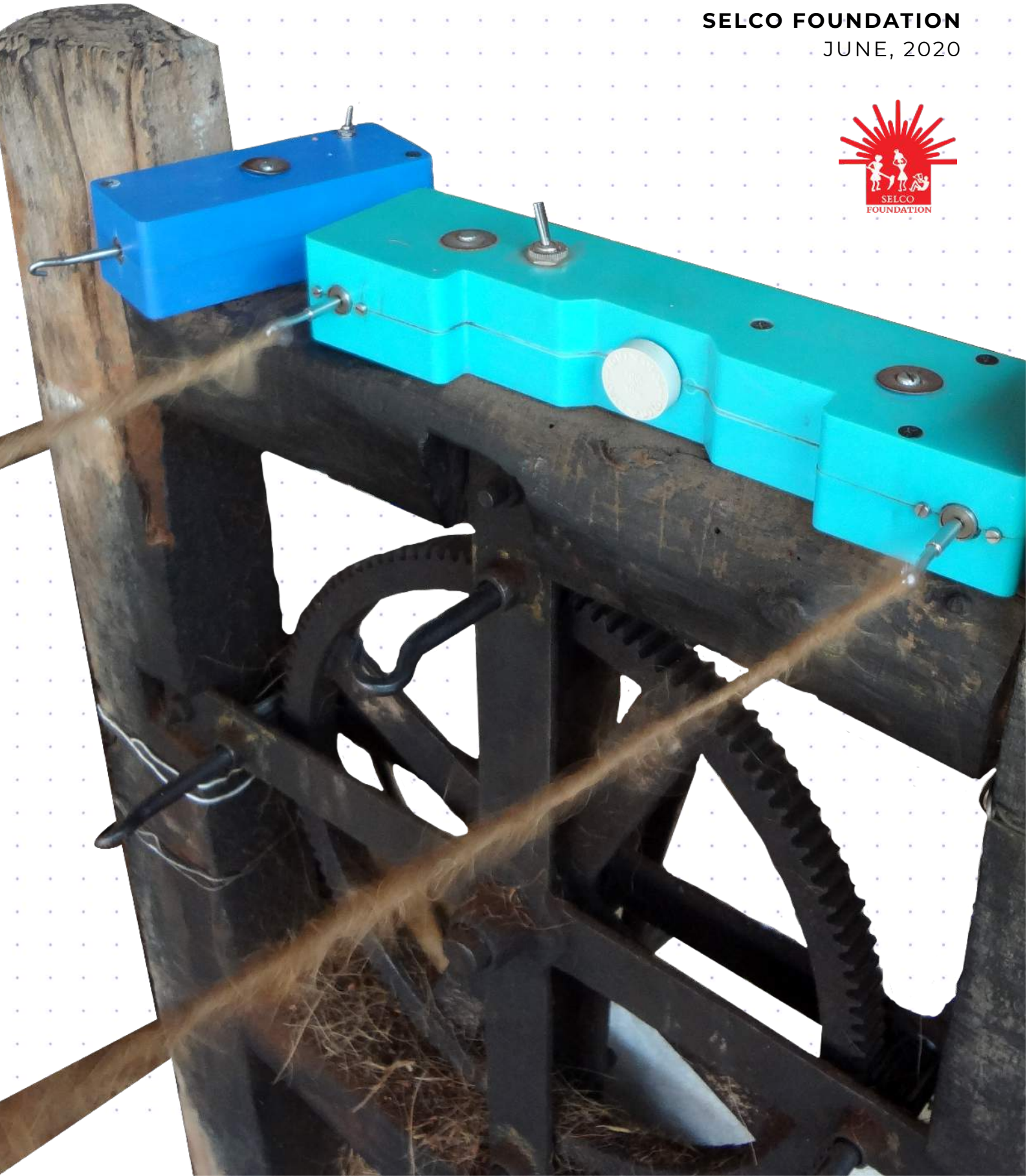
TECHNOLOGY INNOVATION

Solar Powered Coir Yarn Making Machine

SELCO FOUNDATION

JUNE, 2020



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BACKGROUND & INTRODUCTION

SELCO Foundation first identified the problem of coir yarn making communities via SELCO India's Chitradurga Branch in Karnataka, India. These communities were producing coir yarn using manually operated Traditional Ratts. This presented an opportunity to help the communities improve their productivity using motorised machinery – which would eventually will reduce the drudgery of the operation, and also reduce the number of people required to make a single yarn, therefore enabling workers to produce more yarn (using several machines in parallel). Traditional Ratt Machines are extremely labour intensive, with accounts of some individuals stating that they have been carrying out the single rotatory motion of the traditional pulley system for more than 35 years.

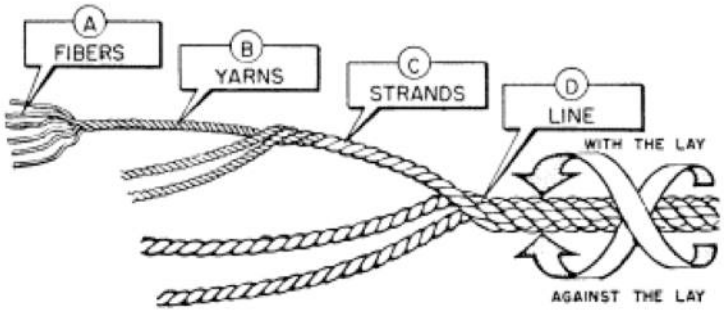
Communities practicing this trade, often have settlements in clusters of the same trade. In some cases more than 30 traditional ratt machines would be operational at one time creating a lot of noise, not allowing children to study or cause longer term hearing problems. Such communities also face power cuts daily, making the need of a reliable and sustainable source very visible. SELCO Foundation took up the role to carry out extensive user research and market research to find the best solution catering to the communities need. It was able to do so, via borrowing learnings from a manufacturer in neighbouring Kerala and improving the design of the machine for better usability, consumer acceptance, productivity improvement and energy efficiency improvements.

