DESIGN AND FABRICATION OF LEAF LOGGING MACHINE

A final year project report

Presented to

SCHOOL OF MECHANICAL AND MANUFACTURING ENGINEERING

Department of Mechanical Engineering

NUST

ISLAMABAD, PAKISTAN

In Partial Fulfillment

of the Requirements for the Degree of

Bachelors of Mechanical Engineering

by

Muhammad Uzman Hameed

Murtaza Nasir

Hassaan Khan

June 2017

EXAMINATION COMMITTEE

We hereby recommend that the dissertation prepared under our supervision by:

Muhammad Uzman Hameed	NUST201305153BSMME11113F
Murtaza Nasir	NUST201305556BSMME11113F
Hassaan Khan	NUST201306700BSMME11113F

Titled: "Design and Fabrication of Leaf Logging Machine" be accepted in partial fulfillment of the requirements for the award of BE, Mechanical Engineering degree.

Supervisor: Col. Naveed Hassan	______________ Dated:
Committee Member:	______________ Dated:
Committee Member:	______________ Dated:
Committee Member:	______________ Dated:

______________________ ____________

(Head of Department) (Date)

COUNTERSIGNED

Dated: ________________ __________________________

(Dean / Principal)

ABSTRACT

With the rise in global warming all around the world and the growing energy crisis in Pakistan, there have been many calls for a new environment friendly source of energy. The aim of our project is to design and fabricate a machine which is capable of compressing dry leaves into a briquette which then can be used a useful source of energy.

To accomplish this project, we have first reviewed previous research on this topic. After this was done, a design approach is undertaken through which the various components of the machine are chosen through comparative analysis and various calculations. The machine is then designed using Solidworks software after which the design is moved forward for fabrication.

Subsequently, the results are shown in which the final machine is presented and the resulting leaf briquette is also shown. Any shortcomings are also discussed and possible methods to overcome these shortcomings are also discussed.

Lastly, the conclusions and the recommendations of this project are presented to the reader.

PREFACE

This report comprises the summary of work we achieved during our final year project (FYP). The task we chose to carry out during the year is the design and fabrication of a leaf logging machine. The effort is conducted under the supervision of Col Naveed Hassan. This report provides a detailed exposition of the tasks we completed towards accomplishing our project goals. We begin by introducing the topic we selected and explaining the primary reasons that encouraged us to select this particular subject as our FYP. We provide all the necessary background on the topic through an exhaustive literature survey. We then go over the primary goals we achieved and provide a brief explanation of the path that was followed in order to achieve these goals. We then present the phases for

implementing the various tasks of the project.

We conclude our report by mentioning the design constraints we came across throughout the life of the FYP and how these constraints were addressed.

ACKNOWLEDGMENTS

First of all we are extremely thankful to Allah Almighty who blessed us with the potential and knowledge to complete this project. We are also thankful to our families who supported and encouraged us throughout this project.

We would also like to express our deepest appreciation and gratitude towards our supervisor Col. Naveed Hassan whose suggestions and guidance enable us to make this project a success.

Lastly we would also like to acknowledge the crucial and pivotal role of DMRC staff who provided their expertise and equipments to complete our tasks.

ORIGINALITY REPORT

We certify that this research work, titled "Design and Fabrication of Leaf Logging Machine" is our work. The work has not been presented elsewhere for assessment. The material that has been used from other sources has been properly acknowledged.

ORIGINALITY REPORT

%13	%10	%2	%7
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	en.wikipedia.org Internet Source	%5
2	www.aub.edu.lb Internet Source	%2
3	Submitted to Higher Education Commission Pakistan Student Paper	%2
4	Submitted to University of Wolverhampton Student Paper	%1
5	Submitted to University of Southern Queensland Student Paper	%1
6	YOSHIZAWA, Takumi, Jun NANGO, and Toshiomi KOGUCHI. "Experimental analysis of a water-pump driving mechanism using an orthogonal double-slider joint", Mechanical Engineering Journal, 2016. Publication	<%1
7	Submitted to Loughborough University Student Paper	<%1

