ME 555 FINAL PROJECT REPORT

OPTIMIZATION OF A MODIFIED COMPACTION PRESS

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Abstract

A compaction press is a mechanical device used for compressing combustible materials into solid form for subsequent use as fuel. Charlie and Jason (2012) proposed a prototype made of wood which is very simple to use and relative affordable for those in the developing world. However, the bulkiness of this device poses a disadvantage in transportation to compaction sites. Hence there is need for improvement in its design. A collapsible device was then proposed by Ayinde et al. (2010). In this project, we further reduce the size of the device while keeping its mechanical advantage above that of Ayinde et al. (2010). The optimization results showed that the length of the upper beam member can be reduced by 13.5% and the length of each lower beam members by 21.4% while the constraint remained satisfied.

Key word: Briquette, optimized compaction press, modified compaction press, mechanical advantage

1.0 Introduction

Several means have been device to compress bales of wastepaper into a form that could be handled. It ranges from the use of primitive methods to the application of hi-tech equipment. The efficiency of each method however, varies. Jason and Charlie (2001) designed and fabricated a wooden press which can compress combustible material such as wastepaper. The wooden press can sufficiently compress wastepaper and other related materials. It is easy to understand and does not require special parts (as opposed to screw presses and hydraulic jack presses). However, the press is quite large and heavy so it is hard to transport and requires two people to run it efficiently. Also, this design only allows for pressing briquettes while some other designs can also be used as oil presses. The bulkiness of the press also culminates into high cost of transportation to wherever the briquetting process is to take place.

Also, moving the machine is rigorous and time-consuming. Overall, this makes the briquetting processes less economical. By reducing the length of the machine its bulkiness would decrease almost proportionately. This will culminate in reduced cost of production of press and its transportation to compaction sites. Also, it will reduce stress in transportation. Altogether, this will sum up in reduction in the overall cost of production of briquette and thereby reduction in its selling price.

2.0 DESIGN PROBLEM

2.1 Problem Statement

This project aims at minimizing the entire lengths of paper compaction press. Technically, this reduces the bulkiness of the machine. Moreover, it reduces its capital cost, its production cost and its market price. It equally reduces the stress that accompanies its movement from one place to another and the cost of transportation. This reduces the cost of production of paper briquette and eventually makes it more affordable to the consumer. Jason and Charlie (2001) came up with this press on which optimization is carried out.

2.2 Mathematical Model

Notations

Length of the upper beam member = u (cm)

Length of the lower beam member = w (cm)

Perpendicular height of the press (to the left) = h (cm)

Perpendicular height of the press (to the right) = r (cm)

Hinge length = l (cm)

Hinge perpendicular height = f (cm)

Lever length = v (cm)

2. 3 Objective function

The objective is to reduce the size of the press by reducing the lengths of upper and lower beam members.. That is the beam lengths of the optimized press would be proper fractions of the original lengths. In the process, there could be proportional change in the hinge dimensions

Minimized length of the upper beam = n*u

Minimized length of the lower beam = p*w

Where n, p are the reducing factors for the original beam

2.4 Constraints

The overall mechanical advantage, which is the ratio of force output to force input, for the optimized press must be at least equal to the mechanical advantage of the modified press.

Mechanical Advantage = $= \alpha = \alpha (l, w, u, \Theta)$

2.5 Design Variables and Parameters

2.5.1 Design variables:

Length of the upper beam member = u (cm)

Length of the lower beam member = w (cm)

2.5.2 Design parameter:

Perpendicular height of the press (to the left) = h (cm)

Perpendicular height of the press (to the right) = r (cm)

Hinge length = l (cm)

Hinge perpendicular height = f (cm)

Lever length = v

Summary Model

The objective of this project is to reduce the size of a paper compaction press. To achieve this, the upper and lower beam members would be minimized – these would be the variables while the height and hinge dimensions would be kept constant as parameter. In this model, the total mechanical advantage which is the area under the curve of mechanical advantage – angle of inclination ($\boldsymbol{\psi}$ on vertical axis against $\boldsymbol{\theta}$ on the horizontal axis) is a constraint. Its value for the optimized press must be at least equal to that of the modified press. The mechanical advantage computed using instant center method. Solid works and Microsoft excel are the software used in the optimization process.

