TECHNOLOGY INNOVATION

Solar Powered Rope Making Machine

SELCO FOUNDATION

JUNE, 2020

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BACKGROUND & INTRODUCTION

A rope is a group of yarns, plies, fibres or strands that are twisted or braided together into a larger and stronger form. The high tensile strength of ropes allows for activities like dragging and lifting. Rope is of paramount importance in fields as diverse as construction, seafaring, exploration, sports, theatre, and communications, and has been used since prehistoric times.

Rope making is a very versatile livelihood, with many practitioners being able to make rope out of any fibrous material with a high tensile strength. One of the most common materials used is coir which is the native name of the fibre extracted from coconut husk, however other materials that are used include, sabai grass, plastic bags and plastic-nylon products. Rope makers can be categorised by the material they are using or the length of rope they produce, the latter of which often dictates the device they use to create the ropes.

In India, coir rope making has become a major livelihood activity especially in the coastal belt. Indian coir industry is an important cottage industry contributing significantly to the economy of the major coconut growing States and Union Territories, i.e., Kerala, Tamil Nadu, Andhra Pradesh, Karnataka, Maharashtra etc. India accounts for more than two-thirds of the world production of coir and coir products. Kerala is the home of Indian coir industry, particularly white fibre accounting for 61% of coconut production and over 85% of coir products. Although India has a long coastline dotted with coconut palms, growth of coir industry in other coastal States has been insignificant.

Employing 5.5 lakhs people and contributing approximately INR 70 Cr to revenues, the rope industry is a significant driver of the Indian economy. Numerous communities are engaged in rope making as their primary occupation and income. However, they are still using traditional methods and practices which are tedious, full of safety risks and have low productivity resulting in low incomes. They have not adopted newer technologies like other professions as such technology is not very common in mainstream markets.

KEY RESEARCH HIGHLIGHTS

Manufacturing of Ropes in India

A wide variety of materials are used in the manufacturing of ropes. A rope may be constructed of any long, stringy, fibrous material, but generally is constructed of certain natural or synthetic fibres. Synthetic fibre ropes are significantly stronger than their natural fibre counterparts. Common natural fibres for rope are manila hemp, hemp, linen, cotton, coir, jute, straw, and sisal. Synthetic fibres in use for rope-making include polypropylene, nylon, polyesters, polyethylene, Aramids and acrylics. Some ropes are constructed of mixtures of several fibres or use co-polymer fibres. Wire rope is made of steel or other metal alloys. Ropes have been constructed of other fibrous materials such as silk, wool, and hair, but such ropes are not generally available. Rayon is a regenerated fibre used to make decorative rope.

Conventional Manufacturing Practice

The process of rope manufacturing in India has failed to adopt technology and largely depends on manual labour. Majority of the communities involved in rope making are located in rural set-ups with lack of education & resources to utilise advanced technology having a negative impact on labourers in terms of safety, health as well as productivity. The major bottlenecks in the rope-making process are

Large Amount of Labour and Low Productivity

Excess labour is required to carry out monotonous tasks which can be automated.The number of people required to make one batch of rope manually is 3-5.

High Drudgery and Chances of Injury

The number of repetitive physical tasks is high in manual operations, for instance the wheel has to be turned 360 revolutions in order to produce one batch of rope. Labourers often experience shoulder pains after work, which in the long run could lead to health issues and disability

Unreliable Power

Coir industry hotspots suffer from power outages on a regular basis which leads to productivity loss.

Role of Coir Industry in India

The coir industry in the 21st century has a diverse market. It has spread its wings to the food industry, upholstery, agriculture industry, fishing industry and many more. From being used for insulation to make cold storages for food preservation, to filling up mattresses, automobile seats and seating systems, coir is an extremely useful fibre. It is also used to make nets which are used to prevent soil erosion.

India is the largest producer of coir in the world with a production of 5,42,000 MT which accounts for around 55% of world production of coir. India is followed by Sri Lanka and Vietnam in terms of production of coir. Government of India is implementing various schemes for promotion of coir in the country and to enhance the production and export of coir and coir products such as Coir Udhyami Yojana, Science & Technology and Coir Vikas Yojana comprising of components like Skill Upgradation, Quality Improvement Scheme and Mahila Coir Yojana, Export Market Promotion & Domestic Market Promotion.

