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Fatigue Analysis Of Cold Pilger Mill Mandrel For Tube Drawing Using Cad/Cae Software

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Abstract

Cold pilgering process is a complex tube making process in which both diameter and thickness of the tube wall are reduced. It is generally chosen for its dimensional accuracy controlled by ratio of diameter to thickness reduction. In pilgering process, the profile of the roller die and mandrel is very important because the outer diameter surface finish depends on the roller die profile and inside diameter surface depends on the mandrel profile. Generally linear tapered profile is used for the mandrel. This paper focuses on optimum shape of Pilger mill mandrel, using FEM software considering different materials. The profile of the mandrel surface was analyzed with linear and parabolic shape using AISI H11 and AISI M4 tool steel material considering the fatigue loadingl. At the end of the analysis, the result shows that the model of the parabolic profile with M4 material gives the better result than linear with M4 material as well as both the profile of H11 material.

1.KEY WORDS: PILGER MILL, PARABOLIC PROFILE, FEM

2.INTRODUCTION

The cold mill pilgering process uses ring dies and a tapered mandrel to reduce tube cross sections by up to 80 percent. It is suitable for every metal (Generally employed for 8 mm to 230 mm OD and 0.5 to 25 mm wall thickness). Figure shows the theory of cold roll mill working process. The pass (section) gradually reduced when roller move forward stroke.

reduction of outer diameter and wall thickness both are occurred. The pass (section) increased when the roller move backward stroke and the shell being rolled and reeled again. When comes to the point where the grove section bigger than the shell pipe section, the shell rotate a certain degree by a mechanical system located at the rear end of a mill. By repeating this process, a finished tube is achieved. [1-2]. The optimum design of a roller die shape for Pilger mill process was carried out using FEM analyses considering the important design parameters of the Pilger mill machine feed rate and profile of the grooved die and investigate effects on forming load and the deformed shape of a material depending on the die surface profiles and proved that out of three shape linear, cosine and quadratic groove shape the third one is the best .[3]

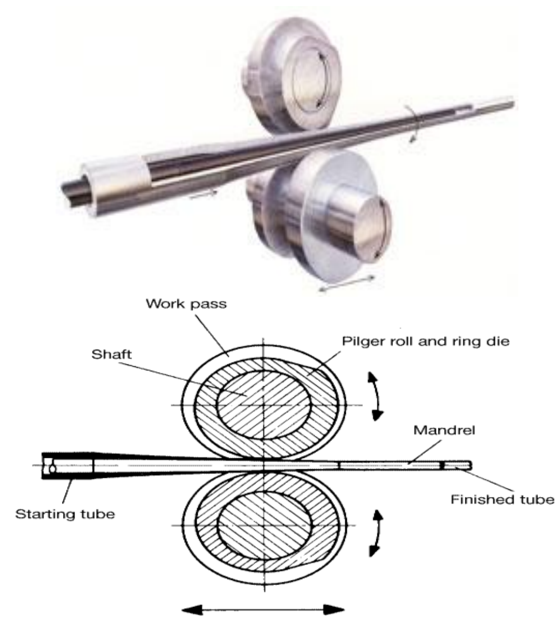

Fig.2.1 Principle of cold pilgering process

. The procedure for Manufacturing tubular cladding and pressure tubes for nuclear industry and Pilgering process is used for manufacturing this type of tubes and it is optimized deformation procedure in pilgering and rotation angle and feed rate[4]. The coefficient of friction between roller die and tube and the coefficient of friction between mandrel and tube by 3d fully finite simulation. [5]

Fatigue is a phenomenon associated with variable loading or more precisely to cyclic stressing or straining of a material. It is Just as we human beings get fatigue when a specific task is repeatedly performed in a similar manner. Metallic components subjected to variable loading get fatigue which leads to their premature failure under specific conditions[12]

2.1 Fatigue Failure

Often machine members subjected to such repeated or cyclic stressing are found to have failed even when the actual maximum stresses were below the ultimate strength of the material, and quite frequently at stress values even below the yield strength. The most distinguishing characteristics is that the failure had occurred only after the stresses have been repeated a very large number of times. Hence the failure is called fatigue failure.
ASTM definition of fatigue

- The process of progressive localized permanent structural changes occurring in a material subjected to conditions that produce fluctuating stresses at some point or points and that may culminate in ***cracks*** or complete ***fracture*** after a sufficient number of fluctuations. Let us first make an attempt to understand the basic mechanism of fatigue failure[12]

2.1.1 Fatigue Failure- Mechanism

A fatigue failure begins with a small crack; the initial crack may be so minute and cannot be detected. The crack usually develops at a point of localized stress concentration like discontinuity in the material, such as a change in cross section, a keyway or a hole. Once a crack is initiated, the stress concentration effect become greater and the crack propagates. Consequently the stressed area decreases in size, the stress increase in magnitude and the crack propagates more rapidly. Until finally, the remaining area is unable to sustain the load and the component fails suddenly. Thus fatigue loading results in sudden, unwarned failure[8].

