Final Report

Team #7
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Introduction to Rubber Production

Natural rubber has been used by man from prehistoric times until modern day, used in all sorts of areas: sport, textiles, medical apparatuses, automotive industry, construction, and much more.\(^1\) Although the technology used to mould rubber into various intricate shapes has improved and become more advanced over the years, many steps in the rubber production process have remained essentially unchanged.

Rubber production is a vital part of the industry of Kerala, India, a state located on the south-western coast of the South Asian subcontinent. The humid, equatorial tropic climate and average of 120-140 rainy days per year both encourage natural rubber trees to thrive.\(^2\) This natural advantage means that Kerala has traditionally been responsible for a majority of the rubber output of India--up to 585000 tons out of 622000 total tons, making Kerala responsible for about 85% of India’s rubber.\(^3\)

The initial steps required to produce rubber, which rely heavily on manual labour, engage a substantial number of small-scale farmers in rural Kerala--an estimated 1,000,000 farmers produce rubber off of farms of a few acres using basic tools (i.e. without the use of tractors, mechanized plows, etc).\(^4\) Rubber is first painstakingly tapped from rubber trees, a process that involves a skilled labourer cutting a series of grooves into the bark of the tree that allows latex to drip out of the tree into a vessel of some sort placed at the bottom.\(^5\)

This raw latex is then processed and coagulated in pans using a combination of chemicals, including a dilute acid. For a single pan, as many as 20 - 30 trees may need

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\(^1\) [http://www.inventions.org/culture/ancient/mexican.html](http://www.inventions.org/culture/ancient/mexican.html)
\(^2\) Chacko T; Renuka G (2002). "Temperature mapping, thermal diffusivity and subsoil heat flux at Kariavattom, Kerala". Proc Indian Acad Sci (Earth Planet Sci), 80.
\(^3\) [http://www.kerala.gov.in/economy/agri.htm](http://www.kerala.gov.in/economy/agri.htm)
\(^4\) [http://rubberboard.org.in/ManageCultivation.asp?id=29#](http://rubberboard.org.in/ManageCultivation.asp?id=29#)
\(^5\) [http://rubberboard.org.in/rubercultivation.asp](http://rubberboard.org.in/rubercultivation.asp)
to be tapped, leading rural farmers to have a much lower output than a large plantation. Over time, the raw latex congeals and hardens into a soft, watery ‘cake’ of rubber.

At this point, water is pressed out of the rubber using a series of rollers--first by hand, and then by mostly manual machines--so that it can be dried and smoked, stabilizing the polymers and rendering it in a form that can be easily transported and sold across the world. Small farmers make in the vicinity of 10 sheets per day and sell their product in the market when they have made enough sheets to fill a buyer’s order, typically once every two weeks or every month.6

**Discovery of a Potential Opportunity**

While looking at areas ripe for possible innovation and improvement, the operation of the rubber presses--the machines used for removing excess water from congealed latex--immediately jumped out. Current rubber presses are manually operated, using a complicated system of gears and pulleys powered entirely by human exertion to press out the liquid and prepare the sheets for smoking.

Although effective, manual rubber presses are difficult to operate. The amount of energy required to operate a press is substantial. This leads to two sorts of issues. One, current farmers are expended excess effort to perform a task. Over time, repeated

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6 [http://rubberboard.org.in/ManageCultivation.asp?Id=192](http://rubberboard.org.in/ManageCultivation.asp?Id=192)
bodily stress can lead to medical issues such as back pain, arthritis, and other debilitating diseases that would impede the ability to continue to practice one’s livelihood. Two, the operation of current rubber presses removes willing and eager workers from the pool of labour. Older farmers, women, and the disabled are all examples of workers who would relish the ability to join the rubber production process.7

As a result, our group decided to work on improving the process of pressing the rubber sheets, and to try and find an alternative solution that would be easier to operate and use, facilitating the work of current farmers and enabling disenfranchised workers to join the rubber production workforce.