Coir is the fibre contained in the husk of a coconut and makes up the primary raw material for this trade other than the Ratt machine. The individual Coir fibre cells are narrow and hollow, with thick walls made of cellulose. Coir comes in two forms: white and brown. White coir is harvested from immature green coconuts (after about 6-12 months on the palm), whereas brown coir is obtained from fully mature brown coconuts. White coir is smoother and finer, but also weaker. Brown coir is thick, strong and has high abrasion resistance. The advantages of using coir rope are: it is one of the few natural fibres resistant to salt water damage; it is relatively water-proof (helping the rope float in water); and it has good elasticity. However, it forms a stiff non-flexible rope (difficult to manage), it is coarse to handle and it is about one quarter the strength of a hemp rope.

This project is mainly considers rope productions, but fibres can be used for manufacturing a variety of other products, like - Door mats; Matting; carpets & rugs; and geo-textiles, used for reinforcing land surface and for promoting growth of vegetation in an eco-friendly manner; reinforced fibre products; Coco peat; Mattresses, etc.

The main types of rope are made using: laid, or twisted, rope, braided rope, and plaited rope. Rope is traditionally constructed sequentially from fibres, yarns, and strands, which are twisted together to form the rope that has a tensile strength significantly higher than the base fibre

The need for a machine with the ability of thicker rope as well as of those made of other materials like plastic led SELCO Foundation to design its Solar Powered Rope Making Machine alongside the smaller Solar Powered Coir Yarn Making Machine.



USER RESEARCH

Selco Foundation began working with coir yarn making communities in Karnataka. Many communities still use manually-operated traditional ratts to make coir yarn. These machines typically require three people to operate it; one person dedicated to turning the handle of the ratt, while two people spin the fibres in to yarn.

Selco Foundation has identified the electronic ratt as a viable solution to help these communities increase their productivity (particularly in areas where labour is hard to find), and reduce chance of shoulder injury (common for person turning handle).

