting PP substitute in good cost break up.	May ask for technology. May work on pricing. Have plan for other uses.

9. Ganges Jute Pvt. Ltd.

Contact	Status	Assessment of company	Rejoinder	Remarks of R & Y
Chatterjee International Centre 33A Jawarharlal Nehru Road Kolkata 700 071. Tel.: 91-33 2227 4954 Fax. 91-33 2227 4955 E-mail: info@angesbags.com Contact: Ashwini Kariwala, E.D. Cell: 098309 20341	Leading manufacturer and exporter of jute products from Eastern India, e.g., Anges Bags, which is the fashion bags division of the company.	Liked samples. Discussed application area.	Involved the project people to brainstorm. Like to see further development. Needs samples to show buyers.	They may come as major taker. Shall diversify.

10. Ecoline Exim Pvt. Ltd.

Contact	Status	Assessment of company	Rejoinder	Remarks of R & Y
8 G.C. Ghosh Road, Kolkata - 700 048. Tel : 91-33-25224417, 25224418 Fax : 91-33 25224416 Email: info@ecoline.net.in Contact: Saurabh Saraogi, Director, Cell: 09830035648	A vision to produce environment friendly products. All manufacturing take place at one place under skilled technical supervision.	Liked the product. Wants to see more diversified products with NR.	Expressed interest to start plant. Had meeting with the PI of the project in their office. Shared technical views with the PI.	Interested in the products and project. Keeps contact with R & Y. Have land and capital to invest.

11. Jutex India Pvt. Ltd./Jute-O-Tech Pvt. Ltd.

Contact	Assessment of company	Rejoinder	Remarks of R & Y
11 Shambhu Chtterjee Street Kolkata-700 007. Phone: 033-32938683, 033-2581 8123 Contact: Mr R C Singhal, Cell: 098305 90693	Liked the products May keep in the retail line if supply is assured. Have doubt about supply.	Interested in plant at later phase. Interested in NR supply. Interested in rubber processing. Seeing scope of business.	Has good sales of jute fabrics in bulk. Good contact with mills. Keeping in touch.

12. APL Polyfab Pvt. Ltd.

Contact	Assessment of company	Rejoinder	Remarks of R & Y
5, Dr Rajendra Prasad Sarani, Kolkata– 700 001. Phone: 033-2230 5125 Contact: Mr Mani Almal, MD Cell: 09831010876 Email: renotexjute@vsnl.net, polyfab@vsnl.com Brands: Polyfab – Toepuff counter, Renotex – Jute Insole Board	Takes interest in modification of the present development. Have plan application in shoes. May take the technology. Concern about NR use.	Came to IIT for right hand information about products. Seen the PI in his factory to give presentation. Have plan to diversify. Have shared views on future prospect.	Keeping regular contact. Giving updates. Trial may take place in his factory. Seems good future.

13. Kadambari Mercantile Pvt. Ltd.

Contact	Status	Assessment of company	Rejoinder	Remarks of R & Y
519/1 G.T. Road, Room No. 2, 2nd floor, Howrah - 7111 01, West Bengal. Phone: 91-33 2641 2079 Fax: 91-33 2638 0409 Email: info@bagsplanet.com Contact: Mr. Mukesh Goyal. Cell: 91 9903137942	Manufacturer and exporter of quality bags and fashionable items, e.g., dyed and printed jute bags, canvas bags, beach bags, hand bag, summer bags, evening bags, tote bags, non woven bags, calico bag, wine bag, bottle bags, apron, gloves, scarves, bandana and fabrics, etc.	Took outstanding interest. Liked to get associated with project.	Like to invest in NR based textiles. Trying to find PP lamination substitute.	Giving updates of development. Liked to come to IIT.

14. Gloster Jute Mills Limited (GJML)

Contact	Status	Assessment of company	Remarks of R & Y
21, Strand Road, Kolkata - 700001. Phone: 91-33 2230 9601 Fax: 91-33 2210 6167 91-33 2231 4222 Email: info@glosterjute.com	Manufacture hessian, sacking fabrics, canvas & tarpaulin, chemical treated fabrics, woven flat bed carpet.	Less interest in fabrics.	1. Satisfied in regular line 2. Can come after price assurance 3. Can come after product trials

15. Ashim Kar & Industries Pvt. Ltd.

Contact	Status	Assessment of company	Rejoinder	Remarks of R & Y
BE 380, Sector I, Salt Lake City, Kolkata 700 064. Ph: 33-23210554/ 23210555 Fax: 91-33-23342434/23210556 Mobile: 919831182760 Email: ashimjute@vsnl.com	Equipped with the State-of-the-Art technology, viz., latest jute yarn and fabric dying machines, automatic driers, power looms, handlooms, sewing machines, and printing machines, well-equipped laboratory, silkscreen printing and heat-transfer technology. Manufacturing capacity: 30,000 bags/day.	Liked the sample. Price point was major concern. Their de-haring is more effective.	Price of rubber coat is biggest issue. Adhesiveness is biggest difficulty for shipment and logistics.	Have required set up for diversification. Interested to go for trial.