8	Submitted to La Trobe Melbourne (NAVITAS) Student Paper	<% 1
9	libres.uncg.edu Internet Source	<% 1
10	Anshar, Muhammad, Ab Saman Kader, and Farid Nasir Ani. "The Utilization Potential of Rice Husk as an Alternative Energy Source for Power Plants in Indonesia", Advanced Materials Research, 2013. Publication	<% 1
11	ccsenet.org Internet Source	<% 1
12	edepot.wur.nl Internet Source	<% 1
13	Sakkampang, Chatcharin, and Tanakorn Wongwuttanasatian. "A Study of Combustion and Environments of Biomass Briquettes from Sawdust Mixed with Glycerin", Advanced Materials Research, 2014. Publication	<% 1
14	www.gsa.gov Internet Source	<% 1
15	scholar.lib.vt.edu Internet Source	<% 1

16	communicatingastronomy.org Internet Source	<%1
17	researchbank.rmit.edu.au Internet Source	<%1
18	d3s.mff.cuni.cz Internet Source	<%1

EXCLUDE QUOTES	OFF	EXCLUDE MATCHES	OFF
EXCLUDE BIBLIOGRAPHY	OFF		

COPYRIGHT

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

The title of our project is the leaf logging machine. The aim of our project is to design and fabricate a machine which has the capacity to compress dry leaves into a leaf log which can be used as a renewable energy source. The objective of our project is to create a leaf log which has a diameter of 6 inches and a length of at least 6 inches. Climate change is one of the biggest dangers facing mankind today. A major cause of climate change is use of fuels which pollute the environment such as coal and oil. Another major cause of climate change is the rapid deforestation which has taken place all over the world over the past few decades. The leaf log aims to help solve this problem by introducing a new renewable energy source in the form of the leaf log. It can help reduce deforestation by replacing wood logs in local villages and small cities where dry leaves are widely available. It also has the potential to replace coal in local restaurants and homes which will help further reduce climate change. This issue is especially important for Pakistan as it is predicted to one of the worst affected countries by climate change.

The report is organized as follows:

In Chapter One, the project is introduced with its title, aims and objectives and the motivation behind the project.

In Chapter Two, the literature review, data on previous studies on biomass briquettes and related topics is presented. In this chapter the reader will also gain information on how much knowledge has already been gathered on this topic.

In Chapter Three, the design approach, we will show the reader how the project was planned and executed. In this chapter we will show the various calculations and analyses which were undertaken ensure the proper working of the project. The experimentation done to verify our assumptions will also be presented in this section.

In Chapter Four, the results of the project will be presented, and the results will be compared against the aims and objectives of the project. Any shortcomings will also be discussed in this section.

In Chapter Five, the conclusions of this project will be presented and any further courses of action or recommendations will also be given to the reader.

CHAPTER 2

LITERATURE REVIEW

2.1 Biomass as an energy source

Biomass has been advocated as an alternative energy source for many years now. USA alone uses > 30% of their maize crop for ethanol production. Brazil uses huge quantity of sugarcane for biofuel production that has significantly reduced the country's dependence on fossil fuels. For Pakistan where there is currently a severe energy crisis, it is especially important to find alternative sources of energy [1]. In Bangladesh, rice husk is being used as an alternative energy source in small restaurants and in low-income households. Cotton sticks have also been proposed as an alternative energy source [2]. For these energy starved low income countries it is vitally important that they find an energy source which is cheap to obtain and which is also not harmful for the environment. Leaves are a great source of energy as they are cheap to obtain and they are carbon-neutral when they are burnt. It has been researched that leaves have a calorific value on average of about 1677740 J/g. In America that leaves of oak leaves have calorific values of 18,200 J/g. With a growing awareness in Pakistan for the planting of trees, such as the billion tree tsunami in the province of Khyber Pakhtunkhwa, it is natural that leaves will be available in massive amounts all around the country.