The government is also implementing the Scheme of Funds for Regeneration of Traditional Industries(SFURTI) for development of Coir Clusters. Under the ASPIRE Scheme of the Ministry of Micro, Small and Medium Enterprises (MSME), Coir Board is in the process of establishing Livelihood Incubation Centres in various parts of the country, which will provide training and handholding support to new entrepreneurs of coir sector.

Other Materials

Apart from coir, ropes are also made of plastic, cotton, tyre and sabai grass(also known as bhabhar, sabia grass is a perennial plant that is grown extensively in the region south of the Himalayas.) Therefore, based on site, accessibility and transport factors the material for the rope is chosen.

Manufacturing Partner - Saaima Engineering

Saaima Engineering Industries was selected as the manufacturer for the rope making machine having already worked with SELCO Foundation on other projects like solar-powered cycles. They are also highly accessible and work on improving the cost-efficacy of the product.

The company was set up in 2005 with an initial focus on manufacturing levers etc. after which it has expanded its areas of focus.

For the last three years it has worked with SELCO Foundation. Mr Javed of Saaima Engineering Industries was involved in the manufacturing and fabrication of the machine.

USER RESEARCH

SELCO's Solar-Powered Rope Making Machine caters to a large market segment and provides livelihood opportunities to the rope-making communities. The machine is affordable and has been successfully tested in Karnataka. The use of the machine eliminates heavy noise, drudgery, and saves labour costs.

A range of mechanised and motorised rope making machines have been innovated which can be used for thin to thick ropes of differing materials. Based on field research of existing conditions and the feedback from pilot operations, SELCO has identified the new machine as a viable alternative.

A series of site visits across various typologies of users was carried out. Coir Rope Production is concentrated in Southern India, and sites in Tamil Nadu and Karnataka were researched. The figure below summarises the working scenario of three coir rope making businesses visited by SELCO. All the businesses run year-round, and are predominantly operated by the women/housewives of the family.

Details	Site 1	Site 2	Site 3
Location	Dhevanampalayam	Oothukuli	Dharwad
Number of Workers	5	4	4
Working Hours	8-10 hours	8-10 hours	6-8 Hours
Raw Materials Used	Coir Fibre	Coir Fibre	Cement Bags/Agri Bags
Production Rate	36 Ft Rope / 2 Mins	36 Ft Rope / 3 Mins	10 Ft Rope / 2 Mins
Type of machinery used	Hand Conventional	Hand Conventional	Hand Conventional
Primary Source of Income	Rope Making	Rope Making	Rope Making
Expenses	er kg, Rim=INR 900, Labo	Per kg, Rim=INR 900, Labou	INR3 to INR 6 per cement bag
Estimated Net Profit (INR)	1200 per day	1200 per day	300 per day
Major Challenges faced by User	Low Productivity	Low Productivity	Drudgery and Low Production

Business Model & Financials

All 3 businesses operate on a direct to customer service model sourcing raw materials from nearby settlements and selling their end product directly in the market. Most businesses indicated that productivity created difficulties towards the profitability of operations and possibility of injury and harm created additional difficulties in maximising output.

Analysing the business financials of the conventional rope making business and measuring it to the cost efficiencies created by Sola Power Rope Making Machine, we see a significant increase in profits driven mainly by cost efficiencies and productivity improvements.

Product	Selling Price	Quantity	Revenue / Day (INR)	Total Revenue / Month (INR)
4 Ply Coir Rope	15	80	1200	31200

Inputs	Expenses/Day (INR)	Expenses/Month (INR)
Coir Fiber	700	18200
Labour	200	5200
Transportation	150 / week	600
Total Revenue (INR)	**31200**	
Total Expenses (INR)	**24000**	
Total Profit (INR)	**7200**	

Expected Increase in Profit from Solar Rope Making Machine	Amount / Month (INR)
Savings from cutting down labour expenses	5,200
Expected increase in productivity (20%)	6,240
Expected increase in expense (20% input cost)	3,620
Total expected increase in profit (1+2+3)	8,180
Expected loan repayment	2,182
Maintenance cost	500
Existing profit	7,200
Net Profit after intervention	**12,698**

