To Control and Optimize the Response of Critical Components of Mandrel

Shivnikar N S[1], Jagtap P V[2], Mate A K[3], Vharkate C B[4] , Gadade R A[5]

[1]*Assistant Professor, Mechanical Department, Aditya Engineering College, beed, Maharashtra, india*
[2]*HOD, Mechanical Department, Aditya Engineering College, beed, Maharashtra, india*
[3]*Lecturer, Mechanical Department, M S Polytechnic, beed, Maharashtra, india*
[4]*Lecturer, Mechanical Department, M S Polytechnic, beed, Maharashtra, india*
[5]*Lecturer, Mechanical Department, M S Polytechnic, beed, Maharashtra, india*

ABSTRACT

Mandrel is the critical part of the rolling mill operation. Mandrel consists of several components which sometimes encounter unfortunate failures. Theses components includes wedge, mandrel shaft, pull rod or segments. In this thesis design and optimization of wedge and mandrel shaft is carried out. To design the wedge there is need to calculate which are the governing parameter while designing of wedge. The 3D modeling and simulation of the wedge is carried out using solid works software. The study also includes the optimization of the shaft. As the mandrel shaft was failed during working so there is need to optimize that shaft. The cause of failure of mandrel shaft was due to fatigue failure. So first of all fatigue failure analysis of shaft is done. For fatigue failure analysis the S-N curve has been created by considering various endurance limit and endurance limit correcting factors. Further study shows that the shaft was susceptible to the fatigue so it needs optimization. By considering various values of the fillet radius optimization is carried out. The shaft is then modeled and simulated in the Ansys v 12.

Keyword : - *Mandrel tension, drums, and sleeves*

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1. Introduction

Mandrel is a very important part of rolling mill and strip processing line industry. The mandrels used are of expanding and collapsing type of mandrel to account for the loading and unloading of the coil. When mandrel is used for uncoiling of the coil then it is called uncoiler type mandrel or uncoiler and when this mandrel is used for recoiling of the coil then it is called recoiler type of mandrel or recoiler. Mandrels are capable of providing the high forward tensions that may be required in rolling, as strip as stretch leveled and wound tightly and uniformly on the mandrel drum. A single mandrel tension reel is generally used at the delivery end of a cold strip reduction mill for strip coiling. The use of such single mandrel tension reels for coiling strip in modern cold strip reduction mills presents a number of problems which are mainly due to the weight of the coils to be handled, tension in the strip and also to the high speeds at which the strip issues from the mill. First, excessive time is required to remove the finished coil from one end of the tension reel. Secondly, mandrel deflection is experienced due to excessive forces over the mandrel length which can create defects in the coil and impose undue wear on the mandrel bearings which support the mandrel at one end. In this regard, when excessively heavy coils are being wrapped on the tension reel, it is also necessary to provide an outboard bearing support on the normally unsupported end of the tension reel mandrel. In addition, expensive heavy duty mandrel bearings are required to support the coil. Conventional tension reels also require the use of expensive coil stripper equipment to remove the coils from the tension reel mandrel for further processing. Furthermore, where coil sleeves are used, considerable valuable time is consumed in mounting the next sleeve into position endwise over the mandrel. Matching the rolling and coiling speed and maintaining constant tension in strip are complicated by the changing diameter of the coil as it is being built up. In old mills, the mill motor drives some drums and speeds were matched by slippage in the drive system (as, for example, in slipping clutches). In modern mills, however, the recoilers are 2 driven by variable speed motor, which ensures matched speed at desired tension level. Moreover, in reversing mills, when the strip is being paid off a coiler, the motor acts as a generator returning energy from the back tension to the power supply.

In some instances, additional support for the mandrel is provided by an outboard bearing, which may be moved aside when the coil is to be removed from the mandrel. Mandrel design for cold mills varies considerably ranging from simple drums no mechanisms for fastening the strip to the mandrel to more elaborate types that clamp the head end of the strip. With the former, a common practice is to fasten the end of the strip onto the drum with a piece of adhesive tape and then rotating the drum to accumulate several wraps on it before applying high tension.

2. Wedge Calculation

the coil as the thick cylinder. The inside diameter of coil is considered as the inside diameter of thick cylinder The wedge in the in out wedge type mandrel was failed. In this chapter we are doing the calculations for the wedge by considering the various forces acting on the wedge. Further the bearing area required for wedge is calculated.

There are two forces acting on the mandrel that is the force acting due to the tension in the strip and weight of the coil. The first thing needs to calculate is that which one of the above parameter is dominant.