2.2 Biomass Briquetting

To be able to use biomass efficiently as a fuel, the concept of briquetting has been introduced all around the world [3]. A briquette is a compressed block of coal dust or other combustible biomass material such as charcoal, sawdust, wood chips, peat, or paper used for fuel and kindling to start a fire. This allows the energy source to be greatly compressed which ensures that it is easy to handle and transport. Previously briquettes have been created using various fuels such as rice straw and sugarcane leaves. Briquettes of these two fuels have shown to have an average gross calorific value 17,000 kj/kg [4]. In the fabrication of our machine it is important, that an approximate compressive strength capacity is taken from previous briquetting machines. A study in Bangladesh has shown that on average 110 bar is required to fully compress the biomass [2]. Many studies have also been done on sawdust and cornstalks been used briquetting machines. However, there are very few research papers available which are focused on the compression of dried leaves. Although there are some commercial leaf-logging machines available in the US and in the UK, there is no scientific proof available for these machines. The major use of biomass briquettes in India, is in industrial applications usually to produce steam [5]. A lot of conversions of boilers from FO to biomass briquettes have happened over the past decade. Although there has been criticism that large amounts of land are required to grow these biomasses, it is a viable solution in countries which have high population densities as large amounts of biofuel is available for use as an energy source.

The use of biomass briquettes is strongly encouraged by issuing carbon credits. One carbon credit is equal to one free ton of carbon dioxide to be emitted into the atmosphere. India has started to replace charcoal with biomass briquettes in regards to boiler fuel, especially in the southern parts of the country because the biomass briquettes can be created domestically, depending on the availability of land. Therefore, constantly rising fuel prices will be less influential in an economy if sources of fuel can be easily produced domestically. Lehra Fuel Tech Pvt Ltd is approved by Indian Renewable Energy Development Agency (IREDA), is one of the largest briquetting machine manufacturers from Ludhiana, India [5].

Pangani, Tanzania, is an area covered in coconut groves. After harvesting the meat of the coconut, the indigenous people would litter the ground with the husks, believing them to be useless. The husks later became a profit center after it was discovered that coconut husks are well suited to be the main ingredient in bio briquettes [6]. This alternative fuel mixture burns incredibly efficiently and leaves little residue, making it a reliable source for cooking in the undeveloped country. The developing world has always relied on the burning biomass due it its low cost and availability anywhere there is organic material. The briquette production only improves upon the ancient practice by increasing the efficiency of pyrolysis [6].

2.3 Biomass Binder

To ensure that the leaves properly compressed together a binder will have to be added to the leaves. It is also important that the binder is eco-friendly to ensure that no pollutants are released when the leaf log is burnt. There have been studies on many binders. A study has been done on the preparation of a binder from sunflower stalk hydrolysis residues. Although it has shown promising results, it is unfeasible due to unavailability of large amounts of sunflower stalk [7]. The use of sawdust as a binder has also been investigated. However, corn starch as a binder shows really good results which makes it suitable for use in our project. Another benefit of using starch as a binder is that it is widely available, it is relatively cheaper and research has shown that it has the least effect on the environment when it is burnt [4]. Microalgae is also being used a binder. A study has shown that it has outperformed starch and enhanced biomass binders in terms of durability, energy values and a slower mass loss when the briquette is combusted. [3] However, due to the difficulty in growing and handling microalgae it is an unrealistic option at the present time.

CHAPTER 3

METHODOLOGY

From the literature review, we can see that a minimum of 120 bar pressure is required to properly form a leaf log. To verify our research, we designed and fabricated a small testing unit through which we used an industrial hydraulic press to verify how much pressure we would require to make a leaf log.

3.1 Testing unit

For verification purposes, a mold was fabricated along with a plunger. The mold had a diameter of 4 inches and a length of 8 inches. The material used for the mold and the plunger was mild steel. The plunger also had a diameter of 4 inches. The compressing mechanism used with this test unit was an industrial hydraulic press which had been already installed at the Manufacturing Resource Centre at SMME, NUST. After creating 3 small leaf logs and taking the gauge readings, we came to the conclusion that 120 bars was the required pressure for creating a sturdy leaf log.

Figure 1: The parts of the testing unit

To achieve this amount of pressure we had a couple of options available to us. The first option which we researched was the slider crank mechanism which would be attached to a motor which would cause a piston to move in a reciprocating fashion. The details regarding this mechanism are shown below:

