Analysis of Spindle Shaft of Scrap Winder Machine In Cold Rolling Trimming Line by Fea Approach

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ABSTRACT
In this paper, Quality is the prime concern for any industry to establish or remain in today's competitive market. Steel industries have 4-Hi reversible cold rolling Mills and cold rolling trimming Line. The objective of trimming Line is to remove excess unwanted edgy material from cold rolled coils before galvanization process. Galvanizing lines has CGL-1 and CGL-2, which produces 20000 mt galvanized coils per annum. Galvanizing is the practice of immersing clean, oxide free steel in to molten zinc to form a protective coating over the metal.

This Paper deals with the redesign and analysis of spindle shaft of scrap winder machine to recover all the problems found in existing condition. It includes analysis of existing gear box, present working conditions with the help of FEA approach. The paper will describe to improve the line continuity, up time and reduces the production loss, maintenance cost, delay time and chances of accidents.

Keywords
Scrap Winder Machine, Cold rolling trimmer line, gearbox, spindle shaft

1. INTRODUCTION
Scrap Winder machine is used for the collection of removed scraps which comes from cold rolling trimming line. Scrap winder machine involves major components such as gear box, spindle shaft, housing and scrap collection pot, scrap pusher, scrap press roll. During the process of winding vibration occurred in gear box causing the fasteners getting sheared along with motor to Gear box coupling gets damaged which deteriorates the production of cold rolled coils increasing the maintenance cost and chances of accidents.

1.1 Cold Rolling Trimming Line
Cold rolling trimming line is to remove excess unwanted edge materials from cold roll coils before galvanizing process to avoid the strip breakages, over edge zinc coating in continues galvanizing line.

This machine is implemented in cold rolling shop. The machine produces 20000 mt cold roll trim coils per annum. CRM shop consisting of Pickling section, two numbers of 4_Hi cold rolled mill, CR Trimmer Line, two numbers of continuous galvanizing line.
When hot rolled coil come in the CRM shop, first it is introduced in the pickling section to remove the scales and rust formed due to oxidation then the sheet fed to CRM_1 or CRM _2 to get thinner sheet. Cold rolled coils contain edge burr and black edges which is to be removed on CR trimming Line. Then it is galvanized and then either it is dispatched to customer or send to CRCTL or for corrugation. The cold rolling shop for steel plant is shown in fig.1

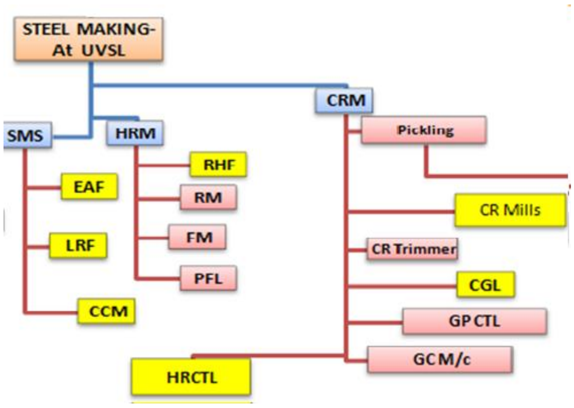

Fig 1: UVSL Process Flow Chart

1.2 Edge Trimmer
This unit is provided to trim the strip at both the edges. It is dual head driven by as geared motor. Trimmer cutter is supported by upper and lower arbors in each head, rotates in grease lubricated roller bearings. Both trimmer head slide in/out as per required with the sheet trimming. Both side of trim strip will come in scrap point & scrap winder machine is used for collection of removed scrap.

1.3 Scrap Winding Machine
Scrap Winder machine is used for the collection of removed scraps which comes from cold rolling trimming line. Scrap winder machine involves major components such as gear box, spindle shaft, housing and scrap collection pot, scrap pusher, scrap press roll.

In scrap winder, gear box has extended spindle which scrap can be wound as sufficient quality of scrap, capacity of scrap, scrap press roll is used to suppress the scrap for accumulating the scrap in terms of volume. Scrap press roll has given two number pneumatic cylinder having 5 bar air pressure over a scrap using scrap press roll.

The whole assembly of gear box and motor mounted on frame which does in/out movement using hydraulic cylinder. As the housing is full of scrap, this assembly moves outwards and bundle of scrap can be pushed by scrap pusher in the collecting pot. Specifications for scrap winder machine are given in table 1.