**Our Working Mission Statement**

Our mission statement evolved over the course of our product iterations, each time being updated to reflect additional knowledge of the market, culture, and limitations related to our goal. Our original mission statement was as follows:

> *Our mission is to improve on the conventional rubber press design to facilitate the production of rubber sheets, simultaneously reducing the workload for current producers and opening up the market to additional disadvantaged groups, such as women and the physically challenged. The new rubber press should be able to press the sheets into a desired shape and size in a semi-automatic way.*

Currently, our mission statement reads:

> *Our mission is to create an attachment that fits at least 50% of current manual personal rubber presses that would reduce the physical force required to operate the*

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The attachment should be able to be easy to use, maintain, and install, and require little technical skills. It should also be as safe as possible, with built-in safety measures to ensure that people, especially children, cannot be accidentally harmed by its operation.

The most relevant changes from the initial mission statement are highlighted in bold. While we believe that this mission statement represents a good and complete understanding of our target market and our desired product, experiences indicates that as we continue developing our product small adjustments might need to be made.

Figure 1: easy to use device

Product Solution

Initially, we attempted to design an entirely new rubber press that operated in a semi-automatic fashion. Our replacement product would have been more expensive than current rubber presses, but we believed that with a combination of effective manufacturing and targeting marketing, we could convince those farmers to upgrade their machines. Our market survey supported this idea, too. About half of all farmers
owned their own machine, and half of those farmers were open to the idea of buying a new machine.

After further thought and analysis, however, we decided to go with an easier, more effective solution to the same problem: an motor-driven attachment that can attach to perhaps 50% of existing machines. With this attachment, we hope to capture both those farmers who were willing to upgrade to an entirely new machine and a portion of those unwilling to expend the capital to invest in new production tools.

Our new design is centred around a small, efficient motor that attaches to the crank wheel of existing rubber presses, since this is a common design element amongst all rubber presses. The machine would turn the wheel of the crank at a steady speed and work on a ‘pulse’ system, aiding workers in manipulating and making necessary adjustments to the rubber sheet as it is pressed.

Figure 2: right hand view of product concept
Current Product Design

All rubber presses share a certain amount of common functionality: the concrete base on which they rest, the crank wheel which transfers motion to the gears, and the ability to pause and start again without having to lock or unlock. Our product has three main components: a stand, a control and motor, and an arm/belt mechanism to transfer rotational energy to the crank of a rubber press. Each component is designed to be separated from the others to allow for ease of assembly, disassembly, and repair.

The stand component involves a sturdy stand that braces against the concrete stands on which all rubber presses are built. The stand’s legs will collapse into the center for ease of transport and will be secured using a simple locking mechanism, as is found on most foldable tables. Descriptive pictures will demonstrate the correct placement for the stand—on the right of the wheel so that the force of the belt drive is driven into the legs braced by the concrete block, as opposed to the legs braced only by the floor (which may be made of any number of materials, including packed earth, wood, stone, reeds, etc).

The stand will also have a locking mechanism for securing the motor to the top. This mechanism is designed for infrequent repositioning but frequent removal of the motor, for cleaning, refueling, etc. Since a farmer generally has the same configuration of space around his or her rubber press, the mechanism for fastening the locking mechanism to the stand will be sturdy bolts and washers, while the mechanism for attaching the motor to the locking mechanism will be clamp-based.

The motor itself will be one of many commercially available motors modified to emphasize safety and usability. If not readily available, a grill casing will need to be attached to the open areas of the motor that might have moving parts or get warm to the touch, to prevent children from being harmed while their mother is turned away. In
addition, a dead man’s switch will be built into the pulse-like operating control. Since rubber sheets need to be watched and manipulated as they come out of a machine, this will be easy to accept.

Finally, the mechanism for attaching the crank wheel to the motor will rely on commonly available parts, motorcycle belt drives, that can be repurposed for our use. We are looking into bike treads serving as de facto ‘gears’ to minimize energy loss from slippage around the crank wheel and welcome the reduction in cost that we will gain.