2.1.2 Fatigue Failure Stages

Thus three stages are involved in fatigue failure namely
-Crack initiation
-Crack propagation
-Fracture

2.1.2. Fatigue analysis using Ansys:

It is estimated that 50-90% of structural failure is due to fatigue, thus there is a need for quality fatigue design tools. However, at this time a fatigue tool is not available which provides both flexibility and usefulness comparable to other types of analysis tools. This is why many designers and analysts use "in-house" fatigue programs which cost much time and money to develop. It is hoped that these designers and analysts, given a proper library of fatigue tools could quickly and accurately conduct a fatigue analysis suited to their needs.

The focus of fatigue in ANSYS is to provide useful information to the design engineer when fatigue failure may be a concern. Fatigue results can have a convergence attached. A stress-life approach has been adopted for conducting a fatigue analysis. Several options such as accounting for mean stress and loading conditions are available.

3. Drawing Load Calculation:

$$Drawing\ stress = \sigma_d$$
$$= \sigma_0 \frac{1+\beta}{\beta}\left[1-\left\{\frac{h_1}{h_0}\right\}^{\beta}\right] + \sigma_b \left\{\frac{h_1}{h_0}\right\}^{\beta} + \sigma_s$$

$$= 362.66 \frac{N}{mm^2}$$

Where $\beta = \frac{\mu_1+\mu_2}{tan\alpha} = \frac{.01+.006}{tan\,1.5} = .6110$,

$$h_1 = final\ thiknessog\ tube = 1.20\ mm$$

$$h_2 = initial\ thikness\ of\ tube = 2.70\ m$$

$$\left\{\frac{h_1}{h_0}\right\}^{\beta} = \left\{\frac{1.20}{2.70}\right\}^{.6110}$$

$\sigma_b = \sigma_s$ for paltering process

$$= 0.6092$$,

$$\sigma_b = \frac{210}{\sqrt{3}} \times \frac{1.5}{2} = 90.9336 \frac{N}{mm^2}$$

$$Area\ of\ cross\ section\ at\ exit = \pi DL$$

$$= \pi \times 19.05 \times 1.20$$
$$= 71.82mm^2$$

$$Drawing\ load \quad = drawing\ stress\ x\ area$$

$$= 362.66 \times 71.82$$

$$= 26045.08\ N$$

4. Fatigue Analysis of Mandrel Linear & Parabolic Profile Analysis with H11 AISI Tool Steel:

4.1.1 Linear Profile Analysis with H11 AISI Tool steel

Table 4.1 material properties

Density (kg/m^3)	Yield strength(Mpa)	Ultimate Strength (Mpa)	Poisson's ratio
7997	4000	5129	0.3

Table 4.2 geometry data:

Length X(mm)	Length Y(mm)	LengthZ(mm)	Mass(kg)
635	37.16	37.16	2.5916 kg

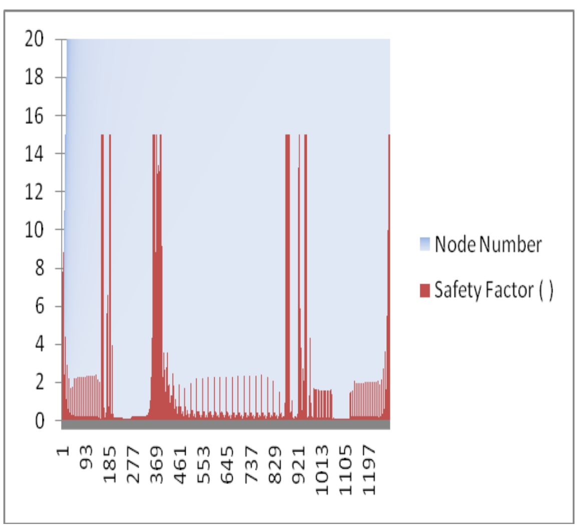

Fig.4.1 Node vs factor of satey graph for H11 material

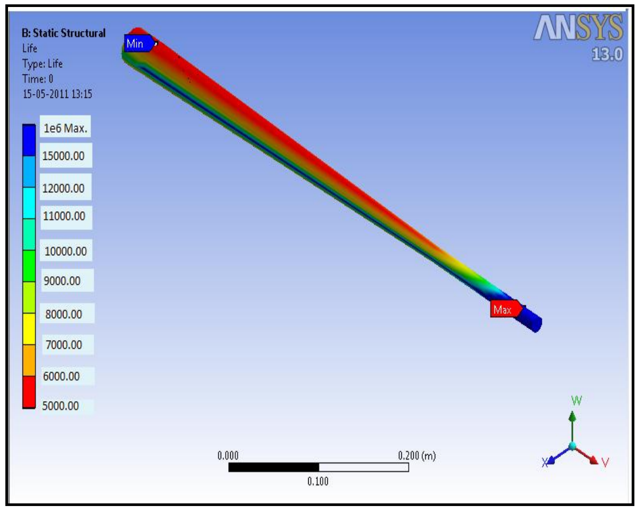

Fig.4.2 life cycle plot for linear H11 material

Table 4.3 Result Table For linear H11 material

Factor of safety	Minimum	6.0261e-002
No of cycles	Minimum	5000 cycles

4.1.2 Parabolic Profile Analysis with H11AISI Tool steel

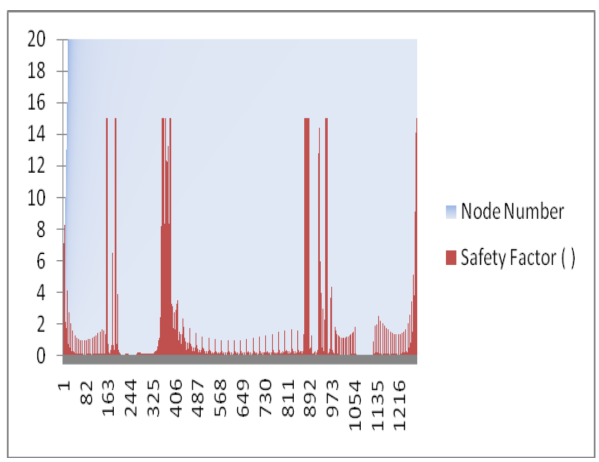

Fig 4.3 Nodes Vs safety factor for parabolic shape of H11 material

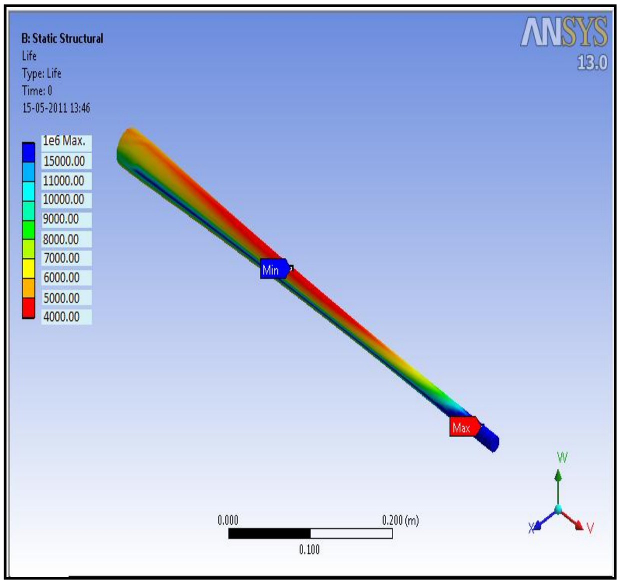

Fig.4.4 life cycle plot for parabolic H11 material

Factor of safety	Minimum	3.4481e-002
No of cycles	Minimum	4000 cycles

Table 4.4 Result Table for parabolic H11 material

5. Fatigue Analysis of Mandrel Linear & Parabolic Profile Analysis with M4 AISI Tool Steel:

5.1.1 Linear Profile Analysis with H11 AISI Tool steel

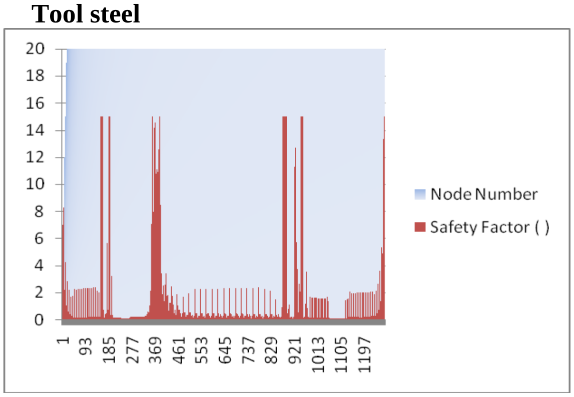

Fig.5.1 Node vs factor of satey graph for H1material

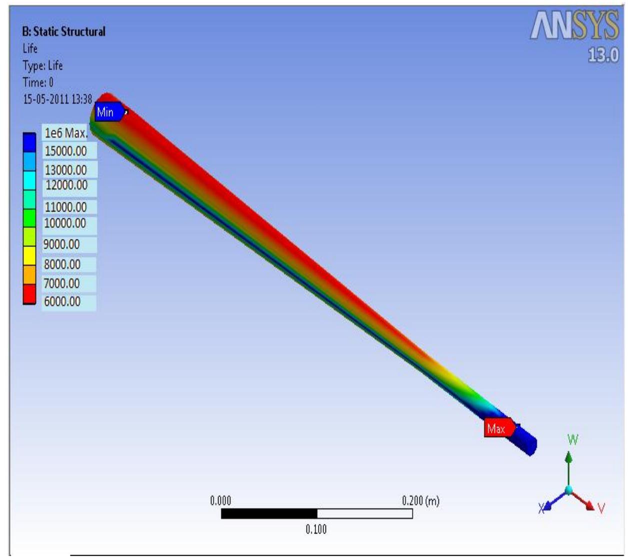

Fig 5.2 Life cycle plot for linear M4 material

Table 5.1 Result for linear profile of M4 material

Factor of safety	Minimum	6.0182e-002