Table 1. Specification of scrap winder machine

Sr.no	Components	Specification
1.	Gear Box	Helical Gear box double stage Horizantal foot mounted Ratio = 18:1 Housing Steel fabricated Make Shanthi gear limited
2	Spindle Shaft	M.S Round Bar Diameter is 140mm Length is 1730 mm tapper from 1040 mm to end. Weight is 150 kg.
3	Scrap Press Roll	Diameter is 450mm, Length is 900mm Two no. pneumatic cylinder working air pressure 5 bar
4	Scrap Pusher	One no. of Hydraulic Cylinder ,Stroke=900mm
5	Coupling	Gear coupling-103

2. PROBLEM FORMULATION

Problem occurred in existing system are

1. Vibration in Gear Box spindle shaft.
2. Gear Box mounting fasteners gets loosen, finally fasteners sheared out & Gear box mounting legs broken.
3. Frequently failure of Motor to Gear Box gear coupling due to misalignment.
4. Gear Box input pinion shaft teeth worn-out.

Problem occurred in Scrap winder machine is due to cantilever loading of rotating spindle shaft and large length of rotating spindle shaft mounted only in gear box.

3. OBJECTIVE

The objective is to do the implementation of scrap winder gear box to increase productivity & efficiency of cold rolling trimmer line.

The aim is to find out the main cause of

1. Assembly disturbance

a. Misalignment of motor and gear box.

b. Misalignment with fixtures/Fasteners of motor and gear box to base frame.

2. Vibration in gear box and spindle

This paper finds out the reason of failure of scrap winder machine and modeling of the existing spindle shaft and analysis of the shaft and suggests the suitable remedial solution for scrap winder machine that is redesign of spindle shaft with the help of FEA approach.

4. ANALYTICAL ANALYSIS OF EXISTING AND MODIFIED SHAFT

After doing calculation analytically, Table 2 shows the comparative study of SFD and BMD calculations. From the comparison in the table, it is shown that, the maximum generated reactions on shaft supports are get reduced due to the modification of shaft.

Table 2. Comparison of SFD and BMD Calculations

Parameters	Existing Shaft		Modified Shaft	
	REACTIONS		REACTIONS	
At a support **A**	- 158067 N		- 39885 N	
At a support **B**	206052 N		88573 N	
	SFD	BMD	SFD	BMD
At a Point **A**	- 158067 N	0 N. M	- 39885 N	0 N. M
At a Point **B**	47745 N	- 43350 N. M	47744 N	- 43340 N. M
At a Point **C**	47399 N	- 24648 N.M	47 400 N	- 24648 N.M
At a Point **D**	0 N	0 N. M	0 N	0 N. M

The table 3 shows the Comparison of stresses in gear box mounting bolts of existing and modified shaft. According to the table it is shown that, the stresses on gear box mounting bolts are get reduced due to the modification of shaft.

Table 3. Comparison of stresses in gear box mounting bolts

Parameters	Existing Shaft	Modified Shaft
Maximum principal tensile stress	160 Mpa	48 Mpa
Maximum principal shear stress	103 Mpa	27 Mpa

5. FINITE ELEMENT METHOD

The finite element method is a powerful tool to obtain the numerical solution of wide range of engineering problem. Finite element analysis models can be used to approximate “stress stiffening” effects in rotating mechanical components (e.g., fan wheels, pump rotors, motor shafts, etc.). Analysis of existing and modified spindle shaft of scrap winder machine is done using FEA.

5.1 FEM Analysis of Existing and Modified Spindle Shaft of a Scrap Winder Machine

FEA model is Mesh with Four node tetra hedral element shape, which has 156399 elements and 46773 nodes. CAD model and meshed model of shaft is shown in fig. 2 and fig. 3 respectively.

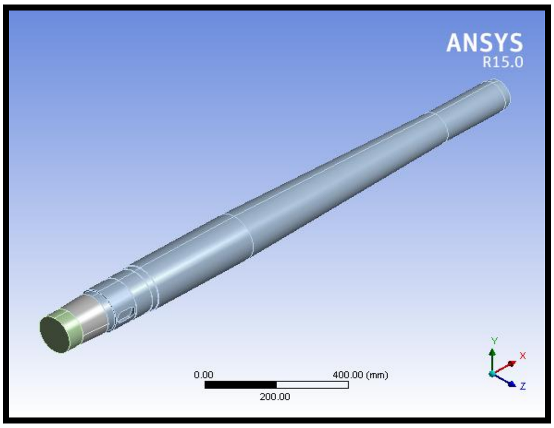

Fig 2: CAD Model of Shaft

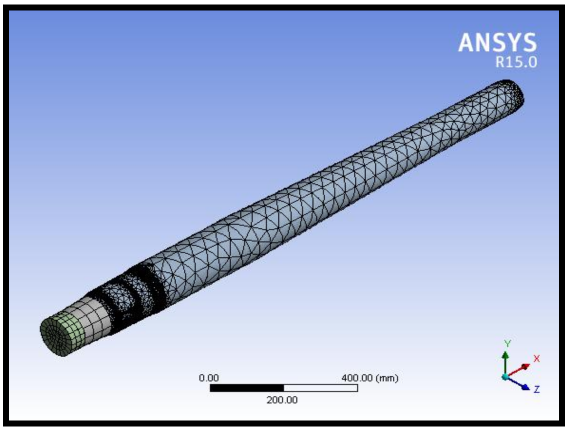

Fig 3: Meshed model of shaft

5.1.1 Static Structural Analysis of existing spindle shaft

Fig.4 shows the Loading & boundary condition of shaft. Application of force 47985 N & moment of 3580.5 N.mm are applied on the shaft at points A & B respectively (Shown in red color). The blue color shows the fixed support at point C.