Based on field research, Selco Foundation has established a set of user requirements for the coir yarn makers, and, based on its pilot installations, produced feedback on the electronic ratt design which was further implemented. The final solution has now been implemented by 45 different users group - each with 2-3 members.

To arrive at the following user needs, a series of site visits across various typologies of users was carried out. Coir Yarn Production is limited to Southern India, and sites in Karnataka, Kerala, Tamil Nadu and Maharashtra were researched. The figure below summarises the working scenario of three coir yarn making businesses visited in Chitradurga in the first site visit where the problem was originally identified. All the businesses run year-round, and are predominantly operated by the women/housewives of the family. Information in yellow. Power cuts in the region lasted from 6am-1pm, and 4pm-6pm.

	Item	Site 1	Site 2	Site 3
1	Location	Adivala Farm, Patrehalli	Adivala Farm, Patrehalli	Dindavara
2	Interviewee name	Lakshmidevi Subramani	Nirmala Bai	–
3	Coir yarn making experience	25+ years	20+ years	–
4	Sources of income	Rope making, auto-driver, manual labour (farming)	Rope making	Rope making
15	Business model	Service	Independent	Service
5	Working hours	6am - 2pm	1-5pm	–
6	Machine type	Hand-operated	Automated spinning	Hand-operated
7	Cost of machine	2nd hand: Rs 3,000	Rs 1 lakh	2nd hand: Rs 2,000 New: Rs 3,500
8	Number of machines	1	3	1
9	How were the machines paid for?	–	Loan from SKDRDP	–
10	Style of yarn	2-ply	3-ply	3-ply
11	Number of operators required per machine	3	2	2
12	Cost of labour	Yarn maker: Rs 150 /day Wheel turner: Rs 130 /day	Rs 1 /rope	Rs 0.75 /rope
13	Length of rope	14-15 ft	15 ft	14-15 ft
14	Time to make one length of rope	45-60 sec	50-60 sec	110-120 sec
15	Coconut husks consumed (kg/day)	–	–	–
16	Cost of coconut husks (Rs/kg)	–	–	–
17	Coir consumed (kg/day)	–	–	–
18	Cost of coir (Rs/kg)	–	–	–
19	Electricity cost, de-husking (Rs/month)	–	9-10,000	–
20	Electricity cost, buffering and yarn making (Rs/month)	–	2,500	–
21	Production rate (m/day)	2,210	1,179	–
22	Selling price of rope (Rs/m)	0.90	0.90	–
23	Estimated profit (Rs/day)	500	400	333

The businesses at sites 1 and 3 use hand-operated Traditional Ratt machines, and operate on a service model – i.e. they convert coir to yarn for a fee. They do not purchase the coir, and are not responsible for selling the yarn; this is dealt with by those supplying the coir. The business at site 2 uses automated spinning machines. It purchases coconut husk from local farmers and has processing machinery to convert the husks in to coir. Once the yarn is made, the business sells directly to the market.

Site 1: Traditional Ratt Machines

This business works on a service model. On working days they produce~500 ropes. Each rope is 14-15 ft in length and generates a profit of Rs 1, resulting in Rs 500 net profit per day.

The business has another working scenario: 1 gadi of coir (= 15 putti/baskets) is purchased for Rs 5,000. This makes approx 1,500 ropes, requiring approx three days work. Each rope is for a profit of Rs 4 – the total revenue is therefore Rs 6,000, resulting in a net profit of Rs 1,000, or Rs 333 per day. Compared to the service model approach, this seems less profitable, as well as more risky due to the capital investment required to purchase the coir.

It is necessary for the coir to be dry when producing the rope. On rainy days, it is necessary to wait for the coir to dry – there is no apparent covering to keep the coir dry and the 'runway' (area where the coir yarn is made) is not waterproof. It has a flat roof made of leaves, but this only provides shade from the sun.

The 'wheel turner' reported shoulder pain, and the 'yarn makers' reported sore hands. If their hands become too painful they put tape on the sore area. They have tried wearing gloves in the past, but the spinning process requires delicate touch to control the yarn quality, and also the gloves wear out due to the abrasiveness of the coir. It is for this reason that mainly older women carry out the work.