16. Camilla International

Contact	Status	Assessment of company	Rejoinder	Remarks of R & Y
Shilpangan, Unit 203 & 204, Block LB-1, Sector 3, Salt Lake, Kolkata – 700098. E-mail:info@earthbags.com Ph: 91-33-2335 6161 / 9830021006 Fax: 91-33-2335 5487 Contact: Anurag Himatsingka Cell: 98300 21006	14 years experience in manufacturing jute shopping bags. Jute bags accounting for 100% of the turnover of the company.	Interested in NR coated fabrics. Looking for new products. Have land and capital to invest.	Much interest in development. Have plan to diversify.	Keeping regular contact. Interested in rubber products.

17. Kamarhatty Company Limited

Contact	Status	Assessment of company	Rejoinder	Remarks of R & Y
16-A, Brabourne Road, 8th Floor, Kolkata – 700001. Phone: 91-33-4021 1900, 91-33-4021 1901 Fax: 91-33-2221 5887 Email: jute@kamarhatty.com Contact: S K Agarwal	The Company has high standards of quality at all levels. Meeting the challenges of a fiercely competitive market.	Interest in NR coated fabrics. Have unit for lamination. Wants samples. Concern about PP threat.	Needs bulk samples. Have plans to diversify. Look for PP/ PE substitute.	Keeping regular contact. Updating with recent developments. Trial can be done. No immediate plan to start project.

18. Dalhousie Jute Company

Contact	Assessment of the company	Rejoinder	Remarks of R & Y
Mody Building, 27, Sir R. N. Mukherjee Road, Kolkata 700 001. Phone: 033-2248 0166 Fax: 033-2248 1922, 033 2243 5607 Email: ho@heilindia.com Contact: Mr Bhojgarhia	Good response to quality. Not be able to sell in domestic market. Have export potential. No immediate plan for diversification.	Good market base for new product line. Advised for diversified sector. Interested to come to project at later phase.	Maintain regular contact. Updating with new development.

19. Ludlow Jute & Specialties Ltd.

Contact	Status	Assessment of company	Rejoinder	Remarks of R & Y
6, Little Russell Street, 4th Floor, Kolkata - 700 071. Phone: 91-33 2283-9081/82/83 Fax: 91-33-2283-9078/4503 Website**:** www.ludlowjute.com Email**:** ludlow@giascl01.vsnl.net.in Contact: Devendra Kumar Bubna (E. Director), Mobile: 098302 64431**.**	Equipped with state-of-the art machines from preparatory to finishing sections and manned by a highly skilled workforce. Developed Jute Mesh/Scrim for Roofing Felt, Agriculture, Horticulture and Webbing for Furniture Industry, Rubber Bonded jute cloth for Landscaping, special fabrics for Furnishing and Apparel, Soil Saver known as Geo-textile and Carpet-backing cloth.	Took major interest in NR coated fabrics. Exported rubber coated fabrics previously to Europe. Concern about PP laminated fabrics.	Involved project people for presentation. Have plans to diversify. Trying to find PP substitute.	Keeping regular contact. Have plan to manufacture thin NR coated fabrics.

20. OSB Overseas Pvt. Ltd.

Contact	Status	Assessment of company	Rejoinder	Remarks of R & Y
33A, Jawahar Lal Nehru Road, 7th Floor, Suite A-7, Kolkata 700 071. Phone: 91-33 30288817 Fax: 91-33 3023 2970 Email: info@jutefabs.com Contact: Sandip Bhojgarhia Mobile: 91-9339523043	OSB Overseas create, redefine and reengineer the use of natural golden fiber, jute by making environment friendly products from natural, bio-degradable and fascinating fibers.	Shown interest in NR coated fabrics. Have client base for NR coated fabrics.	Planning for setting up rubber coating unit. Have plans to diversify.	Keeps contact. Interested in thin NR coated fabric.