The intervention is expected to increase the entrepreneur's income to INR 12,698 on an average, rising 76.3% from the manual alternative. The following details are assumed for the calculation of expected benefit from Solar Rope Making Machines:

- Interest rate is fixed at an average of 15%
- Payment tenure is 2 years translating to 36 monthly EMIs
- Total cost of system (including cost of lending) is Rs 52,366 at the end of two years
- Based on the calculation, the EMI cost coming to Rs 2182
- Number of working day considered: 26 days
- The entrepreneur is contributing Rs 45,000 and the rest is availed through loan

Beyond coir, plastics are also widely used raw materials for making rope. The business model for plastic is as follows:

Assumptions		CAPEX - One Time Cost		OPEX - Annual Cost	
Working hours	6	4 Spindle Motorized Ratt	8,000 INR	Operator	192,000 INR
Working days	25	Stand & Machine Cover for Motorized Ratt	2,500 INR	Raw Material	120,000 INR
Ropes per day	45	Electronics - Charge Regulator, Remote and Speed Controller	9,500 INR	**Total**	**312,000 INR**
Cost of Rope	40 INR	Motor	6,200 INR	**Financials**	
Total selling revenue	540,000 INR	Solar System	63,800 INR	Loan Amount	**100,000 INR**
				ROI	12%
Total operational Income	**171,516 INR**			Tenure	24 Months
	14,293 INR	**Total**	**90,000 INR**	**EMI**	**4,707 INR**

Overall, it was found that women were predominantly involved in this business with the elderly or the disabled working on rotating the machine from a seated position. Typically 3 people were required to operate the machine. It was found that low productivity was a major concern.

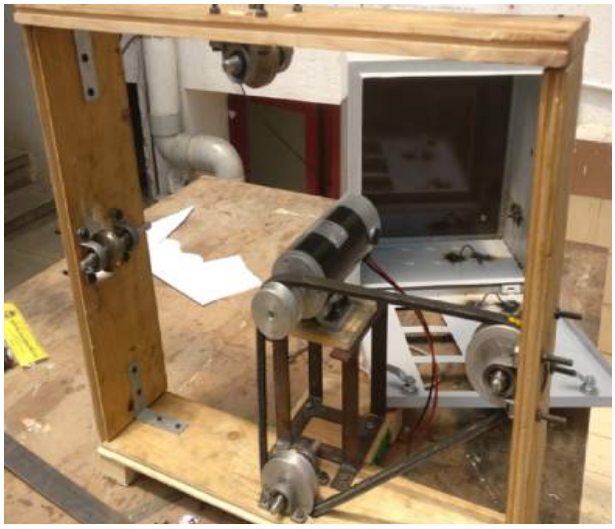
Cost of the product

Rope making machine - 4hrs of back up with Hybrid charger			
Maximum load that can be connected		**370 W**	
System Load		**24 V**	
Type of Ropes can process		**Plastic, Nylon, Cotton**	
System Configuration			
Sl.No.	**Product**	**Capacity**	**Quantity**
1	Solar Module	300 Wp, 24 V	2
2	Solar Battery	200 Ah, 12 V	2
3	MMS (Regular)	300 Wp, 1M	2
4	Earthing kit		1
5	Cables red+black (M-B)	6 sq mm	20
6	Cables red+black (B-B)	16 sq.mm.	4
7	Earthing cable	10 sq.mm	10
8	Single Pole DC MCB (Load side)	32A	1
9	Consumable		1
	Basic Price		**58476**
	TAX 5%		2924
	SB		1000
	Total		**62400**

CHRONOLOGY OF TECHNOLOGY DEVELOPMENT ITERATIONS

Traditional manual systems used widely in villages involve a manual machine with four hooks and small motors (typically 1 HP and 2 HP motors.) These machines are typically useful till only 15 feet distances for 2 yarn ropes and are inefficient and hence solar powering these models was unlikely to be an efficient solution. Thus, it was decided that a new machine had to be built from scratch. Another concern was that children and the elderly are typically employed or engaged in the operation of such machines. Thus, the proposed solution needed to take into consideration their livelihoods as well. Finally, the notion that the nature of the raw material differs from region to region was also taken into consideration. For example, coir yarn is different in Karnataka and Kerala. The major prototypes are listed below, within each prototype multiple iterations took place.

