Redesign and Optimization of Hub Profile of Fibrizer in Sugar Cane Industry

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ABSTRACT

Sugar cane factories began moving away from cane roller crusher in favor of cane fibrizer for achieving good cane preparation for extraction of juice from cane. Three main processes have been done on it, cane-knifing in chopper, cane-crushing in fibrizer, extraction of juice in milling. As per the capacity of the plant, fibrizer are changing in size & model, so which will result in high preparation index (PI). In this project swing-hammer type fibrizer is used, this will result in high preparation index (+85PI) & optimize in power consumption and cost. Purpose of this fibrizer is, sugar factories needs keep up with this technology & take advantages of less expensive, more reliable fibrizer drive design which will be easy in maintenance and operation. By using techniques of optimization and design, we modified old fibrizer by changing number of hammers and hubs profile. So results obtained with new assembly are better and aim of project has done with decreasing cost and power consumption as compared to old fibrizer.

Keywords — Cane Preparation, Fibrizer, Hubs, Optimization

I. INTRODUCTION

The equipment now generally used after knifing to complete the preparation of cane for extraction plant is fibrizer. Previously, initial knifing was followed by heavy crusher to break the cane further, but in this process much of cane was not properly prepared thus power consumption and losses were happened in factories. On overcome these issues lots of study have been done & technology upgraded in industries. So, factories are using fibrizer which produce high levels of preparation (greater than 85PI) & less consumption of power in processing. Previously, steam turbines were used for roller crushing instead of electric motors, now a day slip ring motors with high capacities are used for better operation & less maintenance, low power consumption. Swing-hammer type fibrizer is one of the best type of fibrizer is used in sugar factories for cane preparation and getting high PI. In this type rotating high speed hammers impacting on Cane to rupture it and open fiber cells for further milling process. In this fibrizer hammers are pivoted to hubs and hubs are mounting on shaft which will rotate on high speed, this whole assembly is covered by means of hose. Two objectives can best be achieved by use of swing-hammer type fibrizer are that canes are prepared better for achieving preparation index & operation have done in minimum potential energy and power. This total assembly is easy to mounting so that maintenance, performance, operation is simple & greater for sugar factory. Thus behavior of swing-hammer type fibrizer has become proper subject for study.

S.T. Inskip [1] has studied that there are genuine advantages to be gained from installing and fibrizer in terms of energy savings, installation and civil costs, maintenance savings and co-generation benefits that will factories to operate at higher level of efficiency. Hall DJ [2] replaced old motors with reliable, medium voltage and low maintenance, variable speed drives connected to robust to simple squirrel cage motors. Researchers studied life of hammer and new material for long life of hammer. M.G. Schembri [4] studied improving the understanding of cane preparation by measuring the process of power usage and cane size reduction through the shredder. Recycling the coarse components was found to raise the overall preparation from the 73 PI to 85 PI but the total power...
usage was less than conventional fibrizer. B. ST. C. Moor [6]
have experimentally design and commissioning of the first
of a new type of fibrizer while utilizing the results of recent
research and experimentation with conventional fibrizer, the
tongaat design incorporates several departures from the
traditional type of construction. These innovations yield
significant benefits in construction, maintenance and
performance.

A. zammit and M.G. Schembri [7] investigated the impact
properties of rubber as a material for fibrizer hammer
tips ,testing the impact properties of rubber against cane and
non-cane objects the rubber layers trailed were 6, 10 and 20
mm thick. Two rubber compounds were trailed one at 90
SDH and 70 SDH. They were found to withstand
considerable impact against metallic material and failed
when the impact loading was concentrated due to sharp
edges or corners on metallic objects. Loubser R C, Smith T
and Davis S B [8] investigated a hammerless shredding
technology an innovation which could take sugar cane
processing industry into the future, cane preparation without
knives and fibrizer.

S. Ostlund J.G. Loughran and T. Meyers
[14] a numerical investigation was made into the behavior
of tungsten carbide fibrizer hammer tips on impact with
tramp iron. Residual stress levels are predicted due to
thermal shrinkages associated with manufacturing. Both
analytical and finite element analyses are used to shed some
light on the stress wave phenomena occurring on impact.
This study reports on aspects of tungsten carbide design that
influence tip response at the time of impact
This technology is a complete break from past, knives
and shredder replaced by water, advantages on reductions in
maintenance and downtime, as there will be no more
wearing faces. A demonstration of the use of water jets for
preparation sugarcane.

I. ANALYSIS OF FIBRIZER ASSEMBLY

A. Calculations of Weight of Hub Assembly

1) Volume of one hub = 0.024m$^3$
2) Mass of one hub = 190kg
3) Weight of one hub = 1864 N
4) Total mass of one hub assembly = Mass of one hub +
   3x (Mass of Hammers + Mass of Bush) = 250 kg
5) Total mass of 57 hub assembly = 14250 kg

B. Calculation of Torque

Maximum power transmitted to the shaft of from motor is
3000kw at 750rpm,

\[
T = \frac{60 \times 10^6 \times 36}{2 \times \pi \times 756} \text{ N-}mm
\]

\[
T \approx 39 \times 10^6 \text{ N-}mm
\]

This is total torque produced by shaft of fibrizer.

C. Design Parameters of Fibrizer

In Fibrizer we cannot change swing diameter of hub i.e.
the length of one hammer tip to second hammer tip of hub,
if it has been changed the operation will not be done perfect,
so from design point of view we concentrate on thickness (t)
of hub profile. So thickness (t) is main parameter which has
to be changed.

So new fibrizer is considered on basis of hubs & hubs are
designed with minimum thickness which can safely operate
with that load. Main objective of this consideration is to
decreased total assembly weight & reduced power
consumption.

In the table I, details of hub for study of fibrizer has been
mentioned.

<table>
<thead>
<tr>
<th>Parameters of Hub</th>
<th>Old Hub</th>
<th>New Hub</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness (t) mm</td>
<td>52</td>
<td>40</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>310</td>
<td>190</td>
</tr>
<tr>
<td>Pitch Circle</td>
<td>1600</td>
<td>1600</td>
</tr>
<tr>
<td>Diameter (mm)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Swing Diameter (mm)</td>
<td>2340</td>
<td>2340</td>
</tr>
</tbody>
</table>

D. Comparison of Fibrizer

From the above Considerations for Selecting New
fibrizer, Power Consumption for new one is less than old
fibrizer. In new fibrizer 3000kw motor is used instead of
3500kw because total assembly weight is reduced by nearly
2800 kg. In the below table II comparison of fibrizer is
given for study of optimization.

<table>
<thead>
<tr>
<th>Name of Parts</th>
<th>Old Fibrizer</th>
<th>New Fibrizer</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of Hammers</td>
<td>172</td>
<td>171</td>
</tr>
<tr>
<td>No. of Hubs</td>
<td>44</td>
<td>57</td>
</tr>
<tr>
<td>No. of Leafs of hub</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Total weight (kg)</td>
<td>21300</td>
<td>18500</td>
</tr>
<tr>
<td>Power (kw)</td>
<td>3500</td>
<td>3000</td>
</tr>
</tbody>
</table>

From above table, weight reduction in new fibrizer has been
done with changing the profile of hub & number of hub
leafs, so factors affecting the operation are changes, power
consumption is also reduced & material cost is also
decreased.
E. Fibrizer Configurations Used for the Test Program

In below table III configurations of fibrizer for test program consisted of replicated trials of three fibrizer conditions for three varieties of cane. The varieties (and fibre content in brackets) were Q124 (11.4%), Q138 (14.8%), and Q190 (14.1%).

<table>
<thead>
<tr>
<th>Fibrizer Condition</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hammers</td>
<td>A. Front wall and grid bar section removed. The shredder Consisted of the hammers only.</td>
</tr>
<tr>
<td></td>
<td>B. Front wall installed no grid bar. Leading edge of front wall (anvil bar) set approximately 45 mm from hammers.</td>
</tr>
<tr>
<td>Grid bar</td>
<td>C. Front wall and grid bar installed, i.e. standard shredder configuration. Grid bar set at 0 mm.</td>
</tr>
</tbody>
</table>

From above table III descriptions and test were conducted figure 1 is plotted, with hammers preparation of index is low, so by using front wall is high than previous and with using grid bar is higher than other two conditions.

A. Three Leaf Hub Profile

Following models show new hub profiles made in CATIA software. Fig.2 shows 3 leaf hub profile with thickness of 40mm with boss and having weight 190kg.

![Fig. 2 Three Leaf Hub Profile (New Profile)](image1)

B. Four Leaf Hub Profile

The following figure shows old 4 leaf hub profile with thickness of 52mm with boss and having weight 310kg.

C. Difference between New and Old Hub Profile

<table>
<thead>
<tr>
<th>Details</th>
<th>New Hub Profile</th>
<th>Old Hub Profile</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of Hubs</td>
<td>57</td>
<td>44</td>
</tr>
<tr>
<td>No. of Leafs</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Thickness of Hub</td>
<td>40</td>
<td>52</td>
</tr>
<tr>
<td>Weight of Hub</td>
<td>190kg</td>
<td>310kg</td>
</tr>
</tbody>
</table>

D. ANSYS Result of Hub Profile

ANSYS result has been shown in fig.4.

![Fig. 4 ANSYS Result of Hub Profile](image2)
In above figure Von – Mises stresses shown which is transmitted from shaft to hub, Over entire length of shaft stresses are changes from minimum to maximum and it is under the highest value of stresses. Maximum stress on shaft is 6.3232 MPa and minimum is 1.6048 MPa. Stresses on hub which is due to shaft rotation is minimum, hence is clearly indicate that design of new hub is safe and it can be used in new assembly.

II. CONCLUSIONS
Fibrizer in sugar cane industry constitutes most important part of cane preparation. So modifications are helpful in fibrizer and it updated day by day. This project have achieved its original aims, and shown that redesign and optimization in hub by changing its profile to three leafs gave better results in operation. Weight has been reduced in new hub and also material is saved so that the cost of project is also reduced. Total weight reduced is nearby 2800kg. Total assembly mass of fibrizer is reduced so power consumption is decreased with compared to old one, motor used in new fibrizer operation is 3000kw instead of 3500kw as in old one. So cost of new motor is also less than old motor. Study in ANSYS has shown that stresses on hub gave safe results. Stresses on hub are minimum having value 1.6048 MPa and it is under the maximum value 6.3232 MPa, so it is safe. Hence new hub profile is modified and it is safe in operation. This will help in increasing efficiency of industry.

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