iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 4 Issue: XII Month of publication: December 2016

DOI:

Volume 4 Issue XII, December 2016
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

Analysis of Rotary Kiln Support Roller by using Analytical Method and FEA Software

Tharoon T
UG Scholar, Department of Mechanical Engineering, SNS College of Technology, Coimbatore-641035, Tamilnadu, India

Abstract - Rotary kiln support roller and shaft are located under the kiln, which is contact with kiln ring. After a few periods, corrosions seem on the roller and cracks seem on the shaft at working. These corrosions and cracks are occurred by stresses that applied on roller by kiln load. In recent years there are many roller shaft failures occurs due to continuous loading condition. The shaft is affected by high stresses with respect to kiln load on the roller and this can be avoided by proper design and manufacturing. The analysis of roller and shaft has been done by using Finite Element Method. The loading position is varied according to kiln ring and the support roller for the actual working condition. The geometric parameters of the shaft and roller are to be designed and the analysis has to be carried out by analytical and Finite Element Analysis method. According to coming loads on shaft had been considered various conceptions and had been made stresses analysis and analytical stress calculation again. The ring conception suggestions are made in this model according to coming loads on roller and shafts analyzed results.
Keywords – Rotary, Kiln, Roller, FEA, analysis.

I. INTRODUCTION

The rotary kiln is of simple structure, which composed of kiln shell, supporting device, supporting device with thrust roller, driving device, movable kiln head, and kiln rear sealing device, burning device and etc. It has the simple structure and reliable operation, at the same the production process of the rotary kiln can be controlled easily. With a certain slope to the level, the whole kiln body is supported by supporting rollers and fitted with thrust rollers to control up and down movement of the kiln body. Besides main driving device for driving system, it also fitted with the auxiliary driving device so as to ensure the kiln could be slowly rotated when the main driving power is broken-up and prevent it to be bend and deformed. Rotary kiln is rotary calcine kiln that belongs to building materials equipment, which can be divided into cement kiln, metallurgical and chemical kiln and lime kiln according to different materials. Rotary kiln is used for making of cement clinker and there are dry and wet methods to make cement. There are two types of cement kiln-dry process cement kiln and wet process cement kiln-that mainly used to calcine cement clinker. Metallurgical and chemical kiln is mainly used in metallurgical industry, refractory plant and chemical factory. The basic components of a rotary kiln are the shell, the refractory lining, support tyres and rollers, drive gear and internal heat exchangers. Roller and shaft of Cement Rotary Kiln supporting roller is exposed to high stresses at heavy working situation. High Stresses because of big kiln dimensions are damaged to roller and shaft of supporting roller according to kinds of effects. This is required that, Decreasing stresses are provided longer life and decreasing damaged to roller and shaft of supporting roller with material properties and working situations. Active researching and developing of mechanics of cement factories equipment are not studied in cement factory industries. Researching roller and shaft of supporting roller will be useful in cement factory sector and is very hard for experiment according to economic reasons. However, engineers use model in the computer analysis program with original dimensions of subjects and engineers get results of model analysis on computer. Otherwise, the material properties and working situations are given to analysis program on the computer truly. Roller and shaft model is drawn and made analysis in order to get critical stresses results. The kiln is a cylindrical vessel, inclined slightly to the horizontal, which is rotated slowly about its axis. The material to be processed is fed into the upper end of the cylinder. As the kiln rotates, material gradually moves down towards the lower end, and may undergo a certain amount of stirring and mixing.