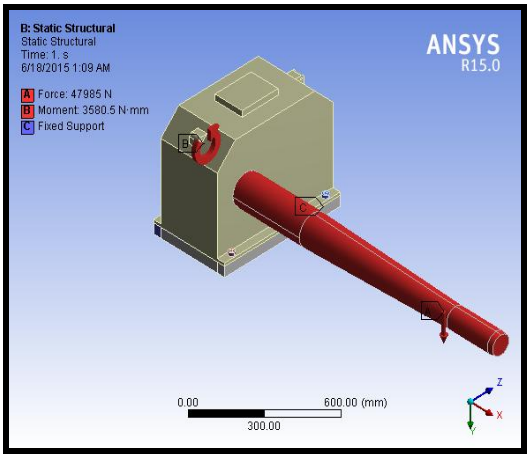

Fig 4: Loading & boundary condition of shaft.

The Results of existing shaft for the maximum equivalent (Von-Misses) stress is computed which is 238.06 Mpa as shown in fig.5.

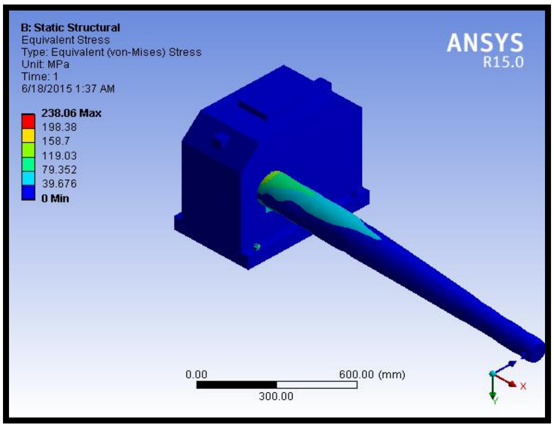

Fig 5: Maximum Equivalent (Von-Misses) stress

Similarly maximum principle shear & tensile stresses for static on existing shaft and bolt are calculated using FEA.

5.1.2 Transient Structural Analysis of Existing Spindle Shaft

Fig.6 shows the force 43984 N & moment of 3580.5 N.mm are applied on the shaft at points A & B respectively.(shown by red color). The blue color shows the fixed support at point C.

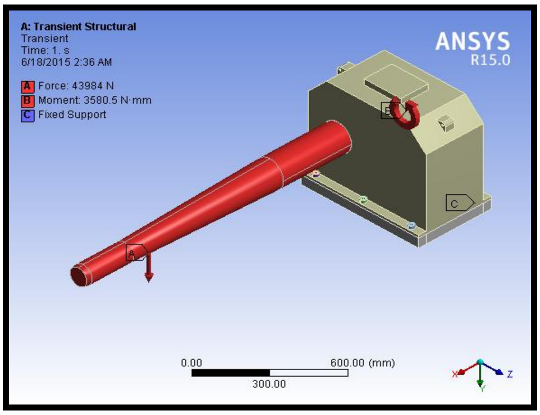

Fig 6: Loading & boundary condition of shaft for transient

Results of existing shaft for maximum transient equivalent (Von mises) stress is calculated which is 142.45 MPa. (shown by red color) as shown in fig.7.

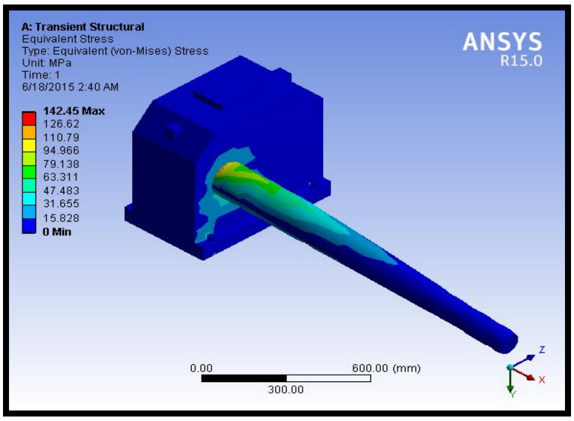

Fig 7: Maximum transient equivalent (Von mises) stress

Similarly maximum principle shear & tensile stresses for transient analysis on shaft and bolt are calculated using FEA.

