Design and Analysis of Handling and Finishing Line Rollers

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Abstract: the rollers would not perform their functionality effectively. This accounts for a significant delay in the process flow. This work therefore lies in analyzing the rollers with a feasible solution for the rollers to account for the loads, improve their life and thereby improving the process flow. Two different grades of steel namely AISI 1045 and AISI 4140 respectively are used as a substitute for existing roller material. Each of these materials are analyzed for deformations and the stress withstanding capabilities. The life cycles are also analyzed for the better life cycles. For performing the analysis A- Handling and finishing line rollers act as material handling equipment in steel plants and are prone to high loads and temperatures. These loads often deform the rollers and NSYS workbench is deployed and CATIA is used for the modeling of the roller.

Keywords- Rollers, Static analysis, Max. Shear stress theory, ANSYS Workbench

1. INTRODUCTION

Steel comprises one of the most essential inputs in all sectors of economy. Steel industry is both a basic and a core industry. The economy of any nation relies to a significant extent on the iron and steel industry in that nation. Iron and steel making in India has been a known craft for long time, the growth of steel industry in India can be conveniently studied by dividing the period into pre and post independent era. By 1950, the whole installed capacity for the ingot steel production was 1.5 million tons per year. The capacity multiplied itself by around 11 times to about 16 million tons by nineties. At present India's steel products are being produced from 4 different sources, namely integrated steel plants, Re-rolling Mills, Mini Steel Plants, Alloy and special steel plants. Integrated steel plants usually consist of naturally occurring raw materials and are processed into finished products in various stages. The plants here are highly capital intensive. It needs approximately Rupees. 2500 crore of money to establish a 1 million tons per year steel plant.

2. LITERATURE SURVEY

- Harshavardhan et.al has studied that by increasing conveyor inclination to 170 to 180 degrees, the these shortcomings, a predictive maintenance and design modification was deployed.
- By using the Hypermesh software the stresses are analyzed and impact on shaft at higher inclinations we will made changes in design accordingly.
- Gys van Zyl et.al stated that Finite element analysis was performed to quantify the stress distribution in the shaft. It was concluded that the shaft failed due to fatigue and that the failure was caused by improper reconditioning of the shaft during routine overhaul. Cyclic load leading to fatigue failure was caused by the weight of the gearbox and partially by the motor which is being carried (partially) by the conveyor pulley shaft. Fatigue failure is most likely to occur if there is an extremely sharp corner machined at the shaft shoulder where its diameter changes. It might also occur due to weld restorations of the shaft caused by a heat affected zone in the sharp corner of the shaft shoulder.
- Amol Kharage et.al studied the alternative material for roller used in gravity roller conveyors for weight optimization. Considering a composite material for conveyor roller is also stated. Linear, static, modal, transient and optimization analysis of existing roller conveyor were performed by simulation software. The material used for roller and C-channel frame is a composite material i.e. carbon fiber.
- Aniket Jagtap et.al identifies the correct choice of roller diameter must take into consideration for the proper belt width. The relationship between the maximum belt speed, roller diameter and the relative revolution per minute. Angle of surcharge is one of the most important characteristics in determining the carrying capacity as it directly governs the cross sectional area of material in the belt and hence the volume being conveyed.
- Lihua ZHAO et.al investigated about theroller surface adhesion material, which is equivalent to increasing the roller local diameter, which causes the conveyor belt to deviate. Strengthened empty segment cleaning of conveyor belt to reduce the adhesive material or dust accumulation on the conveyor belt. In addition, the conveyor belt between the nose and tail parts deviation, called central or local deviation. Such deviation reasons is more complex, it is with the conveyor belt along device exposure to a relationship.
- B Singh et.al developed a method for calculating the line load and the deflection curves for a pair of contacting rollers supported at the ends. The formulation includes the possibility of varying flexural rigidity and the distributed weight of the

rollers, nonlinear force-displacement relationship in the nip, and crowning of the roller surfaces. The resulting equations are solved by the method of "quasi-linearization." The analysis was used to study the effects on line load of the thickness of the compliant layer covering one of the rollers.

- W L Bowen et.al worked with the unique functional characteristics that the use of hollow rolling elements induces in a radial type cylindrical roller bearing. The ability to consistently and successfully preload these hollow rollers between the inner and the outer races together with, of course, the necessary but usual degree of precision of the bearing components, provides an effective control of the shaft run-out. This makes the bearing especially suitable for high precision applications. The roller preloading also eliminates the need for roller guidance from a retainer which, combined with the lighter rollers, generally means higher speed capabilities.