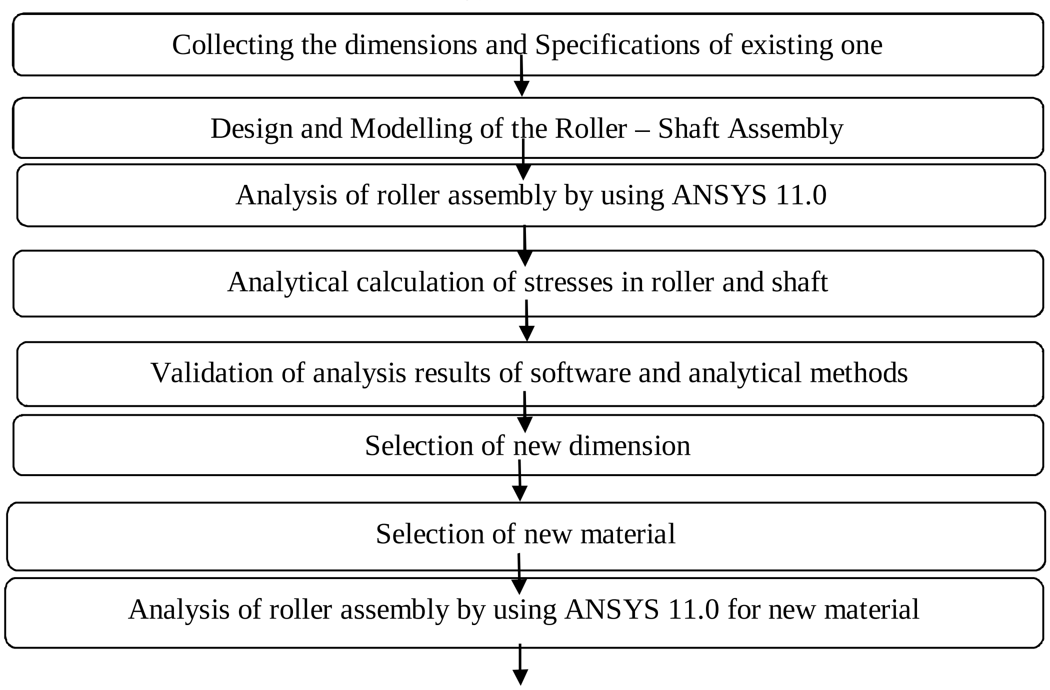
II. LITERATURE REVIEW

Evaluation of rotary kiln, In this paper, the author, B. S. DHILLON, Department of Mechanical Engineering, University of Ottawa, Canada, explains," The fatigue reliability model of the kiln roller in crack initiation stage is developed by using the curve approach in this paper. All related variables are discussed. Among them, the stress variable is obtained from the resultant stress calculated by using the finite element (FE) code ANSYS. Multi axial fatigue life prediction of kiln roller under axis line deflection *by* Yi-ping SHEN , Song-lai WANG, Xue-jun LI , B.S.DHILLON, Department of Mechanical Engineering, University of Ottawa, Ottawa, Ontario, Canada). This paper investigates the multi axial fatigue life of the roller in rolling contact with wheels with respect to axis line deflection. The multi axial fatigue criteria proposed by Wang and Brown, together with the rain flow counting method and Miner- Palmgren’s rule, are applied to the cumulative damage estimation and life prediction. As the axis line deflection of overlong kilns generally results in asymmetric load distribution on each roller, the load ratio is introduced to describe the deflection for quantitative stress analysis. The stress analysis are performed within the finite element code ANSYS. Study of the stress and strain for shaft parts by cross wedge rolling by WANG Nan ZHANG Nai-wei ZHANG Qing-heng , Hebei University of Engineering, Handan, Hebei. By applying the finite element software of ANSYS/LS-DYNA to simulate the rolling process of pairs of cross wedge rolling shaft and to analysis the stress field of the rolling at the stage of stretcher and to analysis the distribution of strain field. what's more, it can make a clear analyse of the metal's situation such as the under force and the movement at the process of the rolling deformation it has provided a good foundation for cross wedge rolling theoretical research and technological elopement in the future. We also made the conclusion that the stress appeared the state that in two directions as tensile stress and another as compressive stress. Numerical analysis of the heat transfer in the wall of Rotary kiln using finite element method. This paper clearly explains about the heat transfer in the kiln wall. Here the author used ANSYS as a tool to analyse the concept. It also explains, “There is a clear temperature distribution across the wall of the rotary kiln for various angular velocities, with different heat transfer coefficients and under different filling degree. Penetration depth, which is the region till where all curves meet together, has been easily observed on the radial side of the wall. Analysis of the causes of recent roll shaft failures in natal sugar mills By M. Reid In this paper theoretical analyses of shaft stresses and fatigue stress concentration factors have been carried out to determine whether present shaft design, machining practices, material specifications and shell assembly techniques are satisfactory and whether they can be improved. The feasibility of using adhesive to fix the shell to the shaft is discussed and some recommendations to users and manufacturers on roll shaft and shell specification, design, assembly and operation are given.

