DESIGN OF A MODIFIED HAND OPERATED MAIZE SHELLER

Case Study of Kapkoi Area, Kwanza Sub County, Trans-Nzoia County

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Introduction

- Maize is the most important cereal grain in the world, after wheat and rice.
- It provides nutrients, produces starch, oil and protein, alcoholic beverages, food sweeteners and, more recently, fuel.
- Analysis of maize processing mechanisms is therefore an important aspect to bring out that desired quality of maize.
Problem statement

• Removing the grain from the cob has been a time consuming and tedious process for the rural maize farmer.
• Traditional shelling methods do not support large-scale shelling of maize.
• Existing motorized shellers cause great damage to the maize seeds besides breaking the cob to pieces and are costly to hire or purchase.
• There is need therefore to develop a maize threshing technique to meet the shelling needs of such farmers.
Site analysis and inventory

- Maize cultivation is done on small scale (1 or 2 acres) and mostly by women (80%)
- Poverty as well as poor cultivation techniques result to low yields 20 sacks or less per acre
- Design composed of Shafts, flywheel, sheet metal, gears, angle steel bars, beater discs, crank handle and chain drive system.
Justification

A conventional maize shelling technique is vital since;

• The farmers practice subsistence farming.
• Hand shelling is time consuming and in most cases results to bruise injuries.
• The cost of shelling at ksh150 per bag using industrial maize shellers is expensive.
• Such industrial shellers are too expensive to be purchased by the rural farmers.
Objectives

Overall
The broad objective of this project is to design a modified hand operated maize sheller.

Specific
• To review existing maize shelling techniques in Trans-Nzoia county.
• To design a mechanical hand operated maize sheller.
• To establish energy requirement for operating the machine.
Statement of the scope

• This modified sheller is to be a manually operated equipment.
• Its work output will depend on the operator(s) as well as on the machine itself.
• This design therefore focuses on energy considerations to improve man-machine system efficiency.
• The energy parameters analyzed are Force, Torque and Power requirements in operating the machine.
Literature Review

• Shelling operations of maize follow harvest and pre-drying processes.
• The different methods of maize shelling are categorized based on mechanization technology. i.e: hand-tool-technology, animal technology, and engine power technology
• Existing shellers can be improved to reduce their limitations and drawbacks
Theoretical Framework

- An average moisture content of 15% to 18% is sufficient for maize threshing.
- Force required to thresh the maize is given by \( F = m \omega^2 r \)
- \( M = m_f + m_d + m_s + m_o \)
- The power delivered by the shaft is \( F \omega r \) or \( F \times v \)
- The Torque developed is given by the relation \( T = F \times r \)
- The relationship in the speed of the driver and driven gears of the spur gearing system is given by \( N_1, T_1 = N_2, T_2 \)
• Length of the chain is given by:

\[ L = p \left[ \frac{(T_1 + T_2)}{2} + 2m + \frac{\csc \left( \frac{180^\circ}{T_1} \right) - \csc \left( \frac{180^\circ}{T_2} \right)}{4m} \right]^2 \] = p.k

• \( m = \frac{x}{p}, \) \( x \)-centre to centre shaft distance

• \( p \) – pitch of chain

• Angular momentum of mounted flywheel

\( L = I \omega, \) where \( I \) is moment of inertia

• For a chain drive system;

\[ \frac{\omega_A}{\omega_B} = \frac{r_B}{r_A} = \frac{N_B}{N_A} \]
Design Methodology

The methods used in this design are in three phases:

• The collection of rural farmer sheller needs associated with agricultural operation.
• The design of an appropriate system to meet their needs.
• The determination on whether their problem will be solved.
Design Specifications

- Overall machine dimension (b x w x h) 1000mm x 690mm x 1500mm
- Length of chain to be 1500mm
- Shaft of at least 700mm in length and 40mm in diameter
- Hopper of Overall Height 520mm inlet allowance of 550mm by 30mm
- Crank handle of length 170mm and height 300mm
- Spur gears of gear ratio above 3, with the driven preferably being a freewheel cog gear
- Small/large sprockets (4-13 STD/8-23STD) respectively. (Table A1)
- Flywheel of at least 14kg in weight.
- Thresher discs of at least 20kg total weight
- Centre to centre shaft distance not less than 500mm
- Angle steel bars of 1.5" 1.5" and 2mm thickness
cob master maize sheller
# Bill of Engineering Measurement and Evaluation (BEME)