Top: Spinning Machine, Left: De-Husking Machine

Site 2: Motorised Coir Yarn Spinning Machines

The site has three automated spinning machines – one was demonstrated to us. They run from 1-5pm, in accordance with the power availability. There is no generator or power backup option. The machines were purchased three years ago – at a cost of Rs 1 lakh each – with a loan provided by SKDRDP, a local banking correspondent NGO. They each have a 1.5kW single-phase motor.

Qualitatively speaking, the yarn is better quality (tighter and finer) than the hand-spun yarn. If a labourer is hired, they work for 6 hrs, or until they have made 10 bobbins (1 bobbin = 50 lengths of yarn). Additionally, workers are paid Rs 1 per length of yarn, or Rs 500 per day.

As mentioned, the business also has de-husking machinery to convert coconut husks (sourced from local farms) to coir fibre. One tractor load of husks costs approx Rs 5,000 (including labour and transport), and generates 5 tractor loads of coir fibre.

Site 3: Traditional Ratt Machines

The business at site uses a second-hand traditional ratt. During our visit, there were two workers making 3-ply yarn – one was turning the wheel and one was spinning the yarn. The yarn spinner takes approx 20 sec to spin each strand; the strands are looped around a rod, and after spinning all three strands, they are combined to form the yarn.

If a labourer is hired, they are paid Rs 0.75 per length of yarn. This equated to Rs 375 per day, assuming a production rate of 500 lengths per day.

Site 4: Perumpallu Coir Yarn Making Co-Operative, Electronic Ratt Made by DD Industries

There are an estimated 250 coir cooperatives across Kerala. We were shown to one in Perumpally by the owner of DD Industries and Mr Sudheer, a Coir Board regional office representative.

The cooperative has a purpose-built shelter, with six electronic ratts side-by-side – the installation is all provided by the Kerala government, as a means to help provide employment. The runway distance inside the shelter is approx 50ft. Individual yarns are spliced together to form a 48-yarn long thread. Once combined, the yarn is wound into a bundle, ready for transportation. There is water pool at the site that was previously used for retting coconut husks. However, this process gives off toxic fumes and results in waste-water pollution, so it is no longer carried out. More environmentally friendly methods are now used.

In recent times, the cooperative does not use locally sourced coconut/ coir; instead they import coir fibre from Tamil Nadu (predominantly white coir from immature coconuts). Tamil Nadu coir is approx half the price of Kerala coir, due to higher employment and electricity costs. It is not known if Kerala coconut husks are exported to Tamil Nadu for processing purposes, or if they go to waste. There is a willowing machine on-site for making sure the coir is 'clean' before it is used for yarn making.

The table below summarises information about the coir yarn cooperative. Note, the reported values for income and net profit differ from the values calculated (based on other information gathered), so the validity of the data cannot be guaranteed.

Item	Value
Cooperative established	1987
Number of employees	22
Working hours	10am - 4/5pm
Working days	Mon-Sat
Days worked per month	26
Daily wage (Rs)	300
Source of coir fibre	Pollachi, TN
Type of yarn produced	Vycome (typically)
Years using electronic ratt	7 yrs (since 2010)
Coir purchased (kg/month)[1]	25,000
Cost of coir fibre (Rs/kg)[2]	29
Yarn produced (kg/month)[3]	21,667
Selling price of coir (Rs/kg)[4]	50
Reported income (Rs/month)[5]	675,000
Reported net profit (Rs/month)[6]	45,000

Expenses	
Coir fibre (Rs/month)	725,000
Electricity (Rs/month)[7]	1,000
Labour (Rs/month)	171,600
Total	**897,600**