III. PROBLEM DEFINITION

Rotary kiln dimensions are big and kiln is rotated by using girth gear with pinion gear. Supporting roller systems are designed for protection of kiln breaking because of long kiln length. Supporting roller is under the kiln ring. Ring is surrounded the kiln and contacted to supporting roller. Kiln load and other loads are affected to supporting roller by using ring. Shaft of supporting roller is broken between shaft and roller. Breaking reason is stresses that happened from kiln loads. This is realized that, these stresses must be reduced or decreased in order to breaking on shaft. The original kiln specifications are stabled and kiln are moved on coordinates. So, Coming loads on supporting roller are fixed and researching of supporting roller is very important in order to get more long life of shaft.

IV. METHODOLOGY



Volume 4 Issue XII, December 2016
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

Comparison of analysis result of the new material with existing material

↓

Analytical calculation of stress in shaft roller assembly for new dimension

↓

Analysis of support roller assembly by using ANSYS 11.0 for new dimension

↓

Validation of analysis result of software and analytical methods for new dimension

↓

Conclusion

Fig.1 Flow Chart

V. DESIGN OF SUPPORT ROLLER AND SHAFT ASSEMBLY MATERIAL SELECTION

The figure 2 shows and 2 – Dimensional views of the support roller and shaft assembly. All dimensions are in mm. The support roller is made up of Cast steel. The properties of Cast steel are given below in the table 1. EN – 8 grade Mild steel is used for manufacture a shaft and the table 1 describes all the properties of the shaft material. EN8 is an unalloyed medium carbon steel with good tensile strength. Tensile properties can vary but are usually between 500-800 N/mm^2. The density of shaft material is 7.80 e-6 kg/mm3.

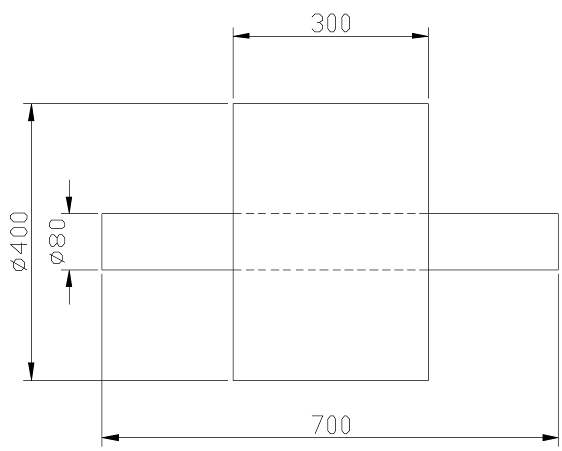


Fig 2 2D view of support roller and shaft

Table 1. Properties of support roller and shaft

S. No	Element	Chemical composition	Young's modulus	Poisson Ratio
1.	Support Roller	C - 0.40% Si - 0.25% S - 0.015% P - 0.035%	2.07E5N/mm^2	0.3
2.	Shaft	C - 0.40% Si - 0.25% S - 0.015% P - 0.015% Mn – 0.80%	2.07E5N/mm^2	0.3

International Journal for Research in Applied Science & Engineering Technology (IJRASET)

VI. ANALYTICAL METHOD

A. Stress Calculation Of Shaft

For Shear Stress:

B. Torsion Equation

$\frac{T}{J} = \frac{\tau}{R}$

Where,

T- Torque

J- Polar moment of inertia

τ- Shear stress

R- Radius

Power (P) = $\frac{2\pi NT}{60}$

$3.7x10^3 = \frac{2\times\pi\times0.666\times T}{60}$

T=53051.64 N-m

T=5305164 N-cm

$\frac{5305164}{J} = \frac{\tau}{4}$

Polar moment of inertia (J) = $\frac{\pi}{32}X8^4$

J=402.12cm^2

$\frac{5305164}{402.12} = \frac{\tau}{4}$

τ=52771.94 N/cm^2

Shear stress τ = 52771.94 N/cm^2

For Normal Stress:

$\sigma = \frac{P}{A}$

Where,

P-Load

A-Area of the shaft

σ -stress

P=382306.96 N

A=$\frac{\pi}{4}X8^2$=50.26cm^2

$\sigma = \frac{382306.96}{50.26}$=7605.75 N/$cm^2$

Normal Stress, σ = 7605.75 N/cm^2

For Bending Stress:

C. The Bending Equation

$\frac{M}{I} = \frac{f}{y} = \frac{E}{R}$

Where,

M = moment of resistance.

I = moment of inertia of the section about neutral axis.

f = bending stress.

E= young's modulus of elasticity.

R = radius of curvature of neutral axis.

Moment of resistance $M = \frac{wl^2}{8}$

Where,

w = load

l = length of shaft

$$M = \frac{382307(.7^2)}{8}$$

M = 23416.25Nm

$Y = \frac{d}{2}$

Where,

d= diameter of shaft

$$Y = \frac{.08}{2} = .04m$$

Moment of inertia of section about neutral axis

$I = \frac{\pi d^4}{64}$ for circular section

$= \frac{\pi(.08^4)}{64}$

$I = 2.01 * 10^{-6} m^4$

Bending stress

$f = \frac{MY}{I}$

$f = 23416.25 * \frac{.04}{2.01} * 10^{-6}$

$f = 46{,}600$N/cm^2.

D. Load Calculation

Total load = 180 Ton = Q

Load on supporting roller P = 180000*9.81 = 1765800.5N

Load per roller = (1765800/4)*cos 30 = 382306.9N.

VII. FINITE ELEMENT ANALYSIS OF SUPPORT ROLLER AND SHAFT

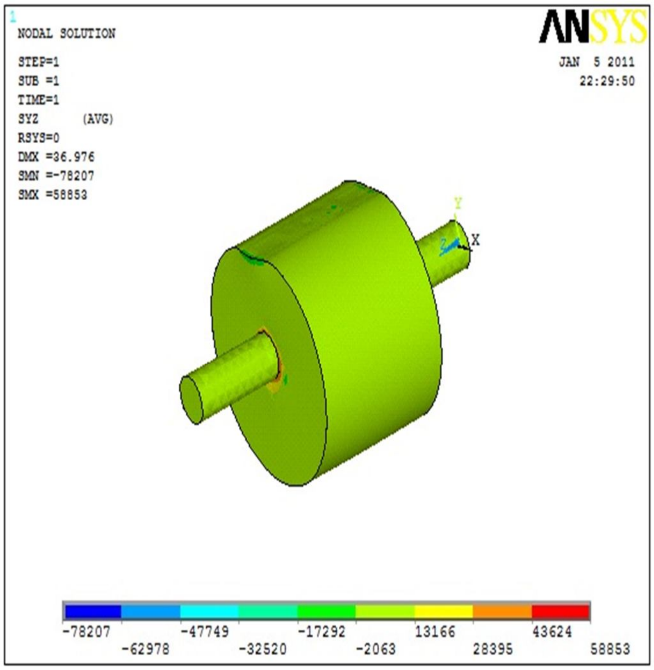


Fig 3 Minimum and maximum Shear Stress On Roller Assembly Maximum shear stress induced on roller assembly is 58853 **N**/cm^2

