International Journal of Scientific Engineering and Technology (ISSN : 2277-1581)
www.ijset.com, Volume No.1, Issue No.3, pg : 148-152 01 July 2012

Design and Analysis of Two Roller Sugar mill using FEA Techniques

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ABSTRACT

The present analysis relates to proposed modifications in the milling process in sugarcane factory. This paper describes the advantage of using two roller sugar mill over three roller sugar mill by designing and analyzing it with FEA techniques. The roller mill needs to be designed in order to satisfy the condition of keeping number of stages same while maintaining optimum crushing rate.

In this study theoretical analysis has been done considering simply supported beam with two conditions 1.determinate beam and 2.indeterminate beam condition. By comparing results of above two conditions one factor has been calculated i.e. Bending moment factor which helps in finding actual results. By changing various parameters the performance of roller mill is studied using FEA software and the same is compared with above theoretical results. Based on results the optimum design is proposed.ANSYS software is used to calculate stress-strain state of roller mill.

Keywords- **Two roller sugar mill, Bending moment Reduction factor (BMRF), FEA techniques, ANSYS.**

1. INTRODUCTION

Sugarcane is a grass of the genus *Saccharum* which is grown throughout tropical and subtropical regions, producing approximately 94 million tons of raw sugar worldwide. Factory processing of sugarcane begins with shredding and crushing of harvested cane stalks to extract the sucrose-containing juice. The extraction of juice from prepared sugarcane is commonly performed using sets of counter rotating rolls. The rolling process is energy intensive and must obtain a high degree of liquid extraction without compromising the processing rate.

Usually three roller mills are used for extraction of juice which consists of three rollers i.e. Top, Feed and Discharge rollers. Sugarcane is being fed into top and feed rollers which further passes through top and discharge roller along with trash plate. This trash plate is having a downside that 25% of total hydraulic load is shared by this trash plate in overcoming friction and remaining 75% only the useful one. i.e. 25% hydraulic load is shared by feed roller and 50% is shared by discharge roller. Crushing rolls are designed with high coefficient of friction and very low rotational (4–5 rpm) speed.

Considering above pitfalls two roller mills can be the best option because it don't require trash plate, no trash plate adjustment and replacement. Two roller mills consist of only two rollers i.e. top and bottom roller. 100% of hydraulic load is available for compression at bottom roller. Hydraulic load required is 70% of same size conventional 3-roller mill which is not shared and directly transferred to the bottom roller. 2-roller has better drainage because of its simplicity; capital cost is 12% less than traditional mill, no slippage and less juice absorption by bugasse. So in sugar industry it is very essential to design 2-roller mill as it has got above advantages and analyzing it with FEA techniques for its safe working. In this, shaft of bottom roller is a critical part which should be designed.

In this paper it has been considered two conditions first with determinate shaft and second with indeterminate shaft conditions. In first condition only two supports are considered to determine bending moment (BM) but in actual practice there is continuous support at bearing width for that second case is useful, in this four supports are used to calculate bending moment which can be compared with first case to determine variation. From that one factor is calculated called Bending Moment Reduction Factor. The contact stresses and normal stresses at critical locations are calculated which further compared with FEA results.

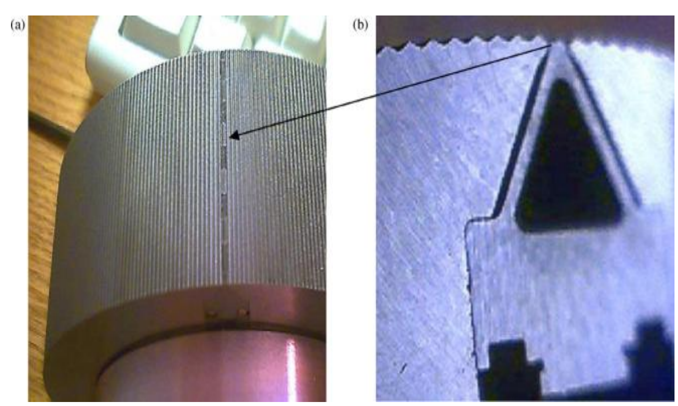

Figure 1. Closed view of roller mill

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Figure 2. Roller mill assembly

2. METHODOLOGY (THEORETICAL ANALYSIS)

In this study, a roller shaft is chosen for design and analysis for known shaft diameters. A C.I shell is shrink fitted on shaft. Shaft is supported on two journal bearings. Drive is direct shaft mounted one. The roller is subjected to bagasse pressure thus subjecting it to rotational bending, torsion, shrink fit stress, direct shear. A pinion drives a bottom roller, sugar cane gets crushed between the top and bottom roller.
In design of shaft of two roller mill few assumptions are made as follows:

a. Bending moment reduction factor for consideration of bearing width effect.
b. Taper has less stress concentration factor than fillet.