![Diagram of crank and belt system](image)

**Figure 3: top down view of crank/motor conversion**

**Target Market**

The primary target market for our new product, as mentioned before, encompasses small scale farmers who own up to five acres of land and a manual rubber press. We are focused on those farmers who have expressed an interest in investing further in their machine—which consists of roughly half the surveyed farmers. These farmers tend to be older on average (around 50 years old), which also matches with the ease of use that we will use as a selling point.
Our secondary market consists of appealing to those workers who are currently disenfranchised from the rubber production process—women and the disabled. We aim to target these customers through empowerment programs in place in Kerala, both through the Rubber Board of Kerala and the regional/national government. Groups such as the Rubber Producers’ Societies and Self Help Groups receive substantial monetary stipends from the government, and either are required or choose to give preference to women who present proposals. 8

Scenario

A useful technique for visualizing the utility of our product is the construction of a scenario, which illustrates why an attachment-based product would appeal to farmers who have been managing without substantial problems for generations.

Bhim is a 47 year old farmer in the Kottayam region of Kerala. He owns a farm of 3 acres, on which he grows primarily rubber trees along with a few garden-variety plants that his wife, Vanaja, uses to make her famous aviyal dish for dinner. Bhim’s farm has been passed down from his father to him, and amidst the turmoil of Indian independence, the slight decline in interest amongst young people to work on rubber farms, and the volatility in rubber prices, Bhim continues to farm rubber.

Bhim rises a little bit after dawn to go and check on the day’s cuts in his rubber trees. Overnight, latex has collected in the coconut shells that his hired workers have placed at the foot of every tree. Satisfied by a job well done, he goes to wake up his sons to help before they have to run off to school.

After a hectic dash to get everyone off to school, it falls on Bhim and his hired hands to process the day’s rubber. A number of latex ‘cakes’ have set and are ready for pressing. While he oversees the treatment process, Vanjana comes out, having finished cooking for the day.

Bhim motions over to the trays stacked neatly by their trusty rubber press. The shopkeeper and builder needs to stop by and oil up the gears, but Vanjana only needs a little bit of help fastening the motor attachment before the crank is in motion. She stops frequently, adjusting the sheet as it comes out the other end. It takes her only until the children come home to finish all the work, to no one’s surprise — sometimes she thinks that perhaps she should pretend to take longer!

Designing for ‘X’

Our product has been through much iteration, changing either a lot or a little each time. From radical overhauls to nitpicky details, each new idea has been guided by the idea of ‘designing for x,’ or designing for certain manufacturing, marketing, or engineering specifications to improve on the utility of our product.

Elements of DFX appear throughout the product design process, which can be broken up into ‘Brainstorming DFX,’ ‘Product Development DFX,’ and ‘Prototyping DFX.’ We will examine each of these in turn.

Brainstorming DFX

DFX appeared as early as the brainstorming process. Our market survey, for example, was designed to extract the information we needed from our interviewees without superfluous questions that wasted time. Questions such as “How many sheets per day do you produce with your machine?” allowed us to learn about the production rate, the time spent, the feasibility of sharing machines, etc.
We also had to take into account designing a product that would fit into the cultural landscape of Kerala. Farmers live and die by their land, and are very protective of their product and livelihood. In addition, our initial premise involved appealing to women and the disabled. In the United States, it is accepted and lauded to champion for underrepresented groups, but in Kerala it might have been the case that male heads of family would feel threatened or undermined by our goals. Luckily, our market research dismissed this scenario.

Finally, we had to design a product that we could accomplish given our skill set. Group dynamics are an important consideration when going forward with any business plan, and we needed to set realistic expectations to ensure that our group would be able to meet them.

**Product Development DFX**

The most important DFX considerations arose during our product development phase, in which we hammered out details of the solution that we had agreed upon during the brainstorming process.