3.1 Inputs:

$$ID = 610\ mm$$
$$OD = 2600\ mm$$
$$Width\ of\ Coil = 2300\ mm$$
$$Al\ 3000\ series\ Yield\ Strength\ Y1 = 41.36\ MPa$$
$$Weight\ of\ the\ Coil = 26000\ Kg$$
$$Thickness\ of\ Strip = 2mm$$

In this case we were considering and outside diameter of coil is considered as outside diameter of cylinder as shown in fig

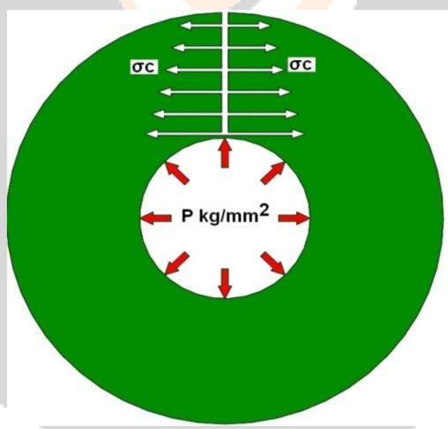

Fig -2.1: Mandrel coil as thick cylinder

3. 3D Modeling and Analysis of Wedge

In this chapter the wedge is 3D modeled and it is analyzed using solid works. For analysis of the wedge we are considering 2 cases by considering the existing design and changing the material of the base and liner material so that the maximum deformation of the wedge can be reduced to avoid the locking of the wedge.

The current wedge design is 3D modeled using Solid Works. The thickness of the liner material is 10 mm and the penetration of liner in the base material is 8mm. The bearing area is 100x150

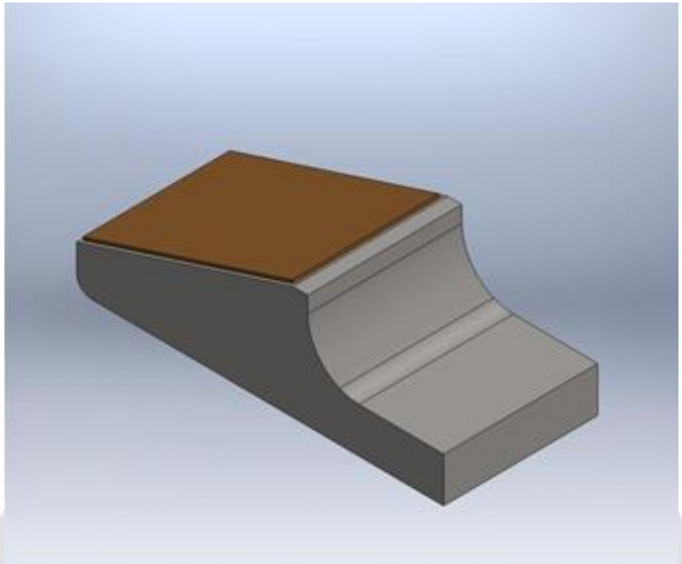

Figure 3.1 : 3D model of wedge

4. STRESS FOR SHAFT CALCULATION

The shaft of the uncoiler mandrel is failed so first of all it needs to calculate the various kinds of stresses acting on the mandrel shaft. And to avoid the fatigue failure of shaft theses calculated stresses must be compared with the endurance limit calculated in the previous chapter.

Fatigue damage of components subjected to normally elastic stress fluctuations occurs at regions of stress (strain) raisers where the localized stress exceeds the yield stress of material. After a certain number of load fluctuations, the accumulated damage causes the initiation and subsequent propagation of a crack, or cracks, in the plastically damaged regions. This process can and in many cases does cause the fracture of components. So, the more severe the stress concentration, the shorter the time to initiate a fatigue crack.
The Fatigue can be defined as follows
"The process of progressive, localized, permanent structural change occurring in a material, subjected to conditions that produce fluctuating stresses and strains at some point or points and that may culminate in cracks or complete fracture after a sufficient number of fluctuations".
Fluctuations may occur both in stress and with time (frequency). Thus, going further from this statement, one can say that, when failure of a moving machine element occurs, it is usually due to so-called fatigue. Fatigue failure occurs because, at some point, repeated stress in a member exceeds the endurance strength (*Se*) of the material. In the case of fluctuating (alternating) loading, where the load is 50 repeated a large number of times, failure occurs as a brittle fracture without any evidence of yielding.

5. CONCLUSIONS

By observing the above results we concluded as fallows
1)The Von Mises stresses are well below the yield strength of the material.
2)The best combination of liner thickness and penetration of it into base material is 9 mm thick liner and 8 mm.
3)The current study shows that the endurance limit or fatigue strength of the mandrel shaft in quill type mandrel can be increased by increasing the fillet radius at the step. But this can also be achieved by increasing the surface finish of the shaft or making the shaft grounded but this increases the cost of the shaft.
4)The studies executed in the scope of both stress and fatigue analyses of the mandrel shaft have revealed the following.
- The analytical calculation shows that the shaft is susceptible to the fatigue

failure.
-The currently provided fillet radius of 7 mm at the step is not enough to account for fatigue.
-The fillet radius must be modified to the 10 mm, to account for fatigue, to have factor of safety in fatigue more than one.

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