5.1.3 Static Structural Analysis of Modified spindle shaft.

Fig.8 shows the two fixed supports are applied at points C & D. At point A, a force of 47985N is applied acting downwards & at point B moment of 3580.5 N.mm.

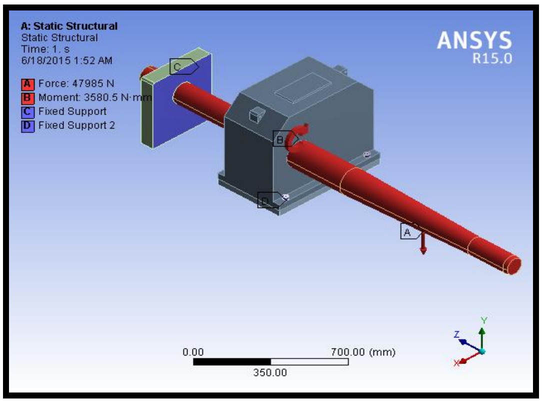

Fig 8: Loading &boundary condition of modified shaft

Fig.9 shows the maximum equivalent stress on the modified shafts which is 122.4 Mpa.(shown by red color).

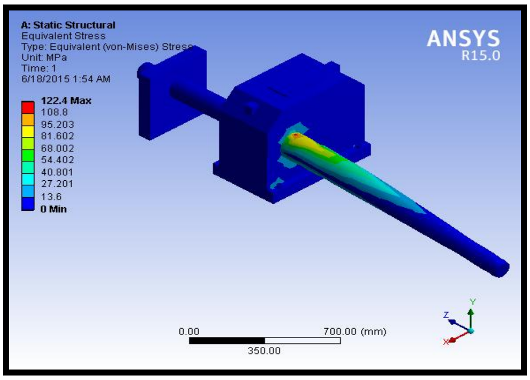

Fig 9: Maximum equivalent stress

Similarly maximum principle shear & tensile stresses for static on modified shaft are calculated using FEA.

5.1.4 Transient Structural Analysis of Modified Spindle Shaft

Fig.10 Shows the maximum equivalent (Von-Misses) stress on the shafts which is 62.659 Mpa.

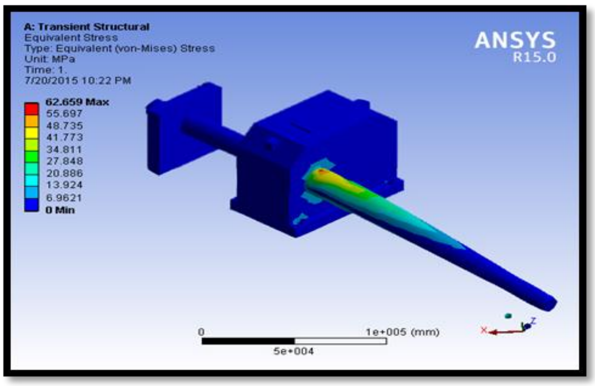

Fig 10: Maximum Equivalent (Von-Misses) stress

Similarly maximum principle shear & tensile stresses for transient on modified shaft are calculated using FEA.

6. RESULTS

Table 4 and table 5 shows the results for static analysis of existing and modified shaft.

Table 4. Static analysis of existing shaft

Sr. No.	Result of existing shaft	Max	Min
1	Von-misses stress or Equivalent stress	238.06 Mpa	0Mpa
2	Max. Principal Tensile Stress on shaft	167.6 Mpa	- 46. 794 Mpa
3	Max. Principal shear stress on shaft	119.8 Mpa	0 Mpa

Table 5. Static analysis for modified shaft

Sr. No.	Result of modified shaft	Max	Min
1	Von-misses stress or Equivalent stress	122.4 Mpa	0 Mpa
2	Max. Principal Tensile Stress on shaft	109.57Mpa	- 16. 708Mpa
3	Max. Principal shear stress on shaft	50.922 Mpa	0 Mpa

According to the table No. 4 and 5, it is concluded that

1. The maximum von-misses stress or equivalent stress is reduced from 238.06 Mpa to 122.4 Mpa.
2. The maximum principal tensile stress on shaft is reduced from 167.64 Mpa to 109.57 Mpa.
3. The maximum principal shear Stress on shaft is reduced from 119.82 Mpa to 50.922 Mpa.

7. CONCLUSION

The scrap winder machine shaft is designed on the basis of static and transient loading. As expected in transient/dynamic loading stresses induced in shaft are higher than static case. The stresses induced in the shaft and gear box mounting bolts are validated by FEA using ANSYS software for both the cases. From the analysis, it is concluded that the stresses generated in the gear box mounting bolts of existing shaft is much higher, resulting the failure of gear box mounting bolts. So shaft is modified by increasing the length of shaft towards the bearing side. The generating stresses in modified shaft is so less than the previous case.

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