FABRICATION OF HIGH PRESSURE ROTORVANE FOR
QUALITY IN ORTHODOX TEA PROCESSING

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Abstract - Orthodox processed tea refers to loose large whole particle tea leaf produced using traditional (or orthodox) methods of tea production, which involve plucking, withering, maceration/rolling, oxidation/fermentation and drying. Current orthodox tea technologies produce teas of very low quality but have large loose-leaf particle teas preferred by Orthodox tea consumers. Conventional black tea process includes CTC (Cutting, Tearing and Curling) which replaces the rolling stage in the Orthodox tea processing. The CTC tea manufacturing process produces high quality teas but is dusty making the tea undesirable to some consumers. From pilot plant laboratory trials, it was found out that the higher the Rotorvane pressure the higher the Orthodox made tea quality up to an optimum at 25 MN/m², which gives the highest quality on Taste (T), Colour (C) and Mouthfeel (M) scores matching CTC made tea quality. Design of the high pressure Rotorvane [1] was done to determine minimum parameters required. This research paper is on fabrication of high pressure Rotorvane as per the design for quality improvement of large leaf teas. The fabrication is expected to produce Orthodox Large Particle Tea that looks and feels like orthodox large leaf tea but has the liquor characteristics, when infused and tasted, matching conventional CTC made tea quality.

Keywords: Rotorvane, Orthodox Tea, CTC, Black Tea, Maceration

1. INTRODUCTION

The conventional CTC black tea process involves withering finely plucked leaf from 78% moisture content to 70 ±2% moisture content (Coyle, 2006). The withered leaf is passed through a standard Rotorvane at a pressure of about 5MN/m² (Coyle, 2006). The macerated leaf (ex-Rotorvane) is passed through an 8 - 10 tpi triplex CTC, fermented for 2 hours before drying and sorting into various grades (Coyle, 2006).

The black tea process flow chart is as shown below:

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Green Leaf → Withering → Maceration → Cutting (CTC) → Fermentation
          ↓                                           ↓                  ↓
          |                                           |                  |
          Dispatch → Packaging → Bulking → Sorting → Drying
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Fig. 1: Black Tea Manufacturing Process (Coyle, 2006).

Fig. 2: CTC process (Coyle, 2006)

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CTC (cutting, tearing and curling), at the cutting stage, in conventional black tea process opens up catechins in plant cells in leaves that later oxidises in the fermentation stage thus producing high quality teas with good attribute of taste (flavour), hue/colour and mouthfeel when infused (Owuor et al., 1989). CTC teas are dusty making the tea undesirable to Orthodox tea consumers who prefer large whole leaf particle teas (Teacupsfull, 2018). However, current orthodox tea technologies produce teas of low quality because the process releases less catechins in plant cells during the rolling process.

The aim of this research paper is to fabricate a high pressure Rotorvane for Orthodox tea processing as per existing design [1] that will subject the withered leaf to a high pressure above conventional manufacturing pressure of 5 MN/m² to rapture leave plant cells so as to release the catechins for the fermentation process. This will lead to elimination of CTC process and production of orthodox large particle teas that looks and feels like orthodox large leaf tea and has the liquor characteristics matching CTC tea quality when infused.

II. STATEMENT OF THE PROBLEM

Orthodox tea consumers prefer large whole leaf particle teas (Teacupsfull, 2018). However, current orthodox tea technologies produce teas of very low quality because the process releases less catechins in plant cells but have large loose-leaf particle teas preferred by Orthodox tea consumers. The CTC cutting process produces high quality teas when infused but are dusty making the tea undesirable to some consumers (Teacupsfull, 2018). The CTC process releases more catechins in plant cells which enables oxidation at fermentation, and brings about flavour, colour, brightness and mouthfeel in made tea quality. Therefore, a
process that produces black tea that looks and feels like orthodox large leaf tea but has the liquor characteristics matching CTC made tea quality is required. High pressure Rotorvane has been designed [1] and needs to be fabricated before commissioning it to check impact on quality of Orthodox made tea.

III. MATERIALS AND METHODS

3.1 Equipment and Experiments Set up

The fabrication and assembly were done in Unilever Tea Kenya Limited, Kerenga Engineering workshops in November and December 2018. High pressure Rotorvane parts and components required were determined as per the design [1]. The items were either fabricated / machined at Kerenga engineering Unilever workshop or sourced as per the approved design [1] from relevant suppliers. All the materials were sourced locally (within Unilever Engineering stores or bought locally within Kenya from importers of tea processing equipment and parts). Standard Rotorvane parts were re-used, where the design allowed.

The following Equipment and materials were used in the fabrication and testing of the high pressure Rotorvane:

- Standard 15” diameter Rotorvane parts, accepted into the design. These included:
  - Standard gearbox pulley
  - Gearbox pulleys
  - Keys and keyways
  - Rotorvane shaft
  - Shaft flanges
- Purchased high pressure Rotorvane parts. These include:
  - 30 kW motor
  - 30 kW gearbox
  - Brass iris plates
  - Rotorvane motor pulley.
  - 4 pieces of B118 rubber 'V' belts.
- Pressure (stress) sensor
- Lathe machine
- Chain block and overhead crane
- Drilling machine
- Shaping machine
- Grinder
- Milling machine
- Welding machine
- Transport Vehicle

The designed high pressure Rotorvane was assembled as per the design parameters obtained [1] and tested dry, ready for commissioning with green leaf.

3.2 Design Parameters

The following were minimum design parameters for high pressure Rotorvane [1].

<table>
<thead>
<tr>
<th>Part</th>
<th>Material</th>
<th>Standard Rotorvane (Rv)</th>
<th>High Pressure Rotorvane Requirements</th>
<th>Recommendation / Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power</td>
<td>Cast Iron</td>
<td>15 hp (11 kW)</td>
<td>40 hp (30 kW)</td>
<td>Purchase 30 kW motor</td>
</tr>
<tr>
<td>Gearbox</td>
<td>Cast Iron</td>
<td>15 hp (11 kW)</td>
<td>40 hp (30 kW)</td>
<td>Purchase 30 kW gearbox</td>
</tr>
<tr>
<td>Barrel (wall) thickness</td>
<td>Cast Iron</td>
<td>13 mm</td>
<td>12 mm</td>
<td>Standard RV barrel to be used</td>
</tr>
<tr>
<td>Iris plate thickness</td>
<td>Brass</td>
<td>15 mm</td>
<td>19 mm</td>
<td>New iris plates to be fabricated</td>
</tr>
<tr>
<td>Motor Pulley diameter</td>
<td>Cast Iron</td>
<td>152 mm</td>
<td>216 mm</td>
<td>New motor pulley to be fabricated</td>
</tr>
<tr>
<td>Gearbox pulley diameter</td>
<td>Cast Iron</td>
<td>398 mm</td>
<td>398 mm</td>
<td>Standard gearbox pulley to be used</td>
</tr>
<tr>
<td>Number of 'V' belts</td>
<td>High tensile Rubber</td>
<td>4</td>
<td>4</td>
<td>No change in number of 'V' belts</td>
</tr>
<tr>
<td>Pulley width</td>
<td>Rubber</td>
<td>89 mm</td>
<td>89 mm</td>
<td>No change in pulley width</td>
</tr>
<tr>
<td>Part</td>
<td>Material</td>
<td>Standard Rotorvane (Rv)</td>
<td>High Pressure Rotorvane Requirements</td>
<td>Recommendation / Remarks</td>
</tr>
<tr>
<td>-----------------------------------</td>
<td>------------------</td>
<td>-------------------------</td>
<td>--------------------------------------</td>
<td>---------------------------------</td>
</tr>
<tr>
<td>Length of the pulley 'V' belts</td>
<td>High tensile Rubber</td>
<td>B102</td>
<td>B118</td>
<td>New 'V' belts to be bought.</td>
</tr>
<tr>
<td>Maximum belt tensions</td>
<td>672 N</td>
<td>492 N</td>
<td></td>
<td>Standard 'V' Belts to be used</td>
</tr>
<tr>
<td>Motor Keyway</td>
<td>89 mm</td>
<td>19 mm</td>
<td></td>
<td>RV motor keyway is sufficient</td>
</tr>
<tr>
<td>Motor pulley Keyway</td>
<td>89 mm</td>
<td>19 mm</td>
<td></td>
<td>RV motor pulley keyway is sufficient</td>
</tr>
<tr>
<td>Motor pulley key</td>
<td>Mild Steel</td>
<td>90 mm</td>
<td>19 mm</td>
<td>40 hp (30 kW) RV motor key is sufficient</td>
</tr>
<tr>
<td>Gearbox pulley keyway</td>
<td>89 mm</td>
<td>30 mm</td>
<td></td>
<td>Gearbox pulley keyway is sufficient.</td>
</tr>
<tr>
<td>Gearbox pulley key</td>
<td>Mild Steel</td>
<td>90 mm</td>
<td>30 mm</td>
<td>Gearbox pulley key is sufficient.</td>
</tr>
<tr>
<td>Rotorvane Shaft diameter</td>
<td>EN24 Steel</td>
<td>63.5mm</td>
<td>63.3mm</td>
<td>No change in Rotorvane shaft size.</td>
</tr>
<tr>
<td>Flange bolt diameter</td>
<td>High Tensile Steel</td>
<td>20mm</td>
<td>15mm</td>
<td>No change in flange bolt sizes.</td>
</tr>
<tr>
<td>Bushes</td>
<td>Phosphor Bronze</td>
<td>50 &amp; 63.5mm</td>
<td>40mm</td>
<td>No change in bush sizes.</td>
</tr>
</tbody>
</table>

4. RESULTS AND DISCUSSIONS

Drawings

The fabrications were carried out as per design drawings as follows:

Based on design [1], the high pressure Rotorvane was fabricated and assembled as per the following drawings:

![Motor Pulley Drawing](image-url)
Fig. 7: Pulley Arrangement Drawing

Fig. 8: Iris Plates Drawing
Fig. 9: Rotorvane Assembly complete with gearbox and motor.

Plate 4.1: Iris Plates

Plate 2: Vanes, Screw and Rotor
The parts were fabricated and assembled to high pressure Rotorvane as per the table of parameters, existing parts and parts purchased / machined as per design drawings for the required components. The assembled high pressure Rotorvane was tested dry to confirm functionality.

5. CONCLUSION AND RECOMMENDATION
It is possible to fabricate and assemble a High-Pressure Factory Rotorvane based on design calculations and analysis giving required minimum parameters, by modifying or upgrading some components of a standard Rotorvane, ready for testing for impact on orthodox made tea quality. There is need to test the fabricated high pressure Rotorvane for Orthodox tea processing to check impact on quality of orthodox teas and possible commercial opportunity.

6. REFERENCES