Shaft inputs are as follows

Power (P) = 940 HP; Roller speed= 3.4 rpm; roller dia.= 1270 mm
Shaft dia. at roller= 660 mm;
Shaft dia. at bearing support= 620 mm;
Shaft dia. at pinion= 580 mm.
Baggase load= 560,000 kgf; Self weight= 40,000 kgf
Total load= 5886 KN. (Acts vertically)
For horizontal loading load is= 775.4 KN
L1= 605 mm; L2= 2540 mm L3= 890 mm;
L4= 385 mm; L= 3750 mm.

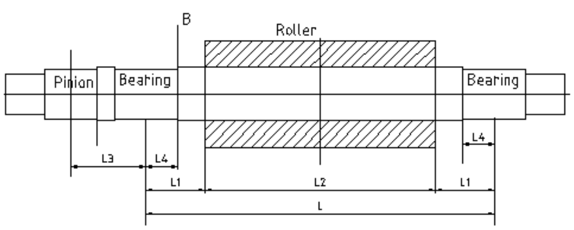

Figure 3. Sectional view of roller mill shaft

There are two ways in which shaft is analyzed theoretically is as follows

2.1. Determinate shaft condition
2.2. Indeterminate shaft condition

2.1. Determinate shaft condition

In this case only two supports are considered at middle of bearing to find Bending Moment and stresses[2].

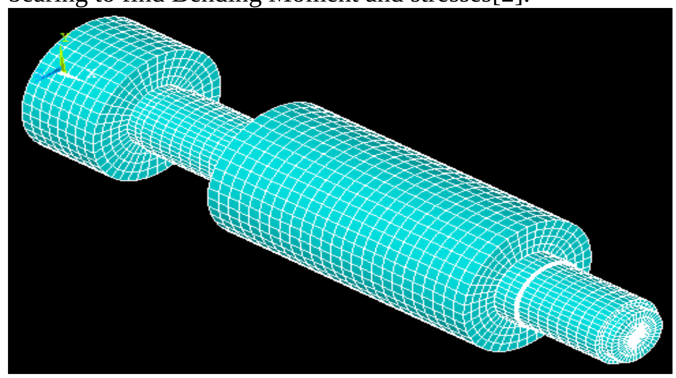

Figure 4. Modeling of roller mill assembly

Again there are two cases with Horizontal loading and vertical loading

2.1.1 Vertical loading

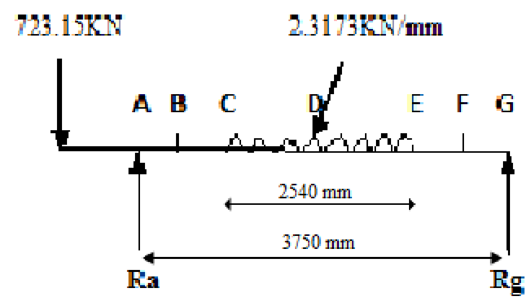

Figure 5. Vertical loading for determinate beam condition

In this critical section is at point ‘B’ so Bending Moment at this point is calculated as

$M_{@_{Bv}} = 694.7345 \times 10^3\ KNmm$ (Sagging)

2.1.2 Horizontal loading

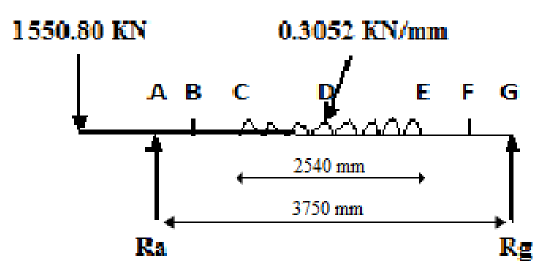

Figure 6. Horizontal loading for indeterminate beam condition

Bending Moment at 'B' $M_{@_{Bh}}$

$= 1089.2457 \times 10^3\ KNmm$ (Hogging)

Resultant Bending Moment @ B

$$= \sqrt{(M_{@_{Bh}})^2 + (M_{@_{Bv}})^2} \qquad (1)$$

$= 1291.9412 \times 10^3\ KNmm$

2.2. Indeterminate shaft condition[4]

In this case there are four supports which are at two ends of bearing width respectively [2].
Again there are two cases with Horizontal loading and vertical loading.

2.2.1. Vertical loading

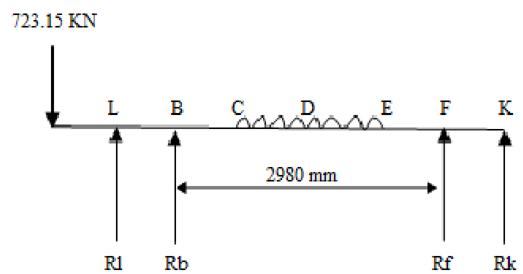

Figure 7. Vertical loading for indeterminate shaft condition

$M_{@_{Bv}} = -528.5959 \times 10^3\ KNmm$ (Hogging)

2.2.2. Horizontal loading

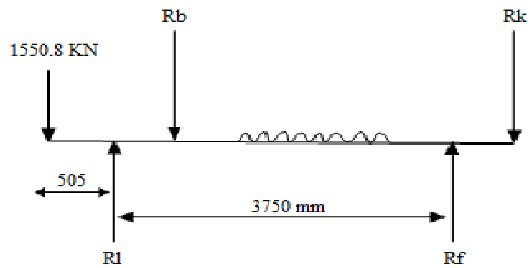

Figure 8. Horizontal loading for indeterminate shaft condition

$M_{@_{Bh}} = -53.0246 \times 10^3\ KNmm$ (Hogging)

Resultant Bending Moment @ B

$$= \sqrt{(M_{@_{Bh}})^2 + (M_{@_{Bv}})^2} \qquad (2)$$

$= 531.2487 \times 10^3\ KNmm$

Bending Moment reduction Factor = 0.4112

2.3. Bending Moment calculated from FEA results

Bending moment at section B is calculated using FEA results as follows

2.3.1. For constraint at centre of bearing

BM at section B= $555.5367 \times 10^3\ KNmm$ for vertical loading

BM at section B= $-1089.229 \times 10^3\ KNmm$ for Horizontal loading

Therefore,

Resultant Bending Moment at section B=

$= 1222.7186 \times 10^3\ KNmm$

2.3.2. For constraint at end of bearing

BM at section B= $-409.9277 \times 10^3\ KNmm$ for vertical loading

BM at section B= $-67.208 \times 10^3\ KNmm$ for Horizontal loading

Therefore,

Resultant Bending Moment at section B=

$= 415.4 \times 10^3\ KNmm$

From above Bending Moment Reduction Factor is calculated as 415.4/1222.7186 = 0.3397 i.e. 33.97%

3. RESULTS AND DISCUSSIONS

Roller mill shaft is analyzed theoretically as well as with the help of FEA software for its safe working by checking various parameters within limits. Considering above two methodologies to determine bending moment of shaft it is observed that bending moment in second case is decreased by an amount 760.6925 KN/mm2. And Bending Moment Reduction Factor is 0.4112 i.e. 41.12%, which is slightly more than factor calculated using FEA results of 33.97%. This variation is due to point of loading is different in FEA analysis than theoretically calculated.

In second case we calculated bending moment by considering four supports which gave good result than the first

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case. The second case helped in finding accurate result than first case.

3.1. Taper vs. Fillet FEA Results

The same shaft is used for checking effect of stress concentration in fillet and taper.
Center of bearing is constrained in12345. Combined loading is considered in comparing results. Bending moment at section B is $1222.7186 \times 10^3\ KNmm$.

Calculated stress at section B is 73.2159 KN/mm2

3.1.1 Fillet: fillet radius used is 20mm. a very fine mesh is used at fillet region to get accurate results.

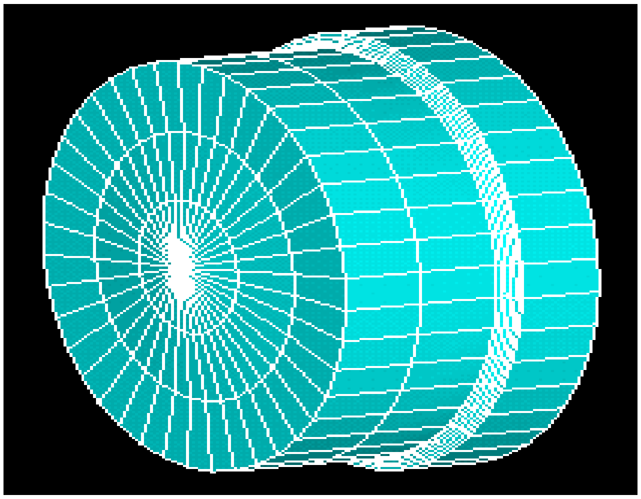

Figure 9. Fine meshing at fillet region

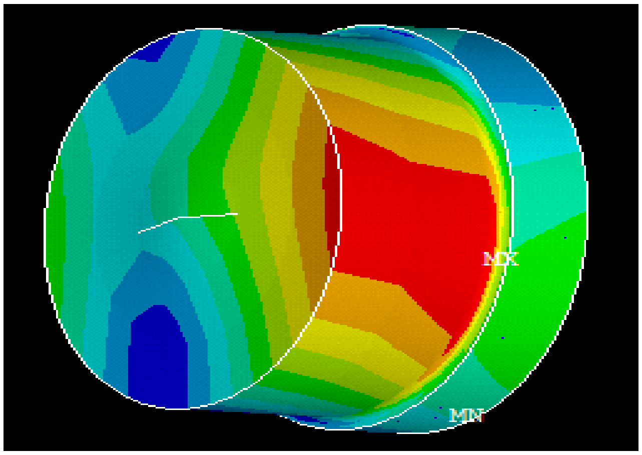

Figure 10. Stress contour at fillet region

Maximum stress at section B is 71.157 KN/mm2

3.1.2. Taper: A taper of 1:4 is used. A very fine mesh is used at taper region to get accurate results.

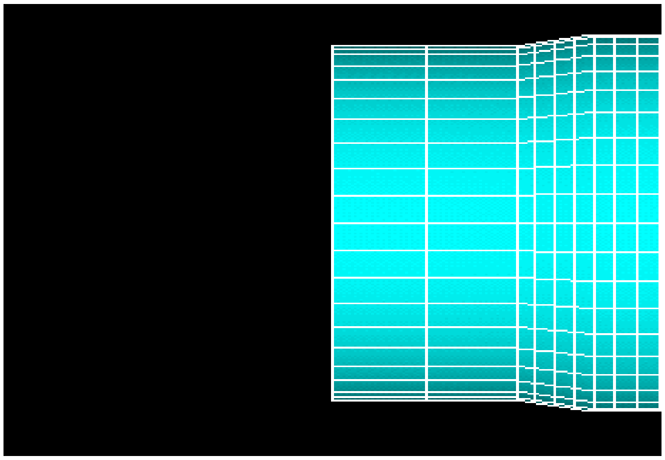

Figure 11. Fine meshing at taper region

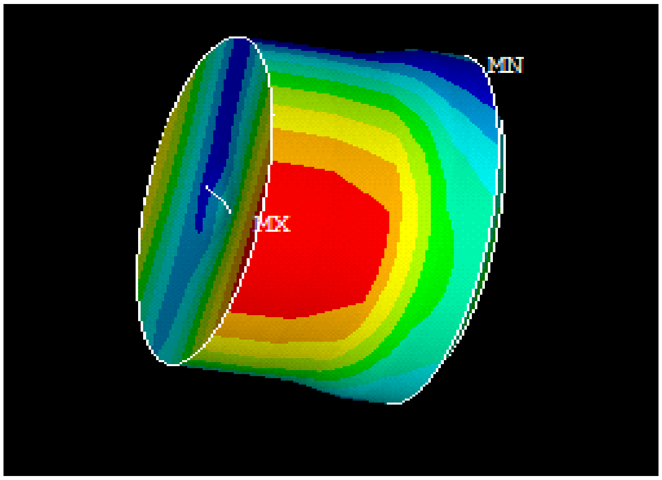

Figure 12. Stress contour at taper region

Maximum stress at section B is 61.737 KN/mm2

Cases	Stress concentration	Calculated results	FEA results	All. Stress
Fillet	2	68.341	71.157	169.2
Taper	1.25	59.645	61.737	169.2

From above results it is obvious that stresses when Taper is used is much less than the stresses when fillet is used due to its low stress concentration factor. And also stresses are much less than the allowable stress.

4. CONCLUSION

There is general agreement on above results and discussions. Bending moment for the second case i.e. for indeterminate shaft condition is decreased as compared to the first case which predicts better result. The stress value calculated theoretically as well as from FEA are nearer and that too much less than the allowable stress value. From above results and discussions it is concluded that two sugar roller mill for above same parameters is safe. Based on the above advantages it is proposed to have two sugar roller mill.

ACKNOWLEDGEMENT

The authors wish to thank **Mr. shailesh Fulse** for his support of this investigation. He has also offered useful suggestions and always there with us for any kind of subject related reference. We sincerely acknowledge for his patience and interest showed for the completion of this project.

REFERENCES

[1] 1408_Uganda_Sugar_Proposal_Q_1-7_22.
[2] Shigley's Mechanical Engineering Design, Eighth Edition Budynas−Nisbett
[3] A text book of machine design by R.S.Khurmi.
[4] Engineering mechanics of solids- Egor Paul popov.
[5] Building better products with finite element analysis- Vince Adams and Abraham Askenazi published by OnWords Press.
[6] Optimising the Design of Sugarcane Rolling Mills using Finite Element Computer Simulation-Adam, Clayton J. and Loughran, Jeffrey G. (2007) Finite element prediction of the performance of sugarcane rolling mills. International Sugar Journal 109(1301):pp. 272-284.