<table>
<thead>
<tr>
<th>S/N</th>
<th>Item</th>
<th>Description</th>
<th>Unit</th>
<th>Cost (Ksh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Sheet metal</td>
<td>16gauge mild steel sheet</td>
<td>7m * 3m</td>
<td>3100</td>
</tr>
<tr>
<td>2.</td>
<td>Bolts and nuts</td>
<td>M10</td>
<td>30pcs</td>
<td>900</td>
</tr>
<tr>
<td>3.</td>
<td>Solid shaft</td>
<td>mild steel(D,40mm L,730mm)</td>
<td>2pcs</td>
<td>2000</td>
</tr>
<tr>
<td>4.</td>
<td>Handle</td>
<td>With sleeve</td>
<td>1pcs</td>
<td>1000</td>
</tr>
<tr>
<td>5.</td>
<td>Gears</td>
<td>Spur gears driven being a free wheel cog gear</td>
<td>2pcs</td>
<td>1950</td>
</tr>
<tr>
<td>6.</td>
<td>Chain</td>
<td>Bush roller chain 1.5m long</td>
<td>1pcs</td>
<td>1000</td>
</tr>
<tr>
<td>7.</td>
<td>Big/small Sprockets</td>
<td>(D8”, D4”)</td>
<td>2pcs</td>
<td>1000</td>
</tr>
<tr>
<td>8.</td>
<td>Bearing</td>
<td>(D,41mm)</td>
<td>6pcs</td>
<td>1800</td>
</tr>
<tr>
<td>9.</td>
<td>Flywheel</td>
<td>D 360mm, d 41mm</td>
<td>1pc</td>
<td>1000</td>
</tr>
<tr>
<td>10.</td>
<td>Threshing unit</td>
<td>Thresher discs and spiked bar</td>
<td>1pc</td>
<td>5000</td>
</tr>
<tr>
<td>11.</td>
<td>Collector and pot</td>
<td>construction</td>
<td>1pc</td>
<td>1000</td>
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<tr>
<td>12.</td>
<td>Angle mild steel bars</td>
<td>11/2” by 11/2” and 2mm thick</td>
<td>4</td>
<td>1850</td>
</tr>
<tr>
<td>13.</td>
<td>Labour</td>
<td>-</td>
<td>-</td>
<td>5000</td>
</tr>
<tr>
<td>14.</td>
<td>Contingencies</td>
<td>-</td>
<td>-</td>
<td>1500</td>
</tr>
<tr>
<td></td>
<td><strong>TOTALS</strong></td>
<td></td>
<td></td>
<td><strong>28100</strong></td>
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</table>
## Results

<table>
<thead>
<tr>
<th>Crank speed (rpm)</th>
<th>( \omega = \frac{2\pi N}{60} ) (rads(^{-1}))</th>
<th>( F = m\omega^2 R ) (N)</th>
<th>( T = F \times r ) (Nm)</th>
<th>( P = F \times v ) (w)</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>4.19</td>
<td>263.34</td>
<td>7.9</td>
<td>331</td>
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<tr>
<td>50</td>
<td>5.24</td>
<td>412</td>
<td>12.36</td>
<td>650</td>
</tr>
<tr>
<td>60</td>
<td>6.28</td>
<td>591.58</td>
<td>17.74</td>
<td>1115</td>
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</table>

<table>
<thead>
<tr>
<th>Crank speed (rpm)</th>
<th>Modified Design (Calculated results)</th>
<th>Cob master Maize sheller (Performance results)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( T ) (Nm)</td>
<td>( F_{\text{crank}} ) (N)</td>
</tr>
<tr>
<td>50 rpm</td>
<td>12.36</td>
<td>412</td>
</tr>
</tbody>
</table>
Discussion of Results

- The rotational force of 8.5 kN in the beater discs represents a 48.82% increase in threshing potential compared to that of the cob master machine.
- The torque of 12.36Nm compared to 18Nm at 50rpm represents a 31.33% reduction in energy input also reflected by 20.59% reduction in crank Force energy input.
- The total cost of fabrication of the design's prototype (BEME) is affordable to a group of rural farmers or even individual farmers compared to the cumulative costs of service hiring or purchase of industrial shellers.
Conclusion

- Self-reliance is the major drive of development and vibrant economy.
- Design permits fabrication from locally available materials.
- The thresher can help to substantially reduce the human labour involved in threshing at an affordable cost and also reduces the time used for threshing operation on small farms.
- Energy requirements solely depend on the crank speed of operating the machine.
- There is no doubt that the machine will ease the long term problem of maize shelling especially for the rural farmers.
Recommendations

• Fabrication and construction of the machine from the design presented in this paper.
• Testing of the machine for its performance and efficiency at 50rpm handle cranking to compare the expected results and the achievable outcome.
• Incorporation of cleaning and separation device for the removal of unwanted material.
References

• ONI, K.C.; and ALI, M.A. 1986. Factors influencing the threshability of maize in Nigeria. Agricultural Mechanization in Asia, Africa and Latin America (AMA) 17(4): 39-44
Appendix
QUESTIONS INVITED

THANK YOU