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Design And Analysis Of Lead Screw For Fixture

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Abstract-Robot is machine which is designed to perform particular task repeatedly and efficiently with speed and precision. There are many different types of robots used for different task in industry and other application. Generally, in industry robot is used to move cutting tool. In this work our aim is to reduce robots efforts by implementing concept of sliding fixture. The fixture is slide by using recirculating ball screw arrangement which drive using servo motor configuration. In this fixture lead screw is main functional element. Lead screw is used as linkage in machine which used to translate and convert turning motion into linear motion. So in this research paper we design and analyze the lead screw against gradual load and by considering different loading condition.

Keywords- FEA, Sliding Fixture, Robot, Stress concentration, Analysis

I. INTRODUCTION

The problem under our consideration is to design lead screw for sliding fixture for MUNGI ENGINEER PVT. LTD.The lead screw also called power screw used in machine to translate rotary motion in to linear motion. The lead screw is compact, simple in design and having large load carrying capacity. Lead screw has wide application in industrial fixture so lead screw is selected for analysis purpose. During loading condition, the different stress acting on lead screw produces deflection which calculated first (initially) by analytically FEA model used for calculating different amount of stresses, deflections and its magnitude using developed new technique. FEA model verifies with the result obtained from load test. If FEA verifies the load lead estimate for working purpose. Hence lead screw is good machining part in analysis of stresses and deflection

1.1 Need to design lead screw:

For design purpose mechanical analysis of lead screw affected by various parameters like efficiency, torque requirement and load capacity. There are numerous important for successful design of lead screw for drive system. Whenever sliding motion exists in machine, system create vibration and which severally affects the function of system. In this work the lead screw is slide with the ball screw as system operate. The most common problem for the lead screw is backlash. The backlash severely affect the position accuracy of lead screw, hence both design and manufacturing of lead screw may reduce the presence of backlash.

II. PROBLEM DEFINATION

The main objective of analysis of lead screw is to determine various types of stress and deflection at different mode shapes. The output needs from this work to investigate strength of lead screw for various loading condition. The deep knowledge of stresses and deflection is involved in this analysis. This work study vital for large scale plants. In industry fixture facing problems like unwanted energy waste and low production rate. This creates economical and technical problems that can solve by this work. FEA software is used for stress and deflection analysis and shows effect of different loads for calculating different parameter and mode shape.

III. DESIGN OF LEAD SCREW

The lead screw is subjected to gradual load as shown in fig,,

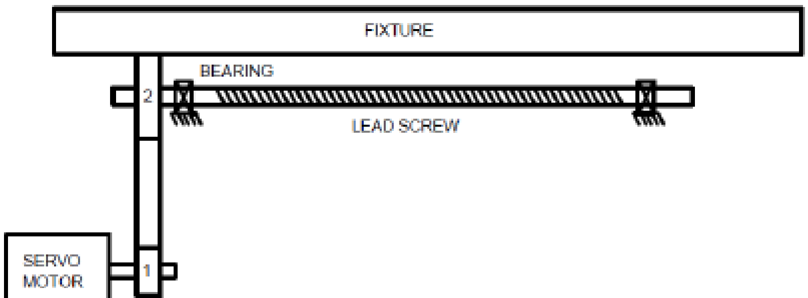

fig. Layout Of Fixture

Take moment at point A,

$M_A = 0$
$1400 \times 4.2 \times 2.1 = Rb \times 4.2$
$R_B = 2940N$
$R_A = R_B = 2940N$

Shear force diagram

$S_{AL} = 0$ N
$S_{AR} = 2940$ N
$S_{BL} = 2940 - 1400 \times 4.2 = -2940$ N
$S_{BR} = 0$ N