Prototype 1: (Proof of Concept)



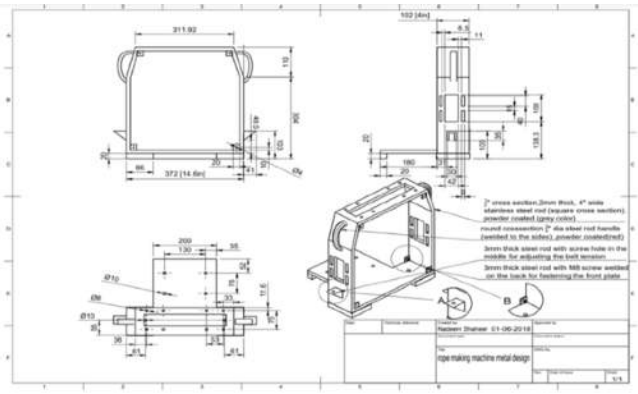
- Prototype 1 was built using wood, pulleys, and a belt-drive mechanism.
- 60W and 80W motors, a significant increase from the efficiency of the pre-existing solution.
- This system did not work well for ropes with lengths greater than 100 feet.
- Additionally, the initial prototype had a relatively large frame which resulted in the hooks being too far. Thus, the frame length and breadth were revised and reduced.
- The prototype was then tested on the field (in off-grid communities) for mechanical design after which the solar electrification aspect was looked into. It only worked for some aspect of the spectrum of the ropes made—different materials. But there was the need for one machine to be able to design everything.

Prototype 2: (Proof of concept 2)

- The second prototype involved a motor with a higher capacity of around 200W or 0.5hp (capped here as beyond this solar electrification costs would be very high.)
- The initial model had a motor in the center with hooks diagonally rotating. In prototype 2 the motor was moved downwards.
- On conducting field tests, a slippage issue was identified. Often the pulley system got stuck and only the motors were running as the mechanism did not have enough grip to hold the pulleys. Field testing: slippage issue, pulleys stuck and motors only running, not enough grip to hold the pulleys

Prototype 3

- To combat the aforementioned problems identified with Prototype 2, a teeth pulley and bike chain mechanism was introduced. This was able to combat the slippage issue.
- A metal frame was introduced to increase rigidity.
- The hooks introduced were curved at right angles but upon taking feedback it was found that the hooks did not provide sufficient grip. Thus, a u-shaped hook was needed. These were introduced and it was found that they were often pulley out if too much force was applied. Therefore, the system was upgraded to include slightly heavier pulleys and chains.
- More than 20+ such systems were implemented throughout India.



Prototype 4

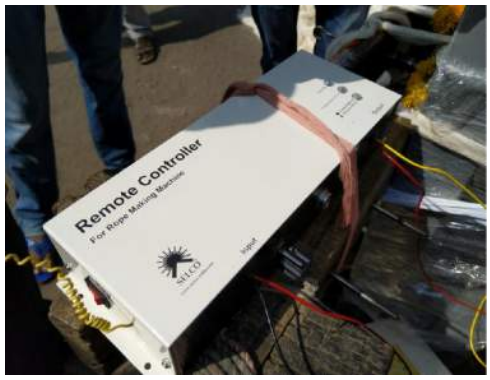
- This prototype worked on aesthetics.
- The covering of the machine was also looked into as it was an electronic mechanism.
- A stand was also added to ensure that the system was above the ground and stable.

Prototype 5

- The hand-driven machine used as well as the previous prototypes developed by SELCO required three people to run. Thus, it was decided to automate the prototype so that fewer people were required for the system's operation.
- The team decided to use a remote-control system with multiple operations like forward, backward, on and off etc. This was successful in reducing the number of people required to operate the machine to 1-2.
- There were three iterations carried out for this prototype involving a remote control:
    - Iteration 1: The remote control simply had a front and back switch.
    - Iteration 2: The speed regulator was placed on the machine.
    - Iteration 3: The speed regulator was added to the remote-control system so that all control functions could take place using the control system
- This was well-received in field tests.

The design was then given to the manufacturers: Saaima Engineering Industries who were accessible and cost-effective. They looked into the design's viability for mass manufacturing, modified the metals used based on ease of sourcing. Having modelled 2-3 samples of the design, the manufacturer identified some issues with the running of the machine with breakage of bearings. He rectified this and added heavier weights for increased stability. Based on market demand, the manufacturer also looked into the colours and aesthetics of the system. He also came up with a heavy-duty model which was more stable and could thus be used for ropes that ranged from 100-150 feet too. The manufacturer also changed the gear-wheel mechanism.