3.2 Slider Crank Mechanism

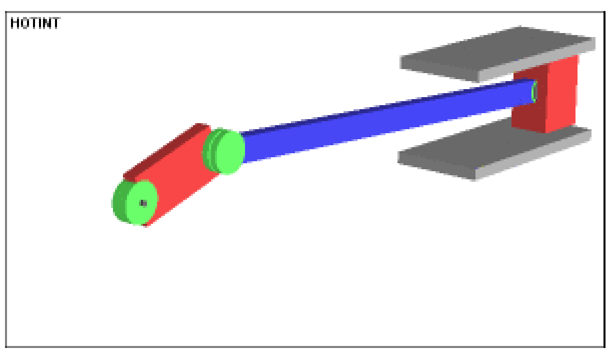

Figure 2: Model of Slider Crank Mechanism

In this mechanism the circular motion of a motor is converted into a reciprocating motion. The main advantage of this mechanism is that the motion is directly converted and it is also easier to assemble and fabricate. However, the main disadvantage of this mechanism, which we have seen through our calculations is that it is very difficult to generate the required 120 bar of pressure without installing a very powerful motor. However, due to our relatively low budget, we were unable to afford such a mechanism. Another major disadvantage of this mechanism is that it has a fixed top-dead and bottom-dead center, which would greatly hinder our ability to compress the leaves.

The second mechanism which we considered was the scotch-yoke mechanism.

3.3 Scotch Yoke Mechanism

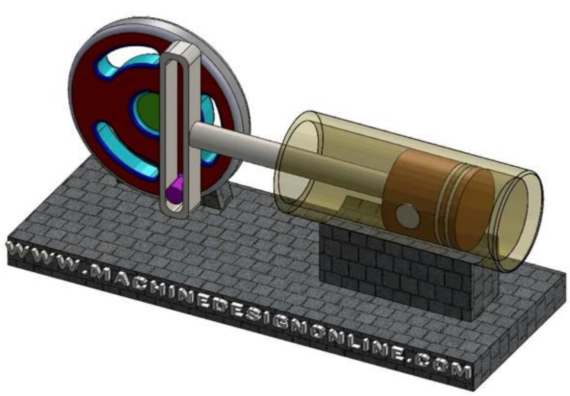

Figure 3: Model of Scotch Yoke Mechanism

As with the slider crank mechanism, the scotch yoke mechanism also converts the rotary motion into a linear reciprocating motion. Its main advantage, when compared with the slider crank mechanism was that it could easily deliver more power than its counterpart with a similar amount of input power. However, its main disadvantages are that it has a significant amount of friction which is not suitable for a continuously running machine and it also has a fixed top-dead and bottom-dead center which is detrimental to our aim of compressing the dry leaves. Therefore, due to these massive disadvantages we decided against adopting this mechanism.

3.4 Hydraulic Cylinder Mechanism

The third mechanism which we considered was the hydraulic cylinder mechanism. In this mechanism a unidirectional force is given through a unidirectional stroke. This stroke is given due the pressure by a hydraulic fluid which is turn driven by a hydraulic motor. This mechanism has numerous advantages. One of the main advantages is that this mechanism has the capacity to produce a large amount of pressure with the help of a moderately powerful motor. Another advantage of this mechanism is that it does not have a fixed top-dead and bottom-dead center which is perfect for our application of compressing dry leaves.

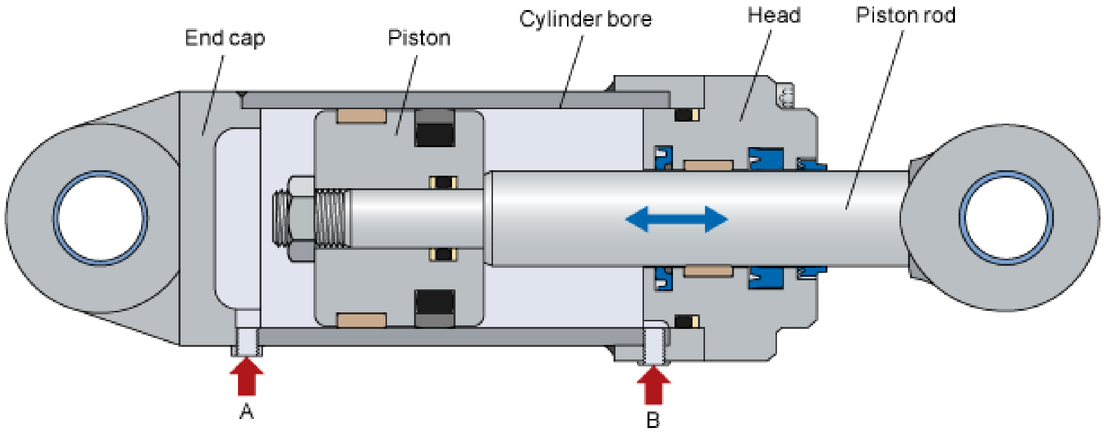

Figure 4: Model of Hydraulic Cylinder Mechanism

3.5 Calculations for the hydraulic cylinder mechanism

Using the following formula, we first calculated the required force to create a log of a diameter of 6 inches.