21. RDB Textiles Ltd. (unit of Victoria Jute Mill)

Contact	Status	Assessment of company	Rejoinder	Remarks of R & Y
16A, Brabourne Road, 6th Floor, Kolkata 700 001. Phone: 033-2225 5450, 2221 6486 Fax: 033-2221 6484 Email: info@rdbtextiles.com; shreekumartoshniwal@gmail.com Contact: Mr N K Bhartia, Cell : 098309 29427	Hessian, D.W. tarpaulin, sacking, plain Hessian bags, Hessian spiral bags, Hessian box bags, Scrim Cloth, Tobacco Sheets, Tree Wraps.	Interest in NR coated fabric. Shall look for new developments.	Want samples to show customers. Concern about NR fabric's performance. Have plans to diversify later.	Keeping contact. Giving IIT's feedback. Getting sample prototypes.

22. Reliance Jute Mill

Contact	Status	Assessment of company	Rejoinder	Remarks of R & Y
Reliance Jute Mills (International) Ltd, Ideal Plaza, South Block, 4th Floor, Kolkata-700 020. Phone: 033-2280 7017, 22807018, Fax: 033 2280 7016 Mail: mktgho@reliancejute.com, shada@reliancejute.com Web: www.reliancejute.com Contact: R C Saboo, Director-Technical Mobile: 098301 61747	Sacking bags in double warps and heavier fabrics in plain and twill weaves.	Took good interest in fabrics. Concern about NR use instead of PP/PE.	Thoroughly studied the products. Plan to diversify. Seeking samples for customer.	Kept contact. Updating IIT's Progress.

23. Mahadeo Jute & Industries Ltd.

Contact	Assessment of company	Rejoinder	Remarks of R & Y
23A, N. S. Road, Kolkata 700 001. Contact: Mr Vyas (CEO), Cell: 09339738184	Took interest in fabrics. Huge export market. Concern about NR use instead of PP/PE	Studied the products. Seeking samples for customer.	Kept regular contact. Updating IIT's progress.

24. Hastings Jute Mill

Contact	Assessment of company	Rejoinder	Remarks of R & Y
Rishra, Hoogly, West Bengal, Phone: 033-64556114, Fax: 033-2672 6904 Email: bsaha@ijmd.co.in Contact: B Saha, Manager, Research, Cell: 098309 49000	Interest in thin NR coated fabric.	Studied NR coated fabrics. Seeking samples for customer.	Keeping contact.

H.7.3. Analysis of most interested companies who wish to have Field Trial and Project Formation on NR coated fabrics

Companies verbally agreed for commercial trial: List of companies who took interest to have commercial trials for NR coated fabrics in thin layers.

1. KE Technical Textiles Pvt. Ltd.
2. Ganges Jute Pvt. Ltd.
3. APL Polyfab Pvt. Ltd.
4. Ashim Kar & Industries Pvt. Ltd.
5. Ludlow Jute & Specialties Ltd.
6. OSB Overseas Pvt. Ltd.

Companies interested in fresh project: Below the list of companies who took interest in fresh project of NR coated jute fabrics and looking for further development towards the same.

1. Ecoline Exim Pvt. Ltd.
2. Camilla International
3. Sunil Enterprises
4. Birla Corporation Ltd.
5. Ganges Jute Pvt. Ltd.
6. Kadambari Mercantile Pvt. Ltd.
7. OSB Overseas Pvt. Ltd.
8. Reliance Jute Mill