Income	
Coir yarn (Rs/month)	1,083,333

Net profit (Rs/month)	**185,733**

[1]Purchase 250 quintal per month
[2]Rs 870 per bundle (30kg)
[3]Production losses mean 30 kg coir fibre produces 26 kg coir yarn
[4]Heavier yarn is Rs 48 per kg, lighter yarn Rs 51 per kg
[5]4-5 loads per month, each load gives income of Rs 1.5 lakh
[6]4-5 loads per month, each load gives profit of Rs 10,000
[7]Rs 2,000 per 2-months (paid by Coop)

Site 5: Coir Co-Operative – KSSDC - Gubbi, Karnataka

The cooperative was established in 1993. It is a coir board funded cooperative for promoting the coir industry. Workers are daily wage labourers who get paid by coir cooperation based on their work output. The produce is sent to retail centres owned by coir board where they sell in retail and wholesale. The mats, carpets, yarn etc, which are produced in excess are shipped to a go-down in Tiptur from where they are further sold. Due to labour unavailability, the production has affected significantly. As the labours are paid irregularly, there is dire need of change in the management of coir corporation to keep the industry afloat Technical issues which has not been resolved for several months, due to which the several machines are not in operation. The centre visited has the machines as stated in the table below.

Machinery	Units	Present status
Defibring machine	1	Working
Electronic ratt	3	Working, need more backup
2 ply single headed automatic spinning machine	6	Under maintenance
2 ply double headed automatic spinning	2	Working
Willowing machine	1	Not working
Power loom	1	Working, some issues
Hand loom	1	Working

The co-operation has facilitated installations of electronic ratts in 14 locations in Karnataka machines. Each site has 3 to 4 electronic ratts in use, totaling upto 40 ratts overall in Karnataka. Each center has 3 to 4 daily wage labors which are working on non-permanent basis.

MARKET RESEARCH

Central Institute of Coir Technology (CICT), Bangalore, Karnataka

The CICT did not have a Motorised Traditional Ratt (MRT) available to see but had maintained a directory of Machine Manufacturers on their website The Technical Director of the Institute was sceptical about the MRT solution because it means the rope making process was still largely manual, and he believed that there is a growing reluctance for people to work in manual jobs. There are approx. 70,000 automated machines in operation across India. The automated machines have a much higher production rate, and also produce higher quality rope.

Central Coir Research Institute (CCRI), Alleppey, Kerala

A visit to Alleppey in Kerala was undertaken to help understand the coir industry and to gather information on coir yarn making technology. Meetings were arranged with the Central Coir Research Institute (CCRI) and several manufacturers of coir yarn making machinery. CCRI has an engineering division that performs R&D on machinery relating to the coir yarn industry. Once it has established a robust design, the technical drawing and specification can be purchased by manufacturers for replication purposes – at a cost of Rs 1,500 per design. Price is generally Rs 3,000 (excluding tax), and includes a double-spindle unit, a single-spindle unit and the overhead switches (i.e. stand not included). Warranty is typically one-year, to match that of the motors. All manufacturers use a CCRI-based design for the electronic ratt. In Kerala, customers requiring electronic ratts are typically fed to the manufacturers by the Coir Federation, and therefore little marketing or sales effort is required on the part of the manufacturers. This consists of:

- **Double-spindle unit:** used for twisting coir fibre in to two threads simultaneously. This unit also has a control-dial for varying the rotational speed of the motors, and therefore the production rate of the yarn. The speed selected will depend on the experience of the operator
- **Single-spindle unit:** the double- and single-spindle units are placed facing one another – the distance between the two units (aka the 'runway') corresponds to the length of yarn produced. Once the operator has spun two threads the length of the runway, they will combine the threads using the single-spindle unit to 'double' the rope. Note, the single-spindle motor spins in opposite direction to help bind the yarn tightly
- **Overhead switches:** coloured string is tied to an overhead switch to help the solo operators control the two units while spinning the yarn. Green corresponds to 'on', red corresponds to 'off'
- **Mount:** the spindle units are mounted at waist height for operator ergonomics. Either a metal stand can be used, or the unit can be mounted directly to a wall or wooden post.