Our market survey made it abundantly clear that one of the most important considerations for our target market was cost. If the attachment were too expensive to buy or to maintain, it would not be feasible. As a result, we focused intensely on designing our product in such a way that the cost would be minimized. Whenever possible, off-the-shelf substitutes for custom parts were incorporated—such as motorcycle belts instead of custom belt drives, standardized bolts instead of odd sized ones, and commercial motors as opposed to ones designed in-house. Each of these changes were made with low cost in mind.
We also wanted to design for user and environment safety, another major concern. Given our hopes of including more women in the production process, we were naturally concerned with the possibility of more children being around a piece of moving machinery. To this end, we added a grill casing to the motor and a dead man’s switch to the control mechanism, ensuring that curious children could not poke their fingers into the motor and that there would always be supervision during the device’s operation.

One element for which we designed represents a cultural exchange: designing for sustainability. In the US, the idea of ‘going green’ is a common one with much publicized support and admiration. This is not yet the case in India, but we knew that we could design in an environmentally friendly manner and be ahead of the curve while being good eco-citizens. Our product, by using repurposed products, minimizes additional waste. In addition, we aim to manufacture our product in an environmentally conscious manner, without the dumping of toxic wastes or by-products.

Finally, we designed our product with our customer’s needs in mind, trying to avoid the sorts of design faux pas which so irritate modern consumers. Our machine is meant to be lightweight, separable, and easily fixable by any qualified mechanic, not just a proprietary trained repairman (a la companies in the US such as Apple!). In addition, we carefully vetted the decision to include a ‘pulse’-type control for the machine, before realizing that this would not impede functionality.

Prototyping DFX

The last portion of DFX, prototyping, remains mostly a theoretical exercise due to time constraints. However, just like with the brainstorming and product
development aspects of DFX, there are some clear areas that we will consider in the future.

One, we will of course design with clear product and engineering specifications in mind, so that there is no miscommunication between us and our manufacturing partners. Too often, products are designed in lab and appear amazing but fall apart when presented to engineers who are forced to make them. All of our specs and tolerances will be carefully vetted with our manufacturers prior to starting production, so that we can ensure a smooth assembly. In addition, we will work with the manufacturers to lay out a design that is primed for an assembly-style production line, without needless redundancies or snags.

We will also utilize rapid prototyping as a tool to fix flaws in our manufacturing process, hopefully adding to our commitment to design a product that is easy to manufacture.

Ethics

One tenant which we now understand to be integral to any business plan is having a solid Code of Ethics. In today’s media and in the minds of a vocal sub segment of the population, large corporations, be they multi-national or not, are seen as ‘evil’ or overly capitalistic. As a social entrepreneurial company, with a focus on both improving the lives of others in a profit-generating manner, it falls to our shoulders to set a good example.

A good amount of time was devoted to outlining and detailing the ethics code to which all team members and/or future business partners would have to subscribe. Issues arise if partners, even ones that might seem inconsequential, are not on board
with the code. Given the low margin for error in starting a new business, we cannot afford to lose resources on a corrupt partner. Our Code of Ethics is as follows:

**We resolve to treat our workers with dignity and consideration, respecting their rights as human beings.** Disregard for the contributions of the working class can only need to high turnover and disgruntled employees, who might be tempted to take general ideas from our factory and sell them to a potential competitor.

**We will respect the local culture and follow local customs provided they do not come in conflict with the rest of the ethical code.** While we are excited by the avenues that our attachment will open for women, the disabled, and other disadvantaged groups, we understand that not everyone can have our more modern, open outlook. Barring egregious violations, we cannot discriminate against potential customers simply due to their adherence to the status quo.

**We will ensure that we create products that are safe for the user, society, and the environment.** Similarly to the situation with overworking workers, it is inexcusable to take advantage of lax laws in India in regards to environmental protection and try to use them to our advantage. While creating products that are safe for the user and society is necessary to have a successful product, this third aspect is not as pertinent in this regard. As a result, the vigilance has to come from within.