$$F_{Push} [kN] = \frac{p_K [bar] * \pi * d_K^2 [cm^2]}{400}$$

From this formula we calculated the required force to be equal to 219 Kn.

Since we intended to install a double acting cylinder, which meant that we would use the hydraulic pump to move it in both directions, we also had to calculate the force required to pull the hydraulic cylinder back. This was done by using the following formula:

$$\mathbf{F}_{Pull}\,[kN] = \frac{\mathbf{p}_{St}\,[bar] \star \pi \star (\mathbf{d}_K^2\,[cm^2] - \mathbf{d}_{St}^2\,[cm^2])}{\mathbf{400}}$$

The Pull force was found to be equal to 190 Kn.

Since the desired length of the log was 9 inches, it was decided that the stroke length of the hydraulic cylinder would be 2 feet. This was done to ensure that there was enough room in the machine to allow the leaves to be inserted while also ensuring space in the machine in which the leaves were compressed. Using this data, we were able to calculate the oil volume necessary for a single piston stroke using the following formula:

$$\mathbf{V}_{St}\,[cm^3] = (\mathbf{d}_K^2 - \mathbf{d}_{St}^2)\,[cm^2] \star \frac{\pi}{4} \star \mathbf{stroke}\,[cm]$$

Using this formula, the volume of oil required for one piston stroke was calculated to be equal to 11,491 cm^3.

Using these values, we were also able to calculate the volume flow rate and the required power using the flowing formulae:

$$Q = n \cdot V_{\text{stroke}} \cdot \eta_{\text{vol}}$$

$$P = \frac{n \cdot V_{\text{stroke}} \cdot \Delta p}{\eta_{\text{mech}}}$$

From our calculations we found the required power to be 2100 W which is equivalent to 2.82 mechanical horsepower. Using this data, we decided that the suitable horsepower will be 3 hp.

After surveying the market, we found a suitable motor which had specifications of a 3 horsepower motor. This was a single-phase motor which operated on 220 Volts. Due to the high cost of a new motor, we decided to procure a used motor which was in good condition. In addition to the motor, we obtained a hydraulic pump, a 5 Liter storage tank for storing the excess hydraulic oil, a pressure gauge and a pressure relief valve. To allow the piston to move back and forth a distance of 2 feet, we also obtained a jack of similar length.

The next step after obtaining these components was to choose the material with which we would construct the frame and to also choose a binder which would aid in keeping the leaves together and which was environmental friendly itself.

Figure 5: The motor, hydraulic pump and other components

Using the modelling software Solidworks, we also created a model which accurately represented all of the parts and also all of the dimensions.