Above: Unit manufactured by Kerala State Coir Machinery Manufacturing Company (KSCMMC) based on CCRI guidelines. KSCMMC's electronic ratt, consisting of a double-spindle part (top), a single-spindle part (bottom-left), and overhead switches (bottom right)

DD Industries

DD Industries shared the technical specification for their electronic ratt – see Table below. They sell the ratt for Rs 2,500 (+ tax) and can also provide a stand for Rs 1,500. They have sold more than 10,000 units in the past 4 years. The company used to provide training for coir yarn making, but no longer have the space available. Training courses are also provided free-of-charge by the Coir Board.

Double spindle unit	Specification
Transformer	12V, 2A rating
Electronic circuit board	Includes rectifier and speed controller
Motors	2x DC motors made by Mabuchi – each 12V, 15 W rating
Casing material	ABS plastic (350 x 65 x 55 mm)
Weight	1.4kg
Maximum power consumption	10W

Single spindle unit	Specification
Motor	DC motor -12V, 25 W rating
Casing material	ABS plastic (150 x 65 x 55 mm)
Weight	0.5kg
Maximum power consumption	10W

Solar components	Specification
Solar panel rating	12V, 20W
Charge controller	15V output limit, to avoid battery overcharging
Battery	12V, 7Ah

Karnataka Coir Federation

Karnataka has a Coir Federation (similar to Kerala's). The Federation has tried to implement the electronic ratt in the Karnataka. Apparently it has not been successful because of the way subsidies are handed out, combined with the beneficiary's approach to work. At present, the Indian government hands out subsidies directly to the beneficiaries who are then expected to purchase the relevant machinery from the manufacturers. It is seen as a way to avoid corruption; beforehand the subsidy would go directly to the manufacturer.

However, the Karnataka Coir Board have experienced problems – once the beneficiary receives the subsidy they then decide not to invest in the new equipment, and choose to keep working with their traditional ratts, keeping the subsidy to themselves. As a result, the manufacturers are no distributing their electronic ratts to the field. In Kerala, beneficiaries appear to be eager to adopt new technology, so the electronic ratt has proven successful there. Whereas in Karnataka, beneficiaries are more likely to continue using traditional methods, even if the newer technology offering has benefits in terms of productivity.

Ms. Premalatha explained that energy access is an issue across rural Karnataka, but they have not yet considered implementing solar power. This may have been a leading reason behind acceptance of new technology.

Coir Museum

The museum explained the history of the coir industry, including machinery used to manufacture coir products, and also showcased some novel coir products. The motorised ratt was one of the items on display. It appeared to be a good solution because it is compact, uses a small motor (compared to automated spinning machine), and permits the user to sit during its operation. The machine was not successful in the field. This is because the productivity was lower (compared to traditional process), and the design was prone to mechanical failures.

Compact motorized ratt, developed in 1992 (left and middle), standing version (right)

Tool & Time - Partner for Electronic Ratt Modifications

1. Business areas: Tool & Time (T&T) have three main products: clock towers, the Electronic Ratt (ER), and a solar-powered grass-cutting machine (not commercially available) ER development: T&T developed the ER ~15 years ago. They commissioned the injection-mould for the plastic casing.
2. Initially T&T tried using motors sourced in India, but there were issues with overheating (the plastic casing would melt due to high temperature). Mabuchi Motors were identified for their superior performance in this regard. In total, T&T has purchased 1-1.5 lakh motors from Mabuchi.
3. Karnataka coir yarn:
    a. T&T work with Karnataka Coir Corporation, which has 89 centres distributed around the outskirts of Bangalore. T&T has distributed ~700 ERs in Karnataka
    b. For the solar-powered ER, installation cost is Rs 9,800 and the battery life is typically 1-2 yrs
    c. In Karnataka, ER typically operated by two persons due to lack of training. Installation is the same as Kerala – double-spindle and single-spindle units are installed at opposing ends

TECHNOLOGY TESTING AND MODIFICATIONS

The electronic ratt was considered as the most suitable option to help assist yarn makers already using a traditional ratt - it reduces number of operators required to make rope from three to one. It is inexpensive (Rs 3,000 without stand) and low power (maximum 20W), thus allowing application of solar power. The electronic ratt was thus purchased by the selected vendor and installed at 3 sites for feedback.