H.8. Plausible process flow diagram for prototype production line

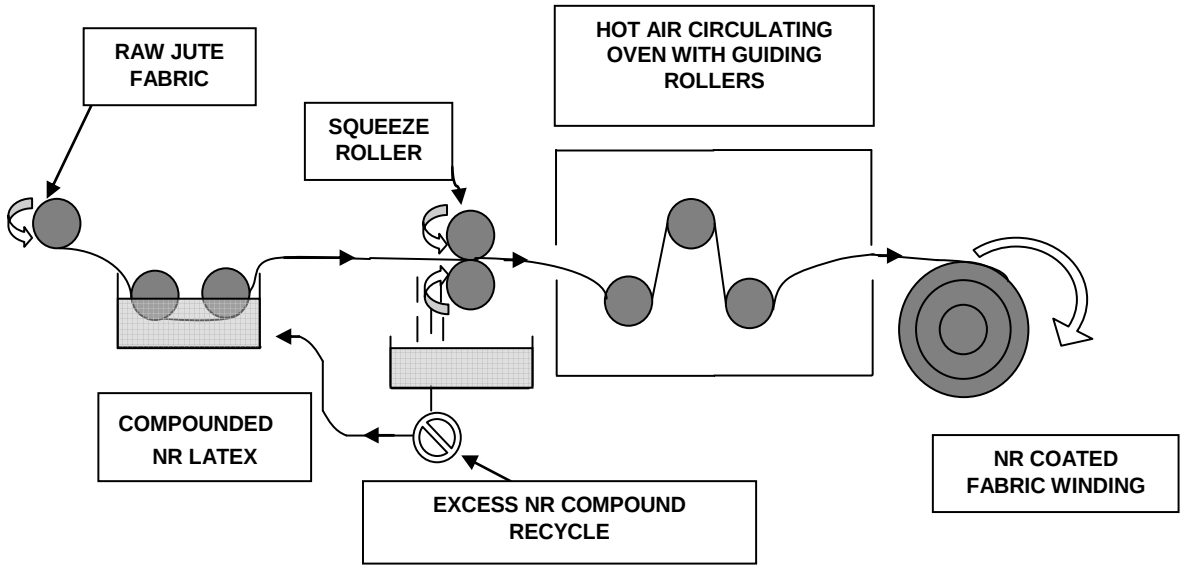


Fig. H1. Plausible process flow diagram for prototype production

H.9. References

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SECTION I

Publication, seminar and workshop

I.1. PUBLICATION AND SEMINAR

International Conference:

P. Chandra, B.B. Khatua, and B. Adhikari (2011). Ultra-thin Natural Rubber Coating on Conventional Jute Hessian Cloth for High and Low-end Novel Packaging Application. International Conference on Advancements in Polymeric Materials (APM 2011), CIPET, Chennai, India.

I.2. WORKSHOP

This workshop was arranged at Indian Institute of Technology Kharagpur for the purpose of mid-term review of all the projects sponsored by National Jute Board (NJB, formerly JMDC) with the title "Research and Development Focus on Jute Mini Mission IV Projects", sponsored by JMDC (2009), Date: 21.12.2009, Venue: Gargi Hall, Vikramshila Complex, IIT, Kharagpur. **Organizers**: Materials Science Centre, Department of Civil Engineering and Department of Mechanical Engineering, IIT Kharagpur.

Suggested actions in the workshop:

(a) Determination of actual cost of NR coating.

(b) Determination of the optimal proportion of rubber in solution as water repellent.

(c) Assessment of chances of absorption of moisture after NR coating.

(d) Measurement of the rate of bio-degradation for jute and rubber separately.

(e) Confirmation whether NR is fully bio-degradable.

(f) Confirmation whether the ultimate product is heat and flame-resistant.

(g) Assessment of durability of the end-product.

(h) Process of application of the NR coating on the fabric and its effect on inherent features of jute.

(i) Confirmation if NR coating is suitable for woven, non-woven and sandwiched fabric.

(j) Confirmation on possibility of application of dyes on the final product.

(k) Confirmation on possibility of NR coating at fibre/yarn to be used in the final product.

(l) Conducting market survey of the product.

All the above points have been discussed and/or solved by different interim, cumulative and annual reports, meetings and R & D activities.

J. RECOMMENDATION AND FOLLOW UP ACTION

J.1. Activities completed:

1. **Laboratory R&D on the development of NR coating process on jute Hessian has been completed.**
2. **Two pilot scale industrial trials on NR coating of jute Hessian have been completed in M/S K E Technical Textiles Pvt. Ltd., Rupnarayanpur, Kharagpur.**
3. **More than 200 m (1.3 m wide) NR coated jute Hessian, produced during pilot scale trial, is available as bulk sample for consumption of trader/user.**

J.2. Observations on pilot scale trial:

1. **During continuous NR coating process on jute Hessian no problem was encountered.**
2. **By varying the machine parameters, viz., speed of production, drying time & temperature as well as curing time & temperature can be easily varied depending on the specification need of the rubber coated jute fabric.**
3. **Extent as well as quality of rubber coating can also be varied depending on the market need.**
4. **Feedback from user/trader based on the bulk samples produced in pilot scale trial should be collected for further minor modification on process parameters.**
5. **Need of specific quality of rubber coated jute fabric and quantum of product demand in the market will gear the commercialization of the developed process in this project.**

J. 3. Next phase action suggested:

1. **Generating liaison between user/trader and interested rubber coated fabric manufacturer.**
2. **Both administrative and financial supports of NJB in the form of project are required to see the commercial success of the project.**
3. **M/S K E Technical Textiles Pvt. Ltd, Rupnarayanpur, Kharagpur, the unit where pilot scale trial was undertaken, has some infrastructural facility for commercialization of the project. Prior to commercialization in a bigger scale they need some addition/alteration of their existing manufacturing facility.**
4. **M/S K E Technical Textiles Pvt. Ltd. has given verbal consent for commercial production of rubber coated jute fabric provided some support is available from NJB or user industry or both.**
5. **Venture investors may also be encouraged.**