Mechanical advantage = = α (l, w, u, Θ)

$\boldsymbol{\theta}$ = Angle of inclination of the lever arm with the horizontal

Minimized length of the upper beam = n*u

Minimized length of the lower beam = p*w

3.0 Design Optimization

- Compute the Mechanical Advantage ($\boldsymbol{\psi}$) of the press using Instance Center method
- Determine the MA at various angle of inclination ($\boldsymbol{\theta}$)of compaction arm
- The compaction arm is varied through fifty degrees angle in the modified press and in the optimized press
- Plot $\boldsymbol{\psi}$ against $\boldsymbol{\theta}$
- Calculate the area under the curve using Microsoft excel
- Replace hinges each of length 10.91in with combined hinge joints of lengths 9in and 11in

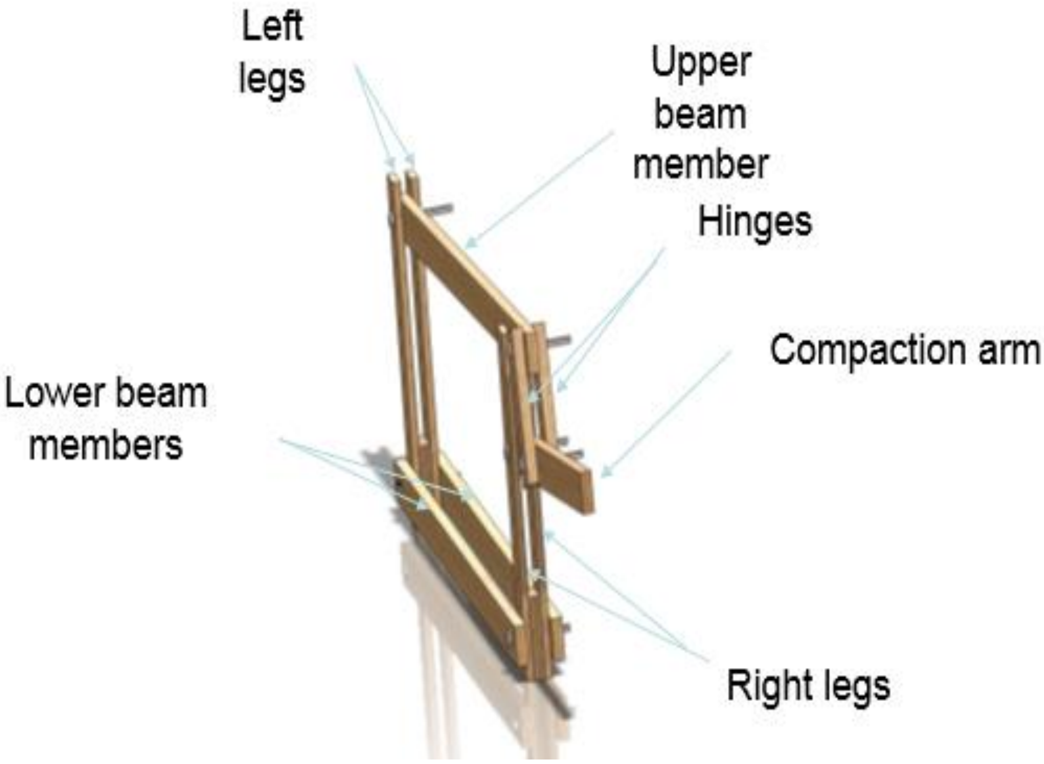

Figure 1. The Modified Compaction Press

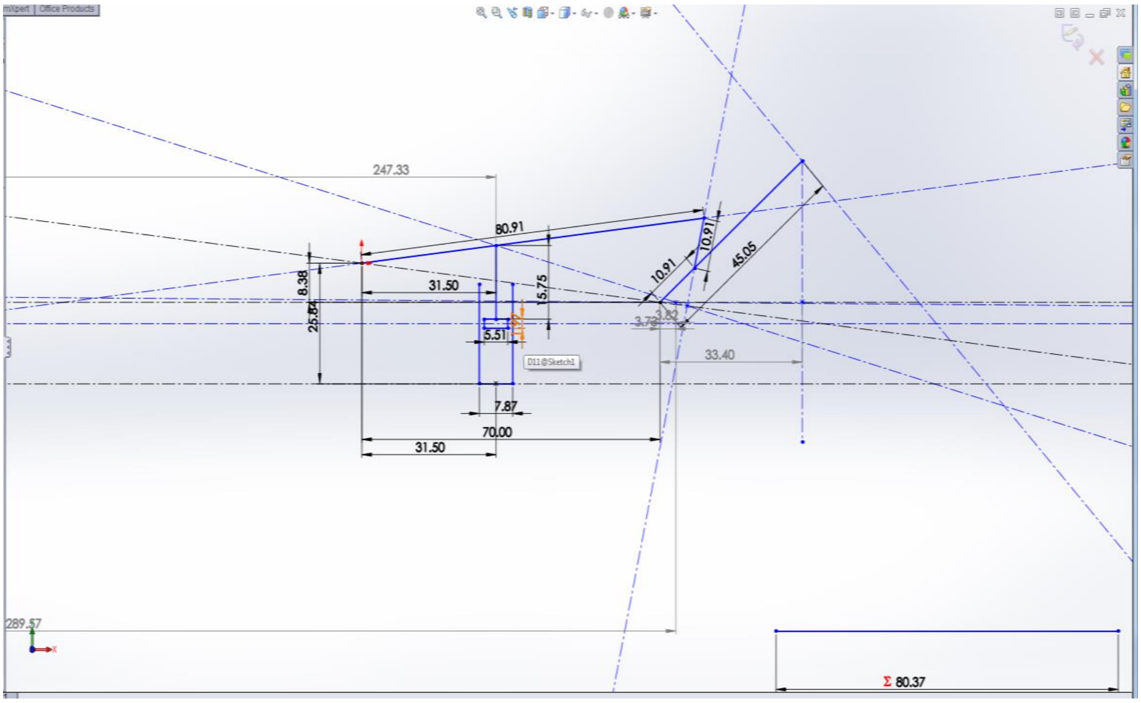

Figure 2. Solid works Sketch of the Compaction Press While Calculating Its Mechanical Advantage Using Instance Centre Method

3.1 Optimization Result

Mechanical advantage was estimated at some dimension of the Upper beam members and the lower beam members. The results are presented in the table below.

S/N	Length of Upper beam (in)	Length of Lower beam (in)	Mechanical Advantage
1.	80.91	70	22,989.34
***2.**	**70**	**55**	**46,966.94**
3.	70	65	16,838.45
4.	65	60	15598.55
5.	60	55	14301.15
6.	55	50	12955.34
7.	50	45	11516.39
8.	45	40	10162.75

Table 1. Mechanical advantage at some lengths of the upper and lower beam members