Volume 4 Issue XII, December 2016
ISSN: 2321-9653

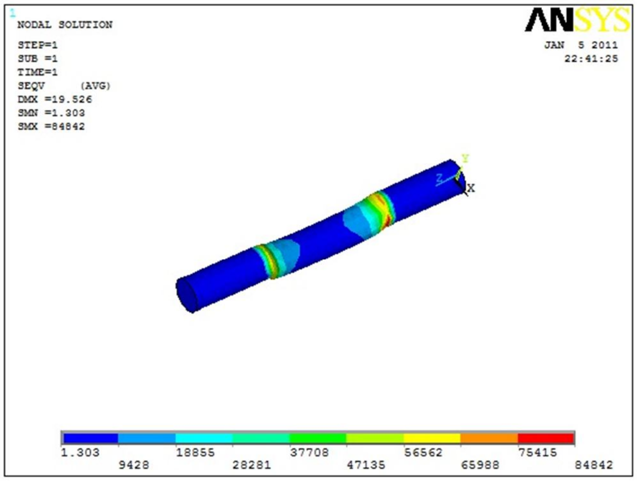


Fig 4. Von misses Stress On shaft Von misses stress induced on shaft is Maximum 84842 **N/**cm^2

VIII. VALIDATION OF ANALYSIS RESULT OF SOFTWARE AND ANALYTICAL METHODS

Roller and shaft of Rotary Kiln supporting roller is exposed to high stresses at heavy working situation. High Stresses because of big kiln dimensions are damaged to roller and shaft of supporting roller according to kinds of effects. This is required that, Decreasing stresses are provided longer life and decreasing damaged to roller and shaft of supporting roller with material properties and working situations. Thus analysis was carried out and the result was compared with theoretical. (i)Theoretical Normal stress calculated was 7605.75 N/cm^2 and Finite Element Analysis was 7686 N/cm^2. (ii) Theoretical shear stress calculated was 52771.94 N/cm^2 and Finite Element Analysis was 56578 N/cm^2. (iii) Theoretical bending stress calculated was 46600 N/cm^2 and Finite Element Analysis was 49160 N/cm^2.

IX. NEW DESIGN OF SUPPORT ROLLER AND SHAFT ASSEMBLY MATERIAL SELECTION

The figure 3 shows and 2 – Dimensional views of the support roller and shaft assembly. All dimensions are in mm. The roller of the support roller assembly is not changed whereas the shaft of the support roller assembly is changed. Generally unalloyed medium carbon steel is chosen for this application. EN 24 grade steel is chosen as the new shaft material because it is having good mechanical properties, high tensile strength, with stand heavy load, etc. And it is suitable for this application. It is economically cheaper than stain less steel materials.

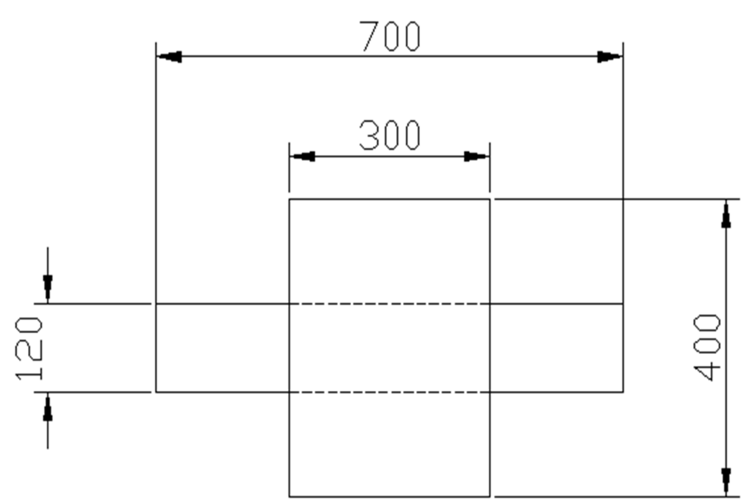


Fig 5 2D view of support roller and shaft

International Journal for Research in Applied Science & Engineering Technology (IJRASET)