Test 1 - Electronic Ratt from Kerala based Manufacturer

Observations

- Three-spindles required to make a bundle (of three yarns) – helps to ensure tight twist and hence package the yarns in to a bundle. Quality of the yarn produced by the electronic ratt is similar to the traditional ratt, but users would still prefer tighter twist
- End users wanted the double-spindle unit spinning during the combination process
- End users used the 'jig' when combining threads in to a yarn – the Kerala coir co-op did not use one, instead using their hand
- Ideally double-spindle unit should also operate in reverse
- End users thought that the single-spindle unit was spinning in the wrong direction – we reversed the direction, which led to the threads unravelling. This misunderstanding was corrected.
- Single-spindle rpm insufficient (c.f. traditional ratt rpm) – leads to reduced productivity
- End users required a light in their house
- Single spindle unit too heavy to hold
- Single spindle unit should be 'quicker' – i.e. higher torque Can this be achieved through system design (changing voltage/ current)
- Require a speed controller

The main feedback received via test one shown to work effectively in certain settings (Kerala Coir Co-op), but also does not meet user requirements based on user feedback. Some main feedback collected was:

a. Spindle hook too small
b. Torque insufficient to create tightly wound yarn
c. More hooks required to make 'bundles'

Furthermore, the electronic ratt system introduced a significant process change in the way yarn was manufactured in the tested areas – for the electronic ratt spinning is performed by two units (placed at opposite ends*), whereas for the traditional ratt spinning is performed at one end. This may introduce difficulties in wider implementation. This led to to a consideration to place a single-spindle unit at same end as double-spindle unit during next installation. In all, three systems were considered as the way forward.

1. Electronic ratt: With Modifications based on user feedback

2. Pulley-driven traditional ratt: bolt-on solution to be adaptable to existing installations

3. In-house design: similar to a motorised ratt solution from Tamil Nadu. This should be designed to be flexible for both coir yarn and rope making

Option 1 is further explored in this document whereas Option 3 is further explored as part of the Solar Powered Rope Making Machine effort. Option 2 would have been quicker to implement than Option 3, but it may not have been as efficient.

Test 2 - In house modifications to improve efficiency and usability



Several high priority modifications were proposed and implemented– see below. Upon being proven successful, ratt manufacturers would be approached adopt recommendations based on the tested results.

a. Placing single-spindle and double-spindle units side-by-side to make it more intuitive to users
b. transitioning from Traditional Ratt
c. Addition of a reverse switch on the double-spindle unit to make it possible to make yarn with double-spindle unit only
d. Addition of a on/off switch to the single-spindle unit to make it easier to operate
e. Redesigning the circuitry to achieve higher torque and higher speed
f. Inclusion of a heat sync to avoid motor overheating

Based on these tests feedback was collected. The table below summarises the user requirements for the coir yarn makers. Note Selco Foundation is also considering rope making communities, who use manually-operated ratts to produce rope from a variety of materials: cotton fibres, recycled car tire fibres, cement bags, silk etc. The main differences are typically product length (rope is longer), and the torque requirements of the spinning device (rope is more tightly bound).