For point of maximum bending moment,

$$\frac{2940}{X} = \frac{2940}{4.2-X}$$

X= 2.1 m

Bending Moment Diagram,

$M_A = 0$ Nm

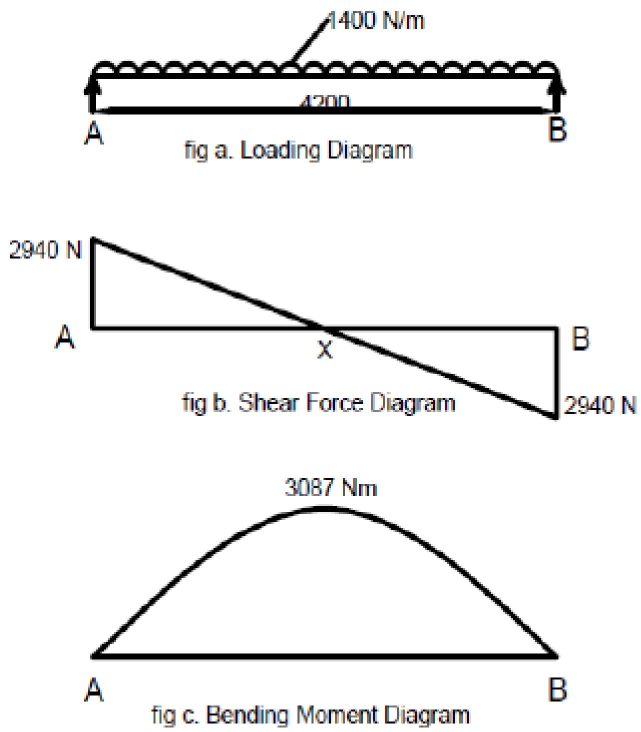

Fig. 1 SFD & BMD of lead screw

$M_C = 2940\times2.1-1400\times2.1\times\frac{2.1}{2} = 3087$ Nm

$M_B = 2940\times4.2-1400\times4.2\times\frac{4.2}{2} = 0$Nm

Now,
Maximum Bending Moment,
$M_{max} = M_C = 3087$ Nm

Torque available at motor
$T_1 = 19.10$ Nm

Power available is same at both point,
$(P)_{\text{at point 1}} = (P)_{\text{at point 2}}$
$\left(\frac{2\pi NT}{60}\right)_{\text{at point 1}} = \left(\frac{2\pi NT}{60}\right)_{\text{at point 2}}$
$N_1T_1 = N_2T_2$
But,
$N \propto \frac{1}{D}$
$\left(\frac{T}{D}\right)_{\text{at point 1}} = \left(\frac{T}{D}\right)_{\text{at point 2}}$
$T_2 = \frac{19.10}{80}\times 140$
$T_2 = 33.425$ Nm
Torque available at point 2 is= 33.425 Nm

Now,
Material selected for lead screw is SSC5 having properties
Ultimate tensile strength, $S_{ut} = 950$ N/mm^2
Yield strength, $S_{yt} = 580$ N/mm^2

Now,
Allowable Shear Stress,
$\tau_S = 0.18\ S_{ut} = 171$ N/mm^2
$\tau_S = 0.30\ S_{Yt} = 174$ N/mm^2 (take smaller value)
$\tau_S = 171$ N/mm^2 is selected

Now,
Equivalent torque,
$T_e = \sqrt{(kb\times M)^2 + (kt\times T)^2}$

Where,
T_e = Equivalent Torque
K_b = Combined shock and fatigue factor for bending = 1.5
K_t = Combined shock and fatigue factor for torsion = 1.0

$T_e = \sqrt{(1.5 \times 3087)^2 + (1 \times 33.425)^2}$

$T_e = 4630.6206$ Nm

$T_e = 4.6306 \times 10^6$ Nmm

Now,

$$\tau_{max} = \frac{16 \times Te}{\pi d^3}$$

Where,

τ_{max}=maximum allowable shear stress

T_e = Equivalent Torque

D = diameter of shaft

$$171 = \frac{16 \times 4.6306 \times 10^6}{\pi d^3}$$

d = 51.6659mm

core diameter=53mm is selected

From Design Data Book,

Pitch=9mm

Nominal diameter=62mm

IV. FINITE ELEMENT METHOD

4.1 Introduction to FEM

The Finite element method is effective discretization technique in structural mechanism. The finite element method is numerical method which can be used for accurate solution of problems arise during design. The basic concept in physical interpretation of FEM is the division of mathematical model into non- overlapping component of simple geometry called finite element

4.2 Design verification by Finite Element Method.

A finite element analysis of lead screw gives following information.

1) Nodal point spatial location i.e. geometry
2) Details of mass properties like stress, deflection
3) Boundary restrains
4) Analysis option

V. DESIGN ANALYSIS BY FEM

5.1 Test Specimen of lead Screw

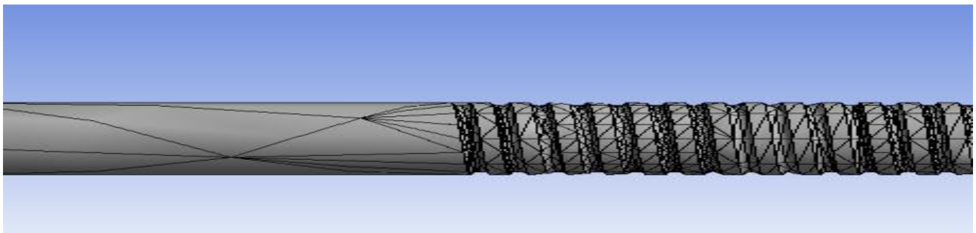

Figure 2: Test Specimen

Table-1.Dimensions details of lead screw

Lead screw parameters	Length (mm)	Core Diameter (mm)	Pitch (mm)	Length of thread section (mm)	Type of thread
Value	4200	53	9	3500	ACME