Table 2. Properties of support roller and shaft

S. No	Element	Chemical composition	Young's modulus	Poisson Ratio
1.	Support Roller	C - 0.40% Si - 0.25% S - 0.015% P - 0.035%	2.07E5N/mm^2	0.3
2.	Shaft	C - 0.40% Si - 0.25% S - 0.015% P - 0.015% Mn – 0.80% Mo-0.25%	2.07E5N/mm^2	0.3

X. ANALYTICAL METHOD

A. Bending stress

σ = 13814.8 N/cm^2

For Shear Stress:

B. Torsion Equation

$\frac{T}{J} = \frac{\tau}{R}$

Power (P) = $\frac{2\pi NT}{60}$

$3.7x10^3 = \frac{2\times\pi\times0.666\times T}{60}$

T=53051.64 N-m

T=5305164 N-cm

$\frac{5305164}{J} = \frac{\tau}{4}$

Polar moment of inertia (J) = $\frac{\pi}{32}$X12^4

J=2035.75cm2

τ=15641.76 N/cm^2

For Normal Stress:

σ = $\frac{P}{A}$

Where

P=382306.96 N

A=$\frac{\pi}{4}$X12^2=113.5cm^2

$\sigma = \frac{382306.96}{50.26}$=3380 N/$cm^2$

Normal Stress, σ = 3380 N/cm^2

XI. FINITE ELEMENT ANALYSIS O SUPPORT ROLLER AND SHAFT

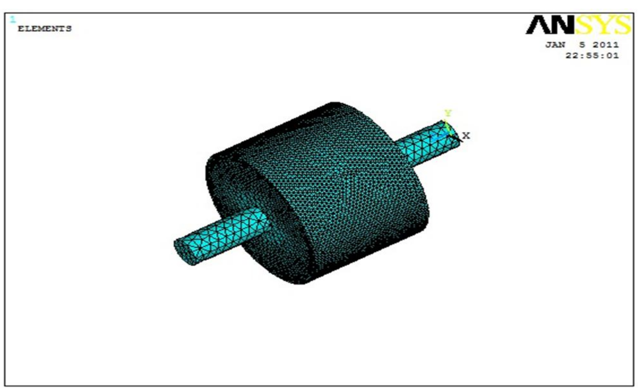


Fig.6 Three-Dimensional Finite Element Model Of Roller Assembly

Three-dimensional finite element model was generated from solid model by using ten-node tetrahedral elements. According to Total number of elements in model was 7349 with16014 nodes.

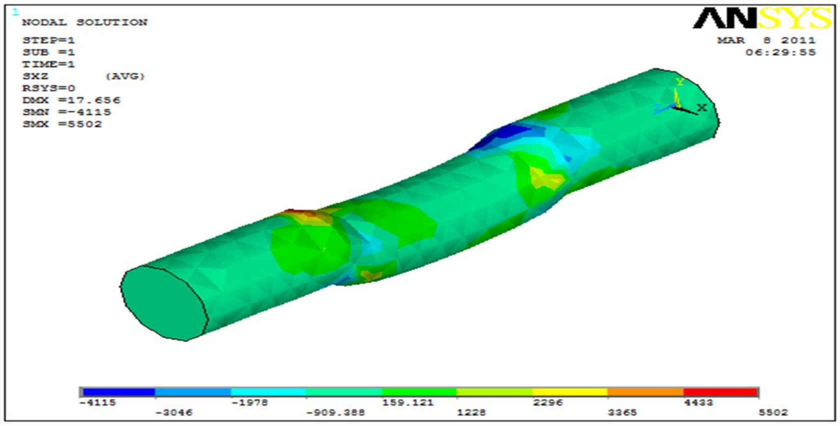


Fig 7 Minimum and maximum Normal Stress On Shaft Maximum Normal stress induced on shaft is 5502 **N/cm^2**