3. MODELING AND ANALYSIS

The design of roller is complex and that makes the repair procedure of it even more tedious. The close study of roller is desirable to comment on the fatigue and the amount of wear it is subjected to. Hence, the roller is modelled as per its existing design specifications. This modelled roller should then be subjected to the same amount of loads as that taken by the handling and finishing rollers in real time. The basic structure of the roller as per the figure3.3 is to be modelled. The initial process involves designing the entire roller arrangement in 3 dimensions from the two dimensional drawing. For this CATIA software is deployed. In CATIA, the two dimensional drawings are to be converted into a three-dimensional solid roller. This modelled frame and roller assembly are saved in ". igs" format respectively and are so done to easily import them into ANSYS.

Fig.1 Basic Structure of HFL Roller

In the latest version of ANSYS i.e. ANSYS v19 the already modelled files of roller and the roller table assembly are imported into ANSYS. In this software we analyse the roller and the roller basing on the loads that are fed onto them in real time. With these parameters what do we find?

- ✓ The deformations are to be found which are prone due to the loads the roller is subjected to.
- ✓ The respective stresses which act on the roller and the roller table assembly respectively.
- ✓ The estimated fatigue life of rollers as per the software is to be found.

4. ANALYSIS OF EXISTING ROLLER MATERIALS

Stainless Steel is the material which is used as the default material for the handling and finishing line roller. When loads are exerted on the roller, it is subjected to axial load as well as the corresponding temperature. The roller doesn't fail instantaneously but the deterioration happens gradually. The roller succumbs to the load and temperature and starts to deform.