Check the figure files for more details

The asterisk (2) is selected as the optimal solution

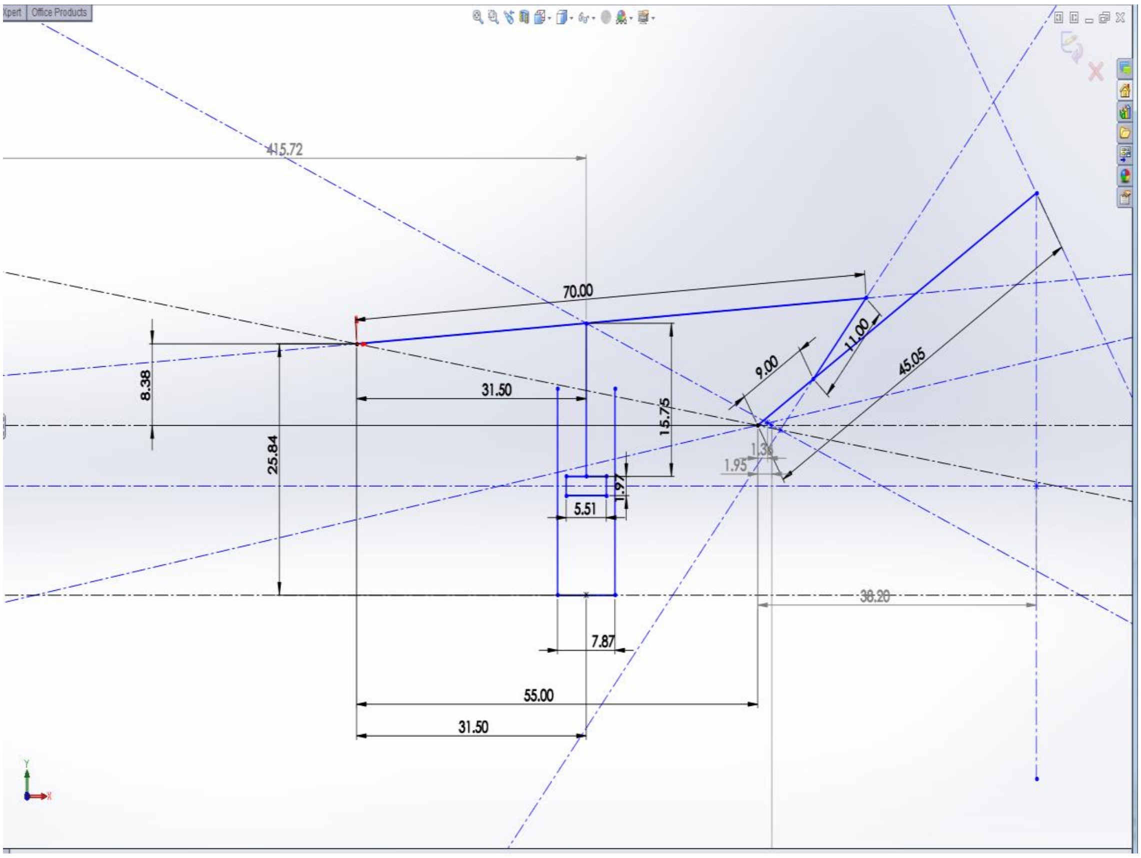

Figure 4. Solid works sketch for the optimized press

4. Discussion

The length of the upper beam member was reduced from 80.91in to 70 in. Similarly, the length of each of the lower beam members was reduced from 70 in to 55 in. That means the entire length of the press is reduced by more than ten percent. This indicate reduction of its bulkiness which make moving it become easier.

Similarly, the mechanical advantage of the optimized press, the ratio of the force output to force input, increases. That means our optimized press would compress more at the same force applied to the modified press

In practice, there may be adjustment in the optimized result. This is because there are some constraints which we do not put into consideration. For instance, overturning tendencies of the shorter press size was not factored in during the optimization work. Other conditions such as the strength properties of the materials used in the manufacturing process is not factored into the equation. To make the project more interesting, other constraints beside mechanical advantage such as inclination to overturning, ergonomics and the limitations due to the working principles of the press, to mention a few, would be taken into consideration. All these constraints were not active during the minimization process.

To improve the results during future work, these inactive constraints may be made active.

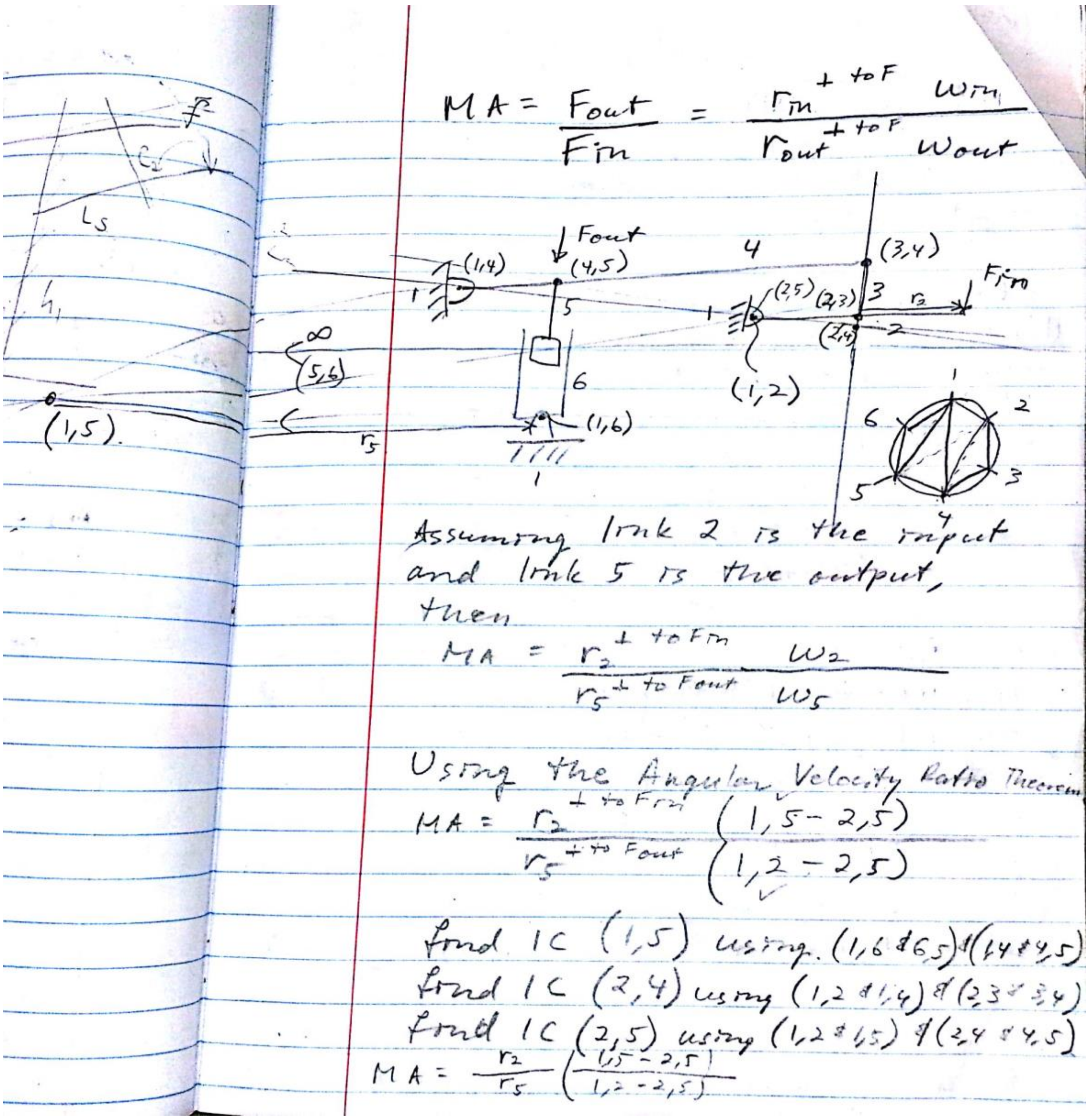

Figure 6. Freehand Sketch Used in the Computation of Mechanical Advantage Using Instant Centre Method

Reference

Ayinde S. O. 2010 Design, Fabrication and Testing of a Modified Paper Compaction Press using wastepaper generated within the faculty of Technology, University of Ibadan, Nigeria (Final year undergraduate project, not published)