VI. FEM MODE SHAPE

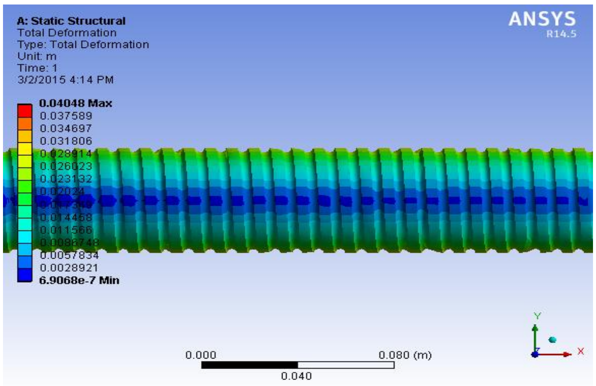

Fig. 3 Total Deformation

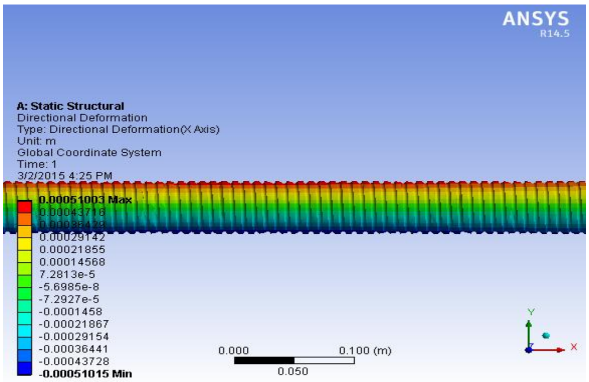

Fig. 4 Directional Deformation

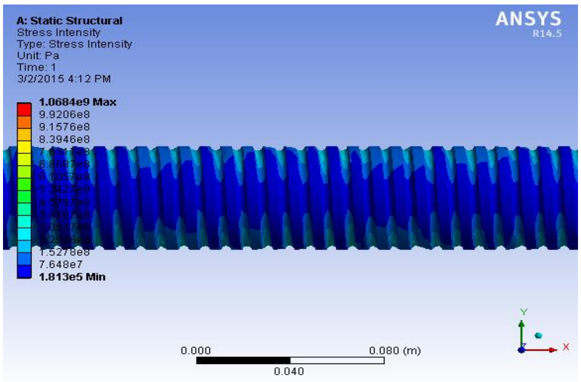

Fig. 5 Stress

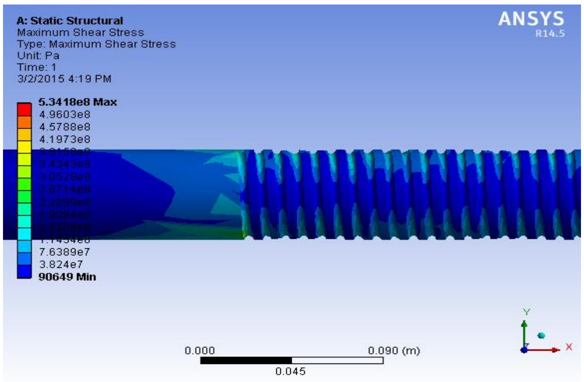

Fig. 6 Maximum Shear Stress

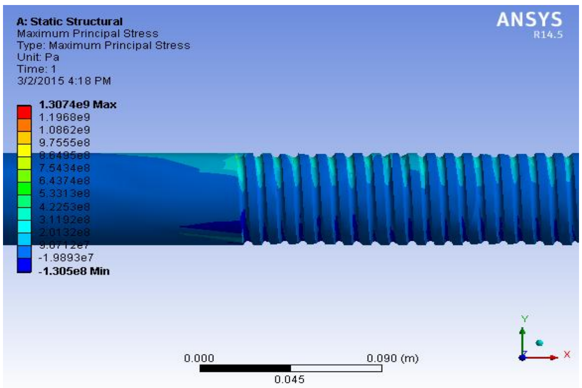

Fig. 7 Maximum Principle Stress

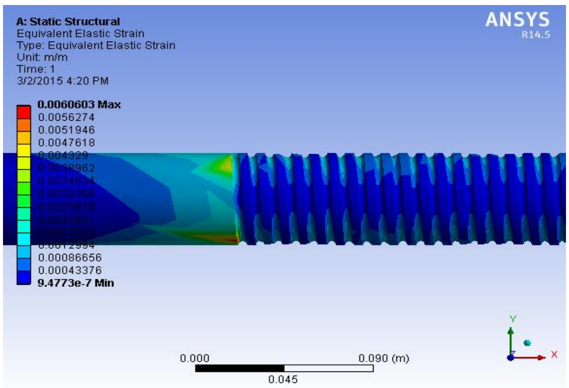

Fig. 8 Equivalent Elastic Strain

RESULT AND CONCLUSION

After calculating the lead screw dimensions by analytical method it verifies by the finite element model. Discussion on result obtained by theoretical analysis is carried out for statement of conclusion

Differences in result are compared for mode and specimen analyses at thread start section and overall thread section

FEM verification result gives stresses, deformation and mode by ANSYS 14.5

Initially the deformation produced in lead screw due to the gradual load applied on it. as we discus mode shape 2:Directional deformation , The contacting surface of lead screw with recirculating baa is under maximum deformation while the bottom most surface is minimum deformation. Where stress is concentrated at the point where thread is start .stress is distributed in lead screw body gradually; mode shape gives the idea of different stresses and deformations produced in lead screw. From this work the statement of conclusion is lead screw safe to work against the given value of load considering deformation and stresses producing in lead screw.

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