CHRONOLOGY OF TECHNOLOGY DEVELOPMENT ITERATIONS



Test 1 – Solar Rope Making Machine in Solapur, Maharashtra

Observations

- Rope makers are very happy with the alternative and claim that it increases the output significantly while reducing physical effort. Production is almost doubling in volume using the Solar Machine
- 2 people can easily work with the machine, instead of employing 5 members for manual machine, so end-users can save labour cost
- The belt drive used in the machine created operational difficulties as slipping occurred while operating at peak load or while reverse operation
- Solar Rope making machine was not suitable for the production of 40mm rope

Feedback

The primary feedback received by end users was used to increase effectiveness of the machines and incorporated into the following steps to improve the rope making machine:

- An increase in speed
- Replacing the belt drive with a chain drive
- Addition of Remote tags for convenience of end user
- Preparation of operation manual for end users to troubleshoot in case of breakdown

Test 2 – Solar Rope Making Machine in Kuderu, Andhra Pradesh

A four hooks machine, which was able to work for all the kind of ropes (Plastic, Cotton, Banana Fibre) was installed with remote control facility, user can control on/ off or directions whether forward or reverse very quickly. Two people can do the rope job instead of manual process which requires three people.

Observations

- End users are very happy and they learned quickly to operate the machine.
- The manpower required in rope making reduces resulting in cost efficiencies.

Feedback

The end users inputs were used to build on the existing set up. An occurrence of injuries related to the hands led to the use of suitable gloves during manufacturing. In addition to this the use of hooks made of stainless steel in order to prevent rusting was implemented.

Test 3 – Solar Rope Making Machine in Erode, Tamil Nadu

Observations

- The number of labourers required reduced after installation of the machine. SELCO's machine also produced much lower sound as compared to traditional alternatives
- End users were still using manual machine for the opposite side of the rope
- The machine was suitable for 11 / 15 / 35 / 100 feet ropes. However use of machine in case of 150 feet ropes was limited.

Feedback

The end users provided feedback mainly regarding the range of remote controller and troubleshooting related matters. The next steps towards improved efficiency were highlighted as:

- Fixing remote controller on support so that it is high enough to receive the remote's signal
- Covering up the top of the machine where the chain is visible
- Prepare a draft operation manual in order to assist end users.
- Extending the remote's signal to work far from the machine

Sabai Grass Rope Making

- The prototype involved 0.25hp Watts motorized solution and a .25hp tightening solution to increase productivity
- The prototype involved purchasing a manual operated machine from Premier Magnetos through IIT Kharagpur and motorizing it
- The testing for the same is still in process partnering with SHGs especially considering the 200 families involved in this in Mayurbunj

Cotton, Tyre and Plastic Rope Making

- Initially 120watts, 150watts and 180watt solution was tested and found that the torque and speed was not sufficient, tested with belt and chain drive.
- The power requirement from the motor was found to be high as the rope from materials plastic and nylon required high power to twist the rope and they also wanted a few ergonomic adjustments to be made which was done.
- Currently we have implemented the solutions at Chamarajanagar, Solapur, Coimbatore and Erode

ADVANTAGES OF SOLAR POWER ROPE MAKING OBSERVED BY END USER

- **Reduced Drudgery:** All the users have positively acknowledged that intervention has made a difference in terms of reduced physical effort.
- **Reduced Expenditure:** When compared to earlier situation, users have seen tangible savings in terms of the wages that he had to pay earlier for labour. This has added to user's overall earnings.
- **Increased Productivity:** Solar rope making machine, increases the productivity in terms of labour as well as in terms of volume of output produced.
- **Reduced Injuries:** Users have witnessed a decrease in workplace mishaps since the adoption of the machines.

SELCO's Solar Rope Making Machine is a breakthrough technology in improving work conditions and business profitability for a large number of communities which are dependent on rope making as their primary source of income. Easing financing conditions through institutions such as SKDRDP reduce the financial burden on end user and allow him to increase output while reducing manual labour and drudgery.

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