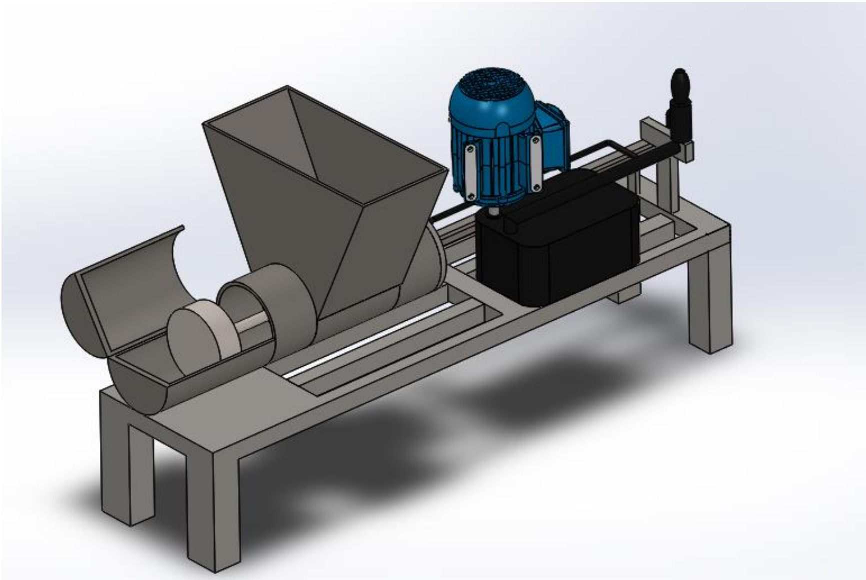

Figure 6: The Solidworks model of the machine

3.6 Selection of material for Frame

To ensure a safe and sturdy structure it was imperative that we chose the right material for our machine. For this purpose, we undertook a comparative study of different materials available in the market. After taking a survey of the market we found that the two most common materials available in the market were mild steel, cast iron and aluminum. So it was natural that we would compare all three of these materials.

3.6.1 Mild Steel

Table 1: Properties of Mild Steel

Mechanical Properties	Metric	Imperial
Hardness, Brinell	126	126
Hardness, Knoop (Converted from Brinell hardness)	145	145
Hardness, Rockwell B (Converted from Brinell hardness)	71	71
Hardness, Vickers (Converted from Brinell hardness)	131	131
Tensile Strength, Ultimate	440 MPa	63800 psi
Tensile Strength, Yield	370 MPa	53700 psi
Elongation at Break (In 50 mm)	15.0 %	15.0 %
Reduction of Area	40.0 %	40.0 %
Modulus of Elasticity (Typical for steel)	205 GPa	29700 ksi
Bulk Modulus (Typical for steel)	140 GPa	20300 ksi
Poissons Ratio (Typical For Steel)	0.290	0.290
Machinability (Based on AISI 1212 steel. as 100% machinability)	70 %	70 %
Shear Modulus (Typical for steel)	80.0 GPa	11600 ksi

3.6.2 Cast Iron

Although cast iron has similar properties to mild steel, it is very expensive to use as all of the parts have to be casted individually if cast iron is used. Another drawback of cast iron is that it is highly susceptible to rusting when the humidity is higher than 65%. Due to addition of binder in leaves it is natural that the compression cylinder will have a high amount of humidity inside it. Another disadvantage of cast iron is that it is hard, brittle and nonmalleable which also makes it suitable for our application.

3.6.3 Aluminum Alloy

One of the most highly valued feature of the Aluminum Alloy is that it is very lightweight as it has a density which is one third of steel. Aluminum has a similar strength to mild steel however it has a disadvantage that when it is operated continuously at temperatures above 100°C, the metal is significantly weakened. Since our operation might involve high temperatures this is a major drawback for us. Aluminum is also suitable for many machining operations such as milling, drilling and cutting. However, after comparing its similar properties with mild steel and taking into account its relatively high cost when compared with mild steel, we decided to go with mild steel for our frame and procured the required amount of it.

3.7 Selection of biomass binder

From our literature review, we have seen that there are various options available to choose from. They are microalgae, sawdust and corn starch. Although microalgae has shown extremely promising qualities as a binder, it very difficult to grow and handle. Therefore, the two realistic options for us are sawdust and corn starch. The major disadvantage of sawdust is that it is not widely available, it is more difficult to handle and it is relatively more expensive than corn starch. The main advantage of corn starch is that it is very cheap, it is widely available in most countries and there are also suitable alternatives available. Another advantage of corn starch is that it is environmentally friendly.

3.8 Conclusion

In this section, we have first discussed the testing unit which was fabricated to verify our literature review. After this, we did a comparative analysis between three mechanisms and discussed the advantages and disadvantages of all three mechanisms. After we selected the hydraulic compression mechanism, we made some calculations to determine the power which would be needed to exert the required pressure. From this we determined the specifications of the motor which needed to be procured. Lastly, we did a comparative analysis for choosing our material and or biomass binder

CHAPTER 4

RESULTS

After obtaining the various components and materials of our machine, we immediately started the manufacturing phase by overseeing the various the various manufacturing processes at a local workshop. The machine was completed well in time for internal FYP defense. The machine is shown below:

Figure 7: The final version of the machine

The machine had a final weight of 30 kg. The high weight was mainly due to the motor and the mild steel compressing compartment. If we had used aluminum instead of mild steel, the weight would have been reduced considerably, however due to budgetary concerns we were unable use this option. The final length of the machine was 4 feet, its width was 17 inches and the height of the machine was 2 feet. This proves that this machine is easily movable and it is also easy to operate. The machine is operated through a two-way valve which allows the user to control the displacement of the ram. A possible improvement is if the system is automated with the help of sensors which would make it even easier to operate.