No of cycles	Minimum	6000 cycles

5.1

5.1.2 Linear Profile Analysis with H11 AISI Tool steel

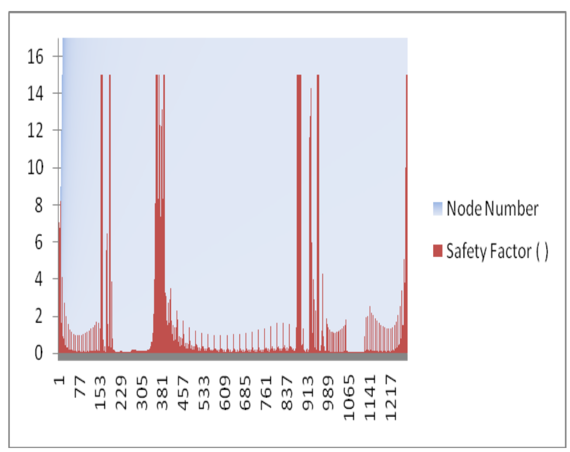

Fig 5.3 Nodes Vs safety factor for M4 material

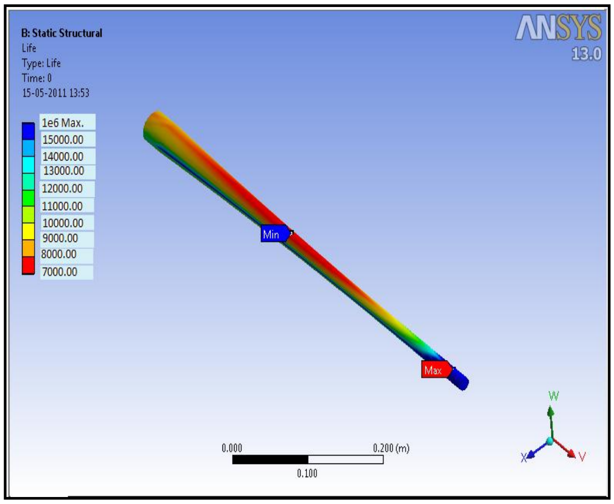

Fig 5.2 Life cycle plot for parabolic M4 material

Table 5.2 Result for Parabolic profile of M4 tool steel material

Factor of safety	Minimum	3.4379e-002
No of cycles	Minimum	7000 cycles

Material	H11		M4	
Profile	L;inear	Parabolic	L;inear	Paraboli
No of Cycle	5000	4000	6000	7000

5.1 Price Comparison:

Material	H11	M4
Price/kg.	Rs.350-450	Rs.300-350

6. Conclusion:

Hence by viewing the results it is advised to manufacture the tapered mandrel with parabolic profile and M4 tool steel material in order to avoid frequent failure of tapered mandrel and simultaneously achieve good quality of finished product as compared to linear profile with H11 tool steel material. Also by comparing the cost effectiveness of the decided result, it is seen that there is only a little variation in price of M4 steel as compared to H11 steel hence it is also economically well suited to use M4 Tool steel instead of H11 tool steel.

7. References:

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