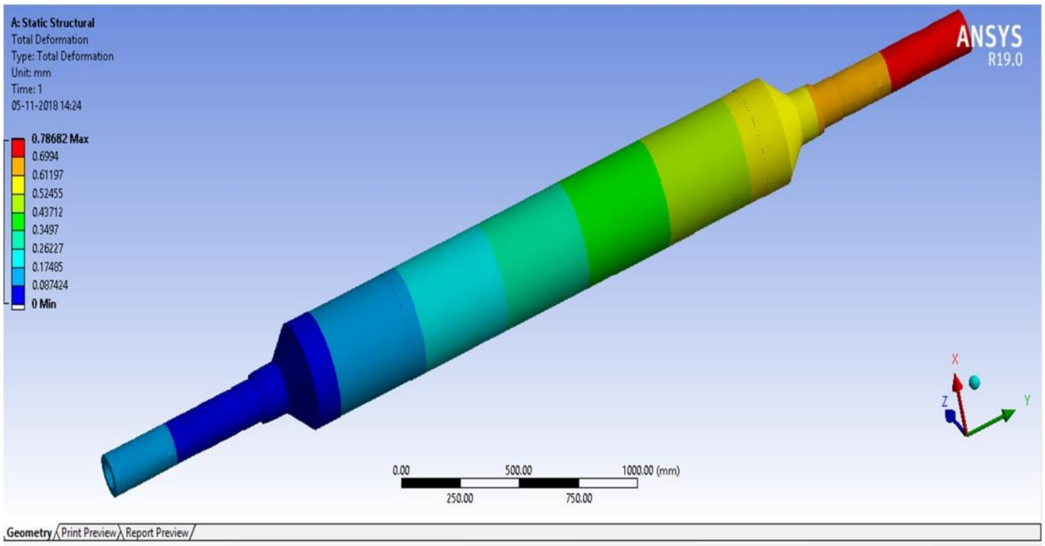

Fig.2 Deformations in Stainless Steel

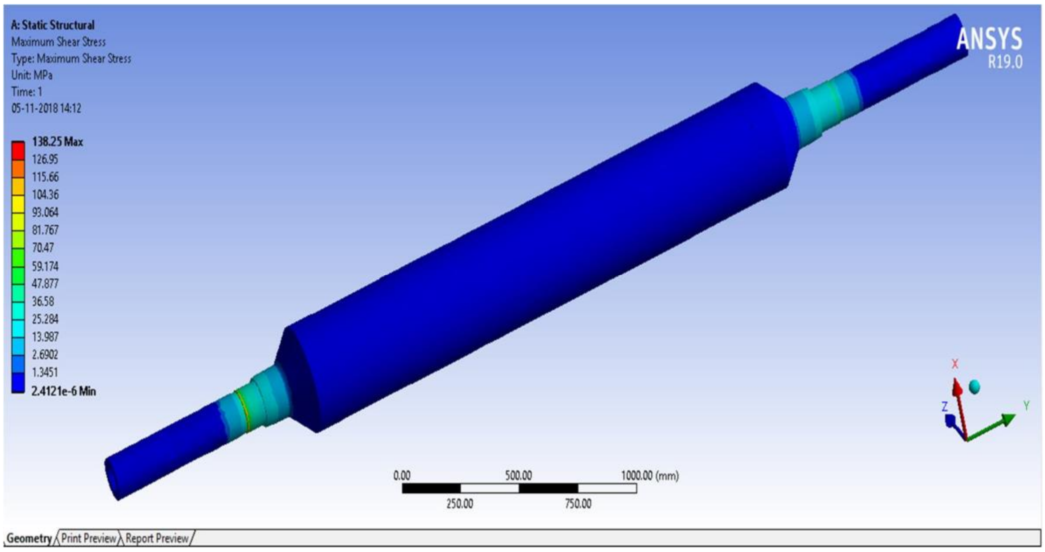

Fig.3 Maximum Shear Stress in Stainless steel

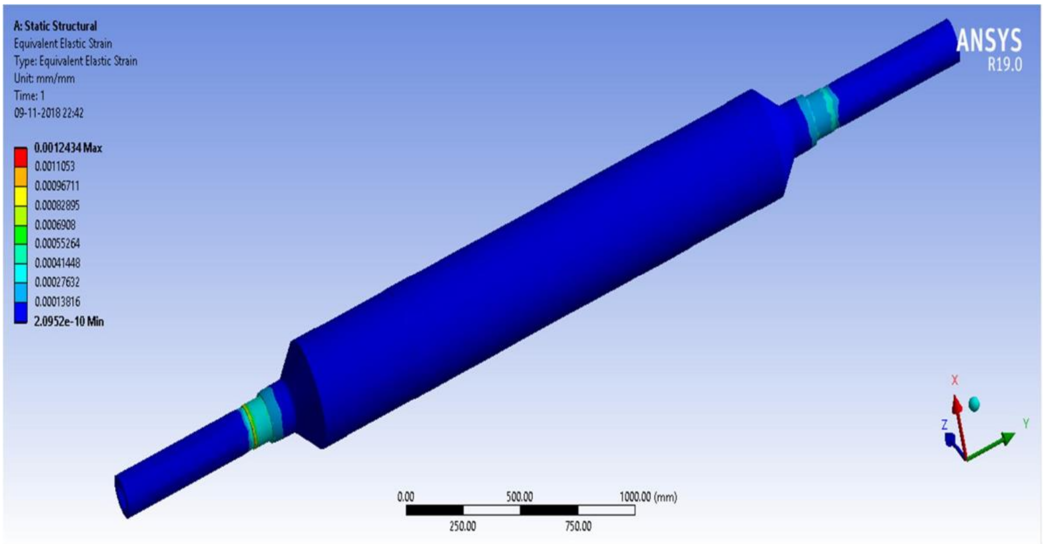

Fig.4 Equivalent Elastic Strain in Stainless steel

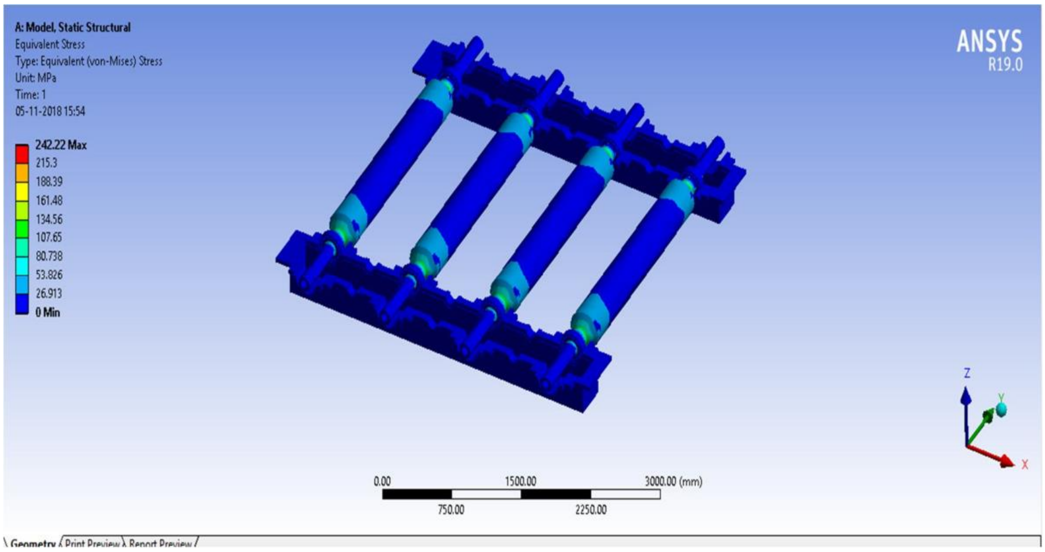

Fig.5 Equivalent (von-Mises) Stress in Stainless steel

Results for Stainless Steel

- Deformations 0.78 mm
- Equivalent (von-Mises) stress 242 MPa
- Maximum shear stress 138.25 MPa
- Equivalent elastic strain 0.0012434
- Life cycles 11738

5. ANALYSIS OF SUBSTITUTE MATERIALS

Stainless steel is replaced by the substitute materials chosen. There is indeed a need to come up with a feasible solution in order to make sure the fatigue life enhances than what it is for the existing material. Hence the four different grades of steel are subjected to the same working conditions.

Why no consideration for change in design of Handling and finishing line roller?

Since the change in design in terms of such a heavy duty roller relies on the basic norm that the change in design is directly proportional to the change in weight. If it isn't heavy, it would succumb to the loads and fail frequently. If it gets bulkier, the running costs of it would be exceedingly huge and there is also a possibility of power shortage as the existing power sources might not be adequate to rotate the rollers. The change in dimensions are also tried and have not proved any fruitful results.

Hence, we choose to alter the materials to see how well the substitute material act as a roller material.

Carbon Steel AISI 1045

Carbon Steel is one predominant grade of steel and that is the next roller material.

- The chemical composition of AISI 1045 is as follows (C-0.45%, Mn-0.6%, P < 0.04, S < 0.05%)
- The simulation process is alike as in the former cases where the carbon steel roller is subjected to the same loads and boundary conditions.

Results for AISI 1045 Steel

- ✓ Deformation 0.72 mm
- ✓ Equivalent (von-Mises) stress 234.6 MPa
- ✓ Maximum shear stress 133.5 MPa
- ✓ Equivalent elastic strain 0.0011605
- ✓ Life cycles 14599

Alloy Steel AISI 4140

Alloy steel is obviously tougher material compared to all the other materials but is slightly expensive to manufacture rollers with this grade of steel.

- The chemical composition of Alloy steel is C-0.38%, Cr-1.1%, Mn-0.15%, Si0.15%, Mo-0.15%, S-0.04%, P-0.035%)
- The life cycles however in this case are to be considered as Alloy steel is worthy to be a material for a roller

- ➢ All the parameters are good with alloy steel however the expenses incurred during its fabrication may not make it the ideal case for a roller material.

Results for AISI 4140

- ✓ Deformations 0.64 mm
- ✓ Equivalent (von-Mises) stress 234.8 MPa
- ✓ Maximum shear stress 132.6 MPa
- ✓ Equivalent elastic strain 0.00112
- ✓ Life cycles 25469

6. RESULTS AND DISCUSSION

The results obtained by using the two different materials are matched against the existing material values. The results include the stress carrying capacity, the extent of deformation and the number of life cycles.

Table 1
Deformation comparison in mm

Material	Deformation in mm
Stainless steel	0.78
AISI 1040	0.72
AISI 4140	0.64

Table 2
Von-Mises stresses of the different materials in Mpa

Material	Von-Mises stresses in MPA
Stainless steel	242
AISI 1040	234.6
AISI 4140	234.8

Table 3
Maximum shear stress in MPa

Material	Maximum shear stress in MPa
Stainless steel	138.25
AISI 1040	133.5
AISI 4140	132.6

Table 4
Life cycles in ANSYS

Material	Life cycles in ANSYS
Stainless steel	11738
AISI 1040	14599
AISI 4140	25469

7. CONCLUSION

- Deformations are least in AISI 4140 with 21.8% as compared to the existing roller material.
- Deformations in AISI 1045 are 11% less as compared to the existing roller material.
- Von-Mises stresses are ideal in AISI 1045 steel which is 234.6 MPa. The existing material exhibits a von-Mises stress of 242 MPa with its yield at 250 MPa.
- Shear stress values are found ideal in AISI 4140 which is 132.6 MPa.
- The life cycles in MS2062 are 14551 which are 23% more than the number of life cycles in Stainless Steel.
- From the analysis values, AISI 4140 has 25469 life cycles as compared to 11738 life cycles of Stainless steel. AISI 4140 has the highest number of life cycles for all the materials analysed.
- AISI 1045 but the manufacturing cost of AISI 4140 will be a deterrent in choosing it is an ideal roller material.
- AISI 1045 which has relatively lesser life cycles (14599 life cycles) compared with AISI 4140 (25469 AISI 4140 has 74.47% more number of life cycles than
- life cycles) but is economical to manufacture at lower costs and with life cycles 24.37% more than Stainless Steel.

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