Category	#	Requirement	Detail/ existing solution
Hooks	1	Positioning of hooks	Hooks positioned at one end only – more intuitive to users (similar to Traditional Ratt)
	2	Spacing of hooks	Hooks should be spaced so multiple users can spin yarn simultaneously (electronic ratt spacing is 28cm)
	3	Size of hooks	Larger than electronic ratt hooks
	4	Number of hooks	Coir yarn making: 3-4 hooks. Rope making: 4-6 hooks
	5	Forces on spindle	Hooks are subject to an axial force and a radial force. Consider using thrust bearing to account for both forces.
Drive system	6	Power/ efficiency	Low power – makes solar power more viable/ economical. Efficiency depends on electrical and mechanical transmission losses
	7	DC motor	Means machine can operate from solar-battery system without need for inverter (thus reducing conversion losses)
	8	Torque	Higher torque than electronic ratt – yields tightly-bound, high-quality yarn
	9	Spinning speed (RPM)	For Coir yarn making: 820-850 RPM for threads; 2,400-2,900 RPM for yarn
	10	Noise	Low noise – Traditional Ratt very loud/ disturbing
Control	11	Reverse operation	Necessary to spin in opposite direction when combining threads into yarn
	12	Speed controller	Possible to control both forward and reverse speed
	13	Remote operation	User should be able to easily turn ratt on/ off during operation (if problem encountered). Pull-cord on-off switches from electronic ratt design work well.
Other	14	Cost	Low cost better - more affordable to end user
	15	Durability	Ideally requires little maintenance – especially consider dusty environments
	16	Repairability	Repairs should be easy and low cost

Advantages of the Electronic Ratt observed and provides as feedback from the end user included:

1. **Low power consumption:** means it is economical to use solar power
2. **DC motor option:** again means that solar power can be used
3. **Remote operation:** ability to turn ratt on/ off using pull-cord switches is a good innovation
4. **Low noise (compared to traditional ratt):** means yarn makers can start work earlier in day (disruption to neighborhood is less), which helps avoid the midday heat and also means the coir quality is softer (reduces chance of hand injuries). Reduction in sound is also beneficial for children studying at home (easier to concentrate)
5. **Commercially available:** several manufacturers making the solution, and widely implement
6. **Low cost:** comparatively low cost, makes it more affordable to end users
7. **Installation process:** unit is small and easy to install

Proposed modifications to electronic ratt could make this a promising solution, especially if the pre-existing fabricators are open to suggestions. The final list of modifications provided to the manufacturers were:

1. **Position all hooks at same end:** This has several advantages. It is more intuitive for users transitioning from Traditional Ratt. This avoids the need for a trainer, and means the design will be more readily adopted – i.e. corresponds to a larger available market
2. **The design is insensitive to rope length:** Fixing the double- and single-spindle units at opposite ends makes it more difficult to change rope length, as per user requiements Fixing the components at one end adds security (safer from theft etc) and means it is easier to protect the components from water damage in the event of rain Installation time is also faster
3. **Larger hooks:** users find it difficult to thread coir on to hooks with current design
4. **Three hooks:** some users produce bundles of 3x yarns – prior to bundling, three yarns are spun in parallel to help them form a tighter bundle when wound together
5. **On/off switch on top of unit:** makes operation easier when starting/ finishing yarn
6. **Forward/ reverse switch on top of unit:** reverse mode is necessary at the end of the yarn making process, when two threads are combined on to a single hook. It is a quick operation, but still required.
7. **Dual speed mode:** two speeds, one for thread making, one for combining threads in to yarn
8. **Higher torque and higher speed (12V DC):** help users achieve tightly bound yarn. Consider modifications to circuit design, or using different motors. Selco suggest using the single-spindle motor (RS-545SH-18150) for double-spindle unit, to increase speed and toque. Tool & Time (T&T) mentioned that an advantage of the double-spindle motor (RS- 455PA-15205) is that it stops if the loads is too high, which avoids cutting the thread.
9. **Address motor overheating:** with current design, motors become very hot because they are enclosed in a plastic casing. Consider using more efficient motors (for 12V DC conditions) or including a heat sink. Solution needs to be very economical/ inexpensive in order to keep unit cost down. T&T is currently not able to afford redesign of the plastic casing – die costs are very high.
10. **Warranty:** standard 1-year, covers design failures but not user misuse. Propose keeping spare motors should these fail in the field. T&T have had very few failures for the ERs they have already installed

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Most of the above modifications were accommodated by Tool & Time Engineering and the Solar Powered Coir Yarn Making Machine is now being scaled with the help of financial schemes. Learnings from these will be be further compiled to reach even more communities engaged in this craft.

TECHNOLOGY INNOVATION

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