**We will ensure that the company will practice a fair and reasonable pricing strategy.** While we subscribe to the idea of price discrimination and are not aiming to be a charity corporation, we intend on selling our product at the lowest price point at which we can be self-sustaining. Perhaps in the future, when we are selling our attachment in other markets where buyers have more liquidity, we can try to incorporate a higher profit margin, but for now we understand the need to keep costs as low as possible.
We will only sell products that we believe will be useful, well-made, and well received in society. Again, we understand that a good portion of this is necessary to have a successful product. However, we will remain every vigilant that our product does not leave the shop defective or of mediocre quality.

We will only provide true and fair information in our promotions to the customer. Misleading advertisements once more are counter-productive in helping our business thrive. If we, along with other companies, continue to lie to each other on air, we cannot expect to be received favourably in Kerala.

We will not take unfair advantage of our customers and workers, as well as the community in general. This final admonition harkens back to the Honor Code at Caltech, which tells students to never take unfair advantage of any other student. We wish to also embody this characteristic in our company’s target market.

In addition, we also have an additional code pertaining to conversation between members of the group. Further evaluation behind the choices for the ‘team rules’ can be found in the Group Dynamic section further below.

Business Goals

Very early on in the product development stage, we came up with a number of ‘Key Business goals’ which we hoped would guide our product through the various design phases. These goals were short, simple, and to the point and were as follows:

1. Have a life time of 6-8 years
2. Cheaper than the traditional alternative
3. Simple construction, can be made locally
4. User friendly
5. Easy to maintain.
6. Attractive appearance
7. Use local materials

Through our constant attempts to ‘Design for X,’ we realize that our initial goals appear in some form or another in our final product design. The only goal that we appear to have focused less intensely on would be goal number seven, which reads ‘use local materials.’ While we detailed our desire to use locally sourced materials in an attempt to cut costs, the cultural implications of contributing to the local economy were not.

Financials and Business Plans

Our financials are based upon preliminary cost estimates of the components that we have highlighted as being essential to any final design that we use. In all calculations, we attempted to go with a worst case scenario—being forced to pay market prices, for example—to try and indirectly account for hidden expenses which we know will arise.

As discussed previously, our final cost estimates for the three main components of our machine are as follows:

<table>
<thead>
<tr>
<th>Component</th>
<th>Price</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control Subsystem</td>
<td>$100</td>
<td>All components found at market value</td>
</tr>
<tr>
<td>Support Subsystem</td>
<td>$25</td>
<td>All components found at market value</td>
</tr>
<tr>
<td>Arm subsystem</td>
<td>$25</td>
<td>All components found at market value</td>
</tr>
<tr>
<td>Overhead</td>
<td>$75</td>
<td>Labour, testing, painting, packing</td>
</tr>
<tr>
<td>Total</td>
<td>$225</td>
<td></td>
</tr>
</tbody>
</table>
The further cost breakdown of the three subsystems was also determined, so that effective cost cutting could be instituted—for example, it is a better use of our time to lower the cost of the motor, since it currently takes up an inordinate percentage of our total cost:

<table>
<thead>
<tr>
<th>Component</th>
<th>Price</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Speed High Torque motor</td>
<td>$ 80</td>
<td></td>
</tr>
<tr>
<td>Dead man’s switch</td>
<td>$ 5</td>
<td>Includes a button mechanism</td>
</tr>
<tr>
<td>Grill plating</td>
<td>$ 5</td>
<td></td>
</tr>
<tr>
<td>Legs</td>
<td>$ 10</td>
<td></td>
</tr>
<tr>
<td>Base support piece</td>
<td>$ 5</td>
<td></td>
</tr>
<tr>
<td>Belt</td>
<td>$ 10</td>
<td>Price calculated from motorcycle belt</td>
</tr>
<tr>
<td>Misc</td>
<td>$ 5</td>
<td>Nuts, bolts, screws, etc</td>
</tr>
<tr>
<td>Total</td>
<td>$ 120</td>
<td></td>
</tr>
</tbody>
</table>

We have also outlined a preliminary three year plan of attack for our business. In the first year, we expect to not make a profit and instead run an operating loss. As a result, our plan involves seeking out enough funding to sustain us through our second year, since conservatively we expect to turn a profit by our third year. This cash stream will hopefully derive from angel investors, local government grants, and NGO funding.