The machine was successfully able to construct a leaf log of a diameter of 6 inches and a length of 9 inches. The maximum length is 9 inches due to the mechanism through which the log is pulled out is only 9 inches long. However, a tangible feature of this machine is that the user can also create smaller logs by inputting a smaller amount of leaves into the machine.

One problem we faced was the bending we faced in center of structure when we begin our operation. Since we had a 10 ton hydraulic compressor mechanism it was understandable that such huge force will inevitably affect the structure.

To counter this problem we welded angled irons across two legs in length of greater dimension in parallel. Then we connected these parallel angled iron rods by welding another one in center. This greatly diminished the bending problem we had and now maximum use of power provided can be ensured. Following figures shows the structure after welding angled irons.

Figure 8: Welded angled irons

We began our log making by connecting our machine to power source. Hydraulic motor is run by providing an electrical source. After initiation motor starts pumping the oil into respective hoses out of a fuel tank. Since however our hydraulic compression mechanism is manually operated by a lever. We can change the direction of movement of rammer either into forward or backward direction. Lever needs to be pressed by and kept in this state to move the rammer in either direction. When pressure is released, lever comes back into its original state and rammer stops moving. It is at this point we add dried leaves into hopper. We also sprinkle some binders onto it as well to attain more compactness in the log at the end. After packing the hopper with enough dried leaves, we press the lever and rammer carries the leaves forward and presses them against the front wall. We keep on pressing the rammer in forward direction to firmly compress the leaves. Then we press the lever in other direction and rammer starts moving backward. It clears the hopper area and then we stop its backward motion by releasing the pressure on lever. Again we add dry leaves into hopper and sprinkle them with liquid binder. Then these leaves are compressed against the already compressed cake of leaves. We can add as many leaves as we like and get the log of our desired length depending upon the application it will be used for.

A 9 inch log typically takes 8-10 minutes to be made. At the end, motor is turned off by disconnecting the power source. Lid of front portion is opened where leaves are compressed against. We saw that the dried leaves we threw in hopper along with binder takes the form of a log. Log appears black in some areas. It is due to liquid binder we added while throwing leaves into hopper. Though the liquid binder gave more compactness to the log, it affected the aesthetics of our log. However shape, strength and size of our log is same as we desired and targeted initially.   Following figure below shows the state of the leaf log right after compression takes place.

Figure 9: A log produced by leaf log maker

Figure 10: A log produced by leaf log maker

We finally got the log we aimed for. However, we would not recommend to use the log in this state. Log, though as compact as it is, has some debris on its surface in form of dust, dirt, grass or small leaves. It will be quite messy to use them at this point. Also it will be damp in some areas due to liquid binder so drying is also recommended to accomplish better results on burning.

We now carried out the packing of log so that we can use them easily. After packing we can also store these logs so that they can be used later. Packing also makes the transportation of logs easier. There are number of options as to how to pack the logs. We made use of brown paper to protect it from humidity. We also packed one sample in polyethylene sheet to present it in our Open House 2017. Following figure shows the log just before packing is carried out:

Figure 11: A log produced by the leaf logging machine

Log is placed on a brown paper. Log is carefully wrapped with paper. Scotch tape or paper tape is used to bind the ends of paper together in order to obtain smooth wrapping. Following figure shows you our end product.

Figure 12: Log wrapped in paper

Since purpose of making these logs was to burn them up and obtain heat energy. So in order to check their flammability we threw few sample of these logs into open fire. A typical 9 inch log took around 20-25 minute to completely burn up. We can vary the sizes of logs (length) as well and different logs of different lengths will burn completely in different times. But more important than time is the energy or output we are getting after complete burning of one log. If we see this whole process in terms of input and output. One 6 inch diameter and 9 inch length log takes around 8-10 minutes to make. We calculated the energy required to keep motor running during this time. We found it to be 1100 kJ. But if we burn that log we will obtain 100,000 kJ of energy. So we are getting a massive output as compared to input in terms of energy.