XII. VALIDATION OF ANALYSIS RESULT OF SOFTWARE AND ANALYTICAL METHODS FOR NEW DIMENSION

Roller and shaft of Rotary Kiln supporting roller is exposed to high stresses at heavy working situation. High Stresses because of big kiln dimensions are damaged to roller and shaft of supporting roller according to kinds of effects. This is required that, Decreasing stresses are provided longer life and decreasing damaged to roller and shaft of supporting roller with material properties and working situations. Thus analysis was carried out and the result was compared with theoretical. (i). Theoretical bending stress calculated was 13815 N/cm^2 and Finite Element Analysis was 13839 **N/cm^2.** (ii). Theoretical shear stress calculated was 15641.76 N/cm^2 and Finite Element Analysis was 20331 **N/cm^2.** (iii). Theoretical normal stress calculated was 3380.33 N/cm^2 and Finite Element Analysis was 5502 **N/cm^2.**

Table 3 Validation of analysis result of software and analytical methods

	ANALYTICAL METHOD (N/cm^2)	FINITE ELEMENT ANALYSIS (N/cm^2)
Normal Stress	7605.75	7686
Shear Stress	52771.94	56578
Bending Stress	46600	49160

Table 4 Comparison of analysis result

	EN-8 Grade Mild Steel	EN – 24 Grade Mild Steel
Bending Stress by FEA	49160 (N/cm^2)	41239(N/cm^2)

Table 5 Validation of analysis result of software and analytical methods

	ANALYTICAL METHOD (N/cm^2)	FINITE ELEMENT ANALYSIS (N/cm^2)
Normal Stress	3380.33	5502
Shear Stress	15641.76	20331
Bending Stress	13815	13839

XIII. CONCLUSION

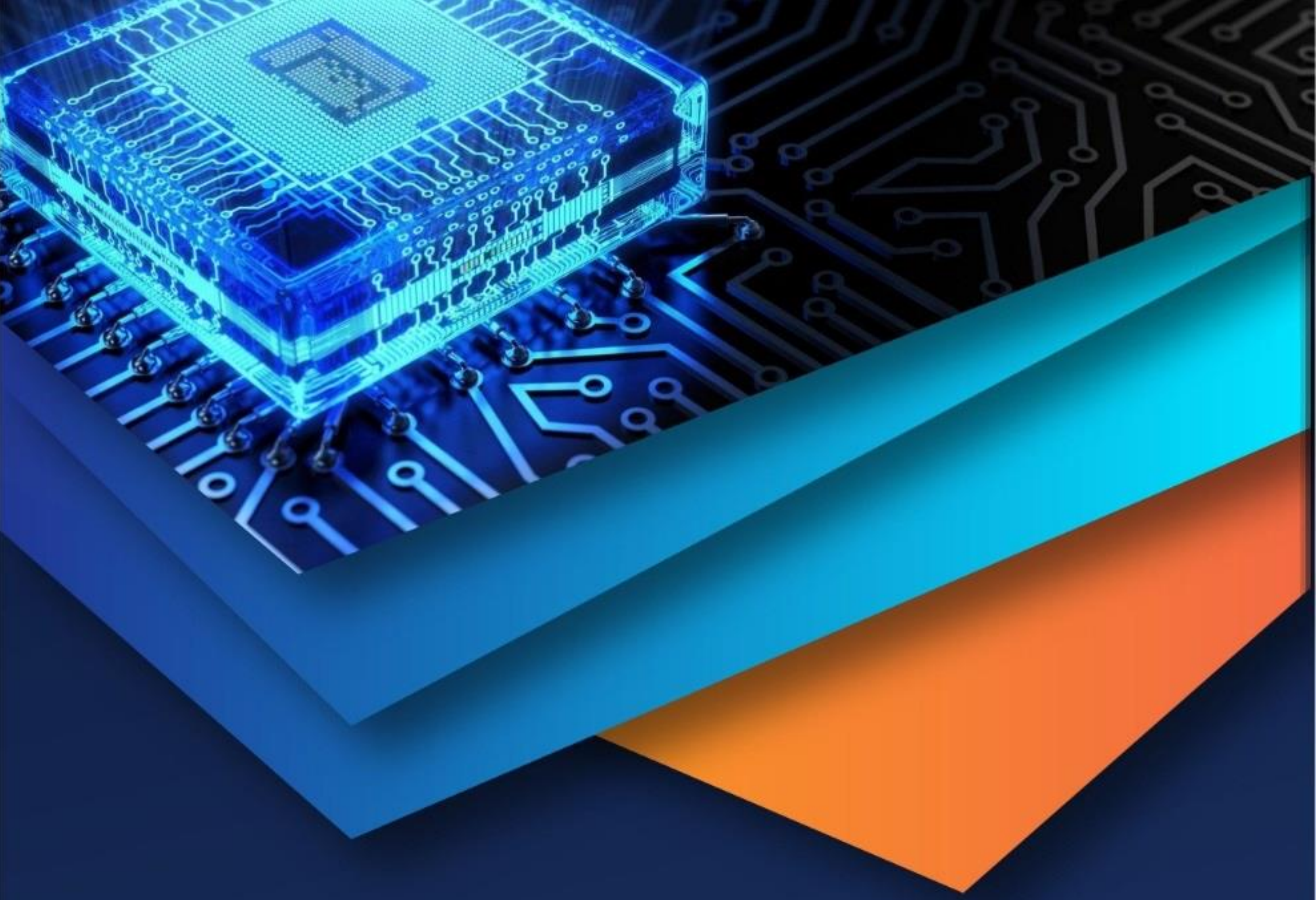
The stress in the existing support roller assembly is determined by finite element method and analytical method. The analysis result