Prior to starting operations, in the first few months of our business, we estimate the following broad costs:
| Costs and fees for detailed market analysis | $1000 | Follow up on survey |
| Product specs (consultant fees) | $500 |
| Follow up on local regulations | $500 |
| Local ‘fees’ | $2000 |
| Local guide/consult | $500 | Supplement Indian members |
| Negotiating costs with suppliers | $500 |
| Factory preparation | $500 |
| Realtor fees for factory location | $500 |
| **Total** | **$6000** |

We further expect the following costs for the production of the attachment:

| Rent for factory | $3000 | Based on |
| Worker training | $500 | Large first time expense |
| Equipment and Personnel Costs\(^9\) | $8000 | Based on current wages |
| Manufacturing prototypes | $1000 |
| **Total** | **$12500** |

As a result, we expect to outlay $18,500 in our first year of operations—an amount that we consider highly conservative and well within the range of most investors. We benefit from producing in an area of lower costs in general.

Within this first year, we aim to open our manufacturing factory and begin initial work, hammer out deals with suppliers and vendors, do more detailed market analysis, and remain proactive to any possible problems that might arise. At this point, we

\(^9\) http://www.paycheck.in/main/officialminimumwages/kerala
would also start searching more actively for a local partner interested in participating in our enterprise.

By our second year, we hope to have our factory and manufacturing process up and running with 90% functionality (and close to 0 accidents!), allowing us to slowly expand our workforce and begin the process of separating out exemplary workers from the pack to cull for upper level status. We expect to build brand recognition through the selling and distribution of units to particularly visible users, allowing us to increase our manufacturing capabilities. We also will continue to locate regional partners and further funding, if required.

By year three, we aim to continue what we outlined in year two, with an emphasis on aggressively going after more market share at a rate harmonious to our capabilities. We expect to be able to dramatically ramp up production with two years of products out in the market, and would be looking into a new expansion at this point.

Our next set of three years will focus on achieving and maintaining profitability by solidifying our existing partnerships and expanding out into new ones, perhaps with an eye to nearby markets or even markets in other areas of India. We would consider bringing in a full time partner or buyer.

**Marketing Strategy**

Our marketing strategy will rely heavily on local machine shops, which are currently the largest producers of semi-custom rubber presses and rubber press repairs in the area outside of campus. We expect that these shops are frequented by owners of rubber press machines, so if we could convince the shop owners that our product is a useful complementary good to their rubber presses, we could attract a much larger segment of our target market.
In addition, we hope to spread word through the local official governmental liaisons—the Rubber Board of India, various smaller governmental groups, national initiatives to include women in the workplace, etc. Partnering with a bank, such as one that specializes in microfinance (while avoiding those big banks recently caught up in scandal due to defaults), would help us reach those farmers interested in taking out a loan to improve their business.

Group Dynamics

While we could certainly qualitatively describe our group dynamics, it is more interesting to go back to our work very early on in the term regarding team rules and judge ourselves on our success in adhering to the set guidelines, fulfilment of goals, and resolution of conflicts.

Our team goals were as follows:

1. To work collaboratively, with each member contributing equally to the team.
2. Use our differing backgrounds to our advantage. Each of us will draw on our own experiences to enhance the team’s thinking.

Of most interest are the implications of goal number two. Our group experienced problems due to the locality of our skill set. The member with the most extensive knowledge on designing a working prototype was in India and therefore separated from those members who were more adept at coming up with solutions to problems and who had ready access to resources to build a prototype.

Ironically, our emphasis on our varied and sometimes lacking skill set led us to underestimate and categorize ourselves more so than one would have originally thought. Members were reluctant to join in on the conversation in an area in which
they were not academically strong. Going forward, switching the focus to ‘every member can contribute to every idea’ might help to counteract this effect.