However one downside of these logs is that these need to be thrown into an open flame. They cannot be lit on their own. Reason for it being that leaves are too tightly packed and heat needs to be applied from all sides and constantly to start burning process. Following figures show the burning of few logs:

Figure 13: Burning of leaf log

Density is another factor we kept in mind during making of these logs. It is important because leaves should be compact enough but not too tightly packed too. If density is too low i.e. larger spaces between leaves for a fixed volume, log will finished up burning more quickly. On the other hand if leaves are too tightly packed it might get difficult for oxygen to enter between crevices. The reason for it being that for something to burn heat and oxygen are needed. So lack of oxygen will not sustain the flame. We made few samples of logs of different sizes. However table below shows the range of densities for different logs. If volume is kept constant i.e. 254.34 in^3 for a 9 inch length and 6 inch diameter log, following table shows the range of densities we can target.

Table 2: Density of leaf log

Mass (kg)	Volume (m^3)	Density (kg/m^3)
3	0.00417	719.42
4	0.00417	959.23
5	0.00417	1199.04
6	0.00417	1438.84
7	0.00417	1678.65
8	0.00417	1918.46
9	0.00417	2158.27
10	0.00417	2398.08

CHAPTER 5

CONCLUSION AND RECOMMENDATION

In this project we have successfully designed and fabricated a leaf logging machine which has the ability to compress dry leaves into a log which has a length of 9 inches and a diameter of 6 inches.

First, through our literature review we researched previous developments into the briquetting of biomass and the various biomass binders which were used to aid the process of this binding. Then we fabricated a testing kit, through which we used an existing hydraulic press through which we verified how much pressure we required to adequately compress the dry leaves.

Then we did a comparative analysis of three possible mechanisms which we could have used to achieve the compression process. After this, we made some calculations through which we decided how powerful of a motor we needed and what type of hydraulic pump we needed. After this we made a comparative analysis of the different materials which we can use to fabricate the frame of the machine. Lastly, we made a comparative analysis of the different biomass binders which we could have used to aid in process of creating the leaf log.

After the fabrication of the machine, we were successfully able to create a leaf log which had a reasonable burning time.

The recommendations we would give to any further student, is that they should do a calorific test for the leaf log as we were unable to do this, due to the unavailability of the required testing kits. Another improvement which could be made to the machine is that it could be automated so that the ram moves forward and backward by itself, a sensor could also be added which would automatically stop the ram when the load passes a certain value, this would ensure the maintainability of the machine.

Another improvement which could be made on this machine is that a system could be installed which would automatically add the binder to the dried leaves. This would quicken the process of creating the leaf log as it would automate an important process.

Other biomass than dried leaves can be compressed in this machine and a study can be done on their properties which could provide an alternative solution for the energy crisis in Pakistan.

REFERENCES

[1] S. Javed, "The Energy Crisis In Pakistan: A Possible Solution Via Biomass-Based Waste," *Journal of Renewable and Sustainable Energy,* no. 8.4, 2016.

[2] M. E. e. a. Hussien, "Green Economy and Renewable Energy Focusing On The Biomass Energy Source," *Journal of Sustainable Development,* no. 9.3, 2016.

[3] Ahiduzzaman, "Rice Husk Energy Technologies in Bangladesh," *Agricultural Engineering International: The CIGR e-journal*, no. 9, 2007.

[4] A. e. a. Kumar, "A Review On Biomass Energy Resources, Potential, Conversion and Policy In India," *Renewable and Sustainable Energy Reviews,* no. 45, 2015.

[5] O. P. e. a. Bhatkar, "Design And Fabrication of Densified Biomass Briquette Maker Machine," *International Journal of Environment, Agriculture and Biotechnology,* no. 2.2, 2017.

[6] Sakkampang and Chatcharin, "Design Of Briquettizing Machine For Biomass Briquette Fuel," *Advanced Science Letters,* no. 13.1, 2012.

[7] Pandey and Sudip, "Analysis And Test Of Biomass Briquette And Stoves," *Nepal Journal of Science and Technology,* no. 14.1, 2013.