Volume 4 Issue XII, December 2016
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

is compared with analytical result. The stress values for analysis result and analytical result are in the same range. Stress for the new shaft material in the support roller assembly is determined by finite element method and it is compared with the analysis result of existing shaft material of the support roller assembly. The stress developed in the new shaft material of the support roller assembly is less compared to the stress developed in the existing shaft material of the support roller assembly. So, EN-24 steel is better material of this application than EN-8 steel and has a greater life period than EN-8 steel. The geometry of the support roller assembly is modified. The stress in the modified support roller assembly is determined by finite element method and analytical method. The analysis result is compared with analytical result. The stress values for analysis result and analytical result are in the same range. The stress in the shaft of the modified support roller assembly is less and has a greater life period.

REFERENCES

[1] M.J.Reid, Analysis of the causes of recent roll shaft failure in natal sugar mills, 1998.
[2] T.NimaliMedagedara, UpulS.Fernando, P.D.Sarath Chandra and M.C.J.Medagedara, Comparision of experimental and finite element results for elastic – plastic stress/strain behaviour of notched shaft under multi axial loading. – International symposium of Research students on materials science and Engineering, 2004.
[3] George Seggewiss.P., Nathan Schachter.p., George Obrmeyer.P, Kiln drive application considerations.
[4] AshaGaikwad, PrachiRajarapollu, Analysis of mechanical stresses developed on T-G shaft during faults. IET – UK International conference on Information and communication technology in Electrical sciences, 2007.
[5] YogeshSonavane, Eckehardspecht, Numerical analysis of the heat transfer in the wall of the rotary kiln using Finite Element Method ANSYS., Seventh International Conference on CFD in the minerals and process Industries, Dec-2009.
[6] Xuejun LI, YipingShen, S.Dhillon, Fatigue reliability evaluation of the kiln roller.
[7] Timoshenko, Strength of Materials
[8] R.K.Rajput , Strength of Meterials.



10.22214/IJRASET

INDEX COPERNICUS 45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY