ISSN (Print) : 0974-6846
ISSN (Online) : 0974-5645
Indian Journal of Science and Technology, *Vol 9(41), DOI: 10.17485/ijst/2016/v9i41/100894, November 2016*

A Study of Tribological Thermal Analysis of Rice Polishing Machine

R. Narasimhan[1] and K. R. Vijayakumar[2]

[1]St. Peter's Institute of Higher Educational and Research University Avadi, Chennai; narasima123@gmail.com
[2]Dr MGR Educational Research Institute University, Maduravoyal, Chennai; lsjv2002@yahoo.co.in

Abstract

Objectives: The Objectives of present research work is to investigate the effect of the mechanisms involved in the rice milling process. So that what is the technological improvement can be made. **Methods/Statistical Analysis:** To identify the rise in temperature and wear patterns present on major machine components of rice polishers. Use of rice milling mechanisms to analyses: temperature, wear, and mechanisms. The testing to identify, the behaviour of the current milling machine materials and their wear resistance in order to set a benchmark from which to measure alternative materials. **Findings**: Using the understanding of the Rice milling processes to determine what improvements can be made to machine design to reduce the rice in temperature percentage of the wear components. **Application/Improvements:** It is known that changes in temperature beyond 500C cause change in material properties increasing in the susceptibility of rice grains to cracking and fissuring. Hence in our design of the polishing system, the rise of grain temperature is kept below 200 C to ensure good polishing performance.

Keywords: Frictional Forces, Grains, Rice, Material, Rice Polishing Cams, Octagonal Sieves

1. Introduction

The Rice is a staple food for more than half the world's population. Though normally considered a semi-aquatic, annual grass plant it can grow in a wide range of conditions. Various production methods are adopted to cultivate and process the grain, generally depending on scale and wealth of the producer, but ranging from very primitive to highly mechanised. Mechanical rice milling technologies involved in milling rice have developed, particularly in material improvements with machine design alterations generally made on a trial and improvement basis. Improvement is measured in terms of quality of product and machine capacity but also in terms of machine wear life, since in processing progressively larger volumes of grain components are likely to fail more rapidly.

2. Thermal Analysis of Rice Polishing in Machine

The rotating mass of Cams is reduced using cored interior so that centrifugal force, $M\,\omega^2 R$, is kept at optimum level to carryout rice polishing. Here, M is the mass of Cams, ω is the angular velocity and R is the radius of Cam Figure 1 and 2.

**Author for correspondence*

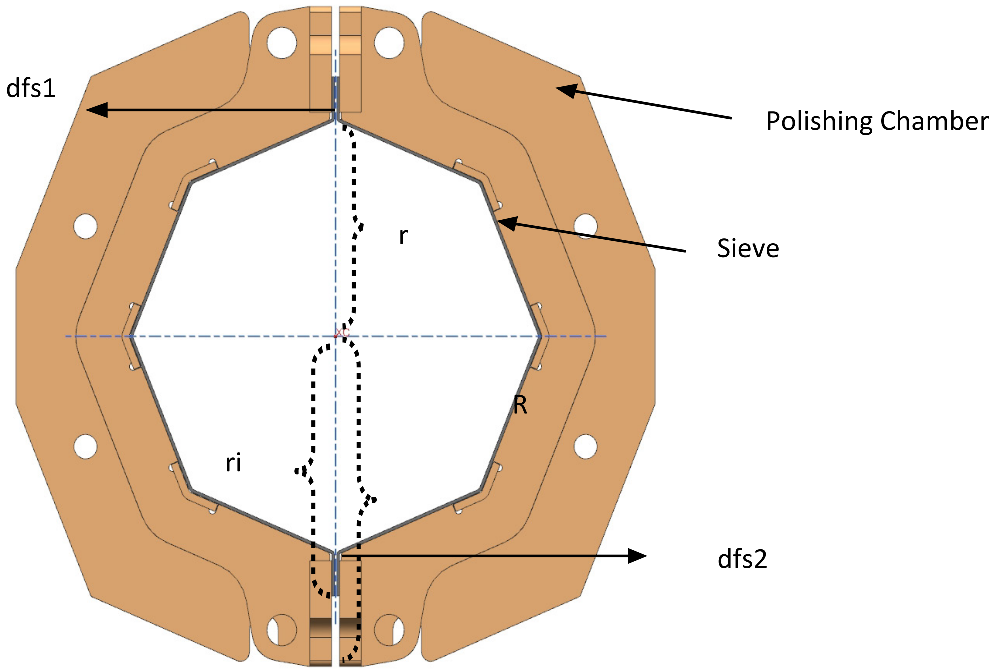

Figure 1. Cams polishing rice grains in a chamber.

3. Energy Requirement of Rotating Cams in Rice Polishing

1. There are three components of energy requirement of rotating cams in rice polishing:
2. Energy required for cams to overcome frictional forces of rice grains on cam peripheral surfaces.
3. Energy required for cams to overcome frictional forces of rice grains on sieves.
4. Energy required for cams to overcome frictional forces of rolling grains in rice polishing.

3.1 Energy Required for Cams to Overcome Frictional Forces of Rice Grains on Cam Periphery, Ec in Time, t

For cams of radius R, consider their periphery and width B, where abrasion of rice grains on steel surfaces of cams ocurrs.

The rice grains in a centifugal thrust in Newtons by the rotating cams of surface area, 2πRB.

The cams, Figure 1 are rotating at speed of ωR, the rice grain mass is the following tangential component of centifugal force, in Newtons.

$$F_c = \mu_c N_c = \mu_c M_g\ \omega^2 R \text{ x } 2\pi RB \qquad (1)$$

Where,

μ_c is the dynamic cofficient friction of rice grains on steel cams = 0. 5

The abrading force in Newton, $F'_c = 2\pi\mu_c M_g R^2\omega^2$

Torque 2π in Nm of the cams at a distance **RdΘ**

$$dM_c = \int_0 2\pi\mu_c M_g\ \omega^2 R^2 R d\Theta$$

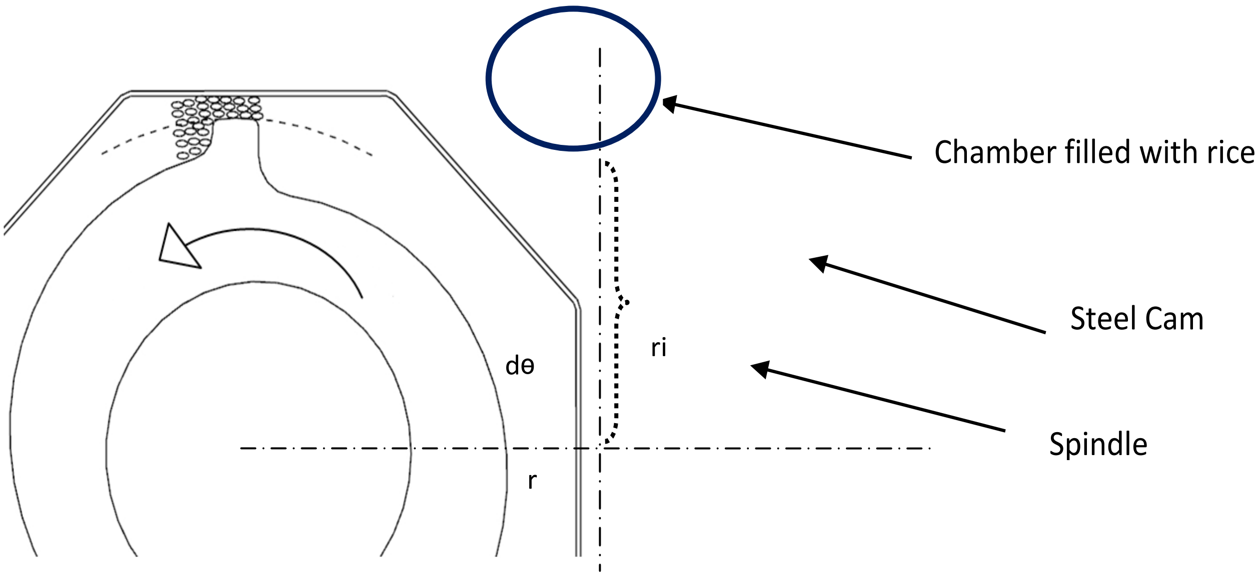

Figure 2. Cams rotating in polishing chamber filled with rice chamber filled with rice.

$M_c = 4\pi^2\mu_c M_g\, \omega^2 R^3 t$

The energy E_c in J, as given in the Equation (2) of cams for a time, **t** sec.

$$E_c = 4\pi^2 \mu_c M_g \omega^2 R^3 t \quad (2)$$

Where μ_c is the dynamic coffecient of friction of white rice grain on milled cam surface = 0.5 and t = 100.

$$E_c = 4\pi^2 \mu_c M_g \omega^2 R^3 t$$

3.1 Energy Required for Cams to overcome Frictional Forces of Rice Grains on Sieves, Es in Time t.

The energy required frictional forces of sieve on grains is given in the Equation (3).

$$E_s = 4\pi^2\mu_s M_g\, \omega^2 R_s^{\,3} t \quad (3)$$

Energy required for Cams to Overcome Frictional Forces of Rolling Rice Grains in Polishing, E_g in Time t .

The energy to overcome frictional forces of rolling grains is given in the Equation (4).

$$E_g = \left\{ \frac{4\pi^2\mu_g M_g}{2} \right\} \omega^2 \quad R_s + r_i t \quad (4)$$

Hence total wear energy of rice polishing, in **J** is shown in the Equation (5).

$$E_a = E_c + E_s + E_g \quad (5)$$

$$L = M_g v R$$

The transfer of momentum L in N ms between the grains can be estimated as:

$$L' = M_g v\,(R - R_s)$$

The power transmited in watts in the process is:
$P_W = M_g v (R- R_s)\ \omega$

Transfer Energy for rice grains, $\mathbf{E_m}$.

4. Balance Energy

Since wear and friction cause the surface temperature, the thermals energy of grains $\mathbf{E_H}$ in J may be expressed as:

The thermal energy of grains, E_H is expressed in the Equation (6).

$$E_H = M_g C_{pg} (T_f - T_i) \quad (6)$$

Where,
$(T_f - T_i)$ is The Rise in Temperature ^{0}C

Power rating of rice polisher, = 75HP = 56.23 kw

Taking in to account, the transmission efficiency of V-belt drive as 95 %, Total energy **E** available at the driving shaft of the polisher.

All the wear energy factors are been time dependent,total energy available at drive shaft, E is the sum of the machine idling energy,abrasion energy, momentum energy and thermal energy of grains, as given in the Equation (7).

$$E = E' + E_a + E_m + E_h \quad (7)$$

However, $E_h = M_g C_{pg} (T_f - T_i)$
Refer equation (6).

Therfore, $(T_f - T_i)$.
Hence, Rise in temperature = 19.5^0 C.

The rise in temperature of rice grains during polishing is 19.5^0 C above the ambient temperature.

5. Conclusion

In tropical weather as high humidity and temperature condition. Most paddy cultivating and processing regions, especially during summer seasons, rice polishing operations yield broken rice grains. While polishing bran is being removed, the temperature of the grains increases, thereby causing thermal stress in the grains. With the prevailing ambient temperature of about 30^0 C, the grain temperature in polishing increases beyond 50^0 C the rise in temperature of the grains is not kept well within 20^0 C, the grain temperature will easily be over 50^0 C and due to this temperature rise beyond the allowable limit may lead to increase in the percentage of broken rice beyond 2%. It is well known that changes in temperature beyond 50^{0}C cause change in material properties increasing in the susceptibility of rice grains to cracking and fissuring. Hence in our design of the polishing system, the rise of grain temperature is kept below 20^0 C to ensure good polishing performance.

6. Acknowledgement

The authors express sincere thanks to Dr. P. Aravindan, Principal Director (R&D), Dr. P. Palanisamy, Dean (Advanced Research Institute), Mr. S. Irudayaraj, Project Manager (Advanced Research Institute), Dr MGR Educational Research Institute University, Chennai, India 600095 and all the colleagues of Advanced Research Institute (ARI) for their guidance, suggestions, inputs, support and encouragement throughout this research work.

7. References

1. Debabandya Mohapatra, Satish Bal. Wear of Rice in an Abrasive Milling Operation. Biosystems Engineering. 2004 August; 8(3): 337-42.
2. Guha. D, Roy Chowdhuri SK. The effect of surface roughness on the temperature at the contact between sliding bodies. Journal Wear. 1996; 197:63-73.
3. Adegun IK, Adepoju SA, Aweda JA. A mini rice processing machine for Nigerian farmers. Journal of Agricultural Technology. 2012; 8(4):1207-16.
4. Mutalubi Aremu, Akintunde. Development of a Rice Polishing Machine. Mechanical Engineering Department, Federal University of Technology Akure, Nigeria AU J.T. 2007 Oct; 11(2):105-12.

5. Purusottam Nayak. Problems and Prospects of Rice Mill Modernization. Journal of Assam University. 1996; 1(1):22-8.
6. Sadegh Afzalinia, Mohammad Shaker and Ebrahim Zare. Comparison of Different Rice Milling Methods. The Society for engineering in agricultural, food and biological system, Paper No: MBSK 02- 214 An ASAE/CSAE Meeting.
7. Mehul Shah, Chetan Bhatt, Jaimin Dave. Temperature Dependent NIR Spectroscopic Analysis for Food Grain Samples. Indian Journal of Science and Technology. 2016 Mar; 9(9). Doi: 10.17485/ijst/2016/v9i9/85306.
8. Omer Badi. Rice Post-harvest Technology, JICA Publication. Thailand. 2013, p. 01-15