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Failure Analysis of Thrust-Ring of A Spline Rolling Machine

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ABSTRACT

Splines are mechanical elements used for positive transmission of power in several power transmitting *elements like gear boxes, automobile propeller shafts and etc. Commercially splines are manufactured by rolling process. Spline rolling is a cold metal forming process used to roll splines on shafts. Spline rolling may be carried out in two ways – either by the use of paired racks or using paired rolling dies having external splines on them so as to generate the same splines by the movement of the work-piece between them or, by the use of spline rollers. This study is intended to carry out the second method. Spline rolling is far superior to other processes of generating splines such as the machined process of cutting splines due to its outstanding advantages such as higher strength due to cold rolling, higher product life, lesser production time, dimensional accuracy and improved surface finish due to the absence of burrs in the component. The thrust-ring forms an important part of the spline rolling machine as it helps to retain the spline roller in position which gives splines on the shaftcomponent.*

In present work an attempt has been made to analyze the cause of failure of an automobile spline cutting thrust-ring used in GROB spline rolling machine at one of leading OEM Spline manufacture. Initially the process of spline cutting was analyzed and there by an attempt was made to validate the strength as well material of spline thrust-ring. Finally the results were compared with numerical method using Ansys Workbench Release 17 software.

KEYWORDS: Spline rolling, thrust ring, wear, stress analysis, workbench,

INTRODUCTION

Splines may be understood as a number of tooth shaped keys or gear like structures provided all over the circumference of a shaft. The main purpose of the splines is to transmit power from one component to another with the help of a coupled member containing splines on the internal of a hollow cylinder like structure so that the splines and the coupled member can be coupled resulting in the transmission of power. Usually splines are used in the transmission of rotary motion from one member to another such as transmission of power from the engine output shaft to the wheel axles in an automobile. [1]

Cold rolling of splines is a cold forming process which has numerous advantages such as higher efficiency of the formed products, high precision, non-chip forming, etc. In comparison to the conventionally manufactured components cold forming of splines have better load carrying capacity. [2]

One of the main advantages of rolled splines is that the rolling process increases the strength by rearranging the grain structure of the tooth profile over the entire tooth profile as shown in figure below. [10]

Failure analysis basically deals with the determination of the cause of a component failure in order to avoid frequent failures of the component due to the same reason if any. When a failed component is replaced without knowing the exact cause of failure, there might be recurring failures. Systematic analysis of the failure to prevent repeated failures assures quality service by avoiding unnecessary downtime.

The true cause of a failure can be better determined by knowing what to look for, determining how a piece of the equipment was running and learning about previous problems.

The main assembly has been modeled in SOLIDWORKS 12 and is as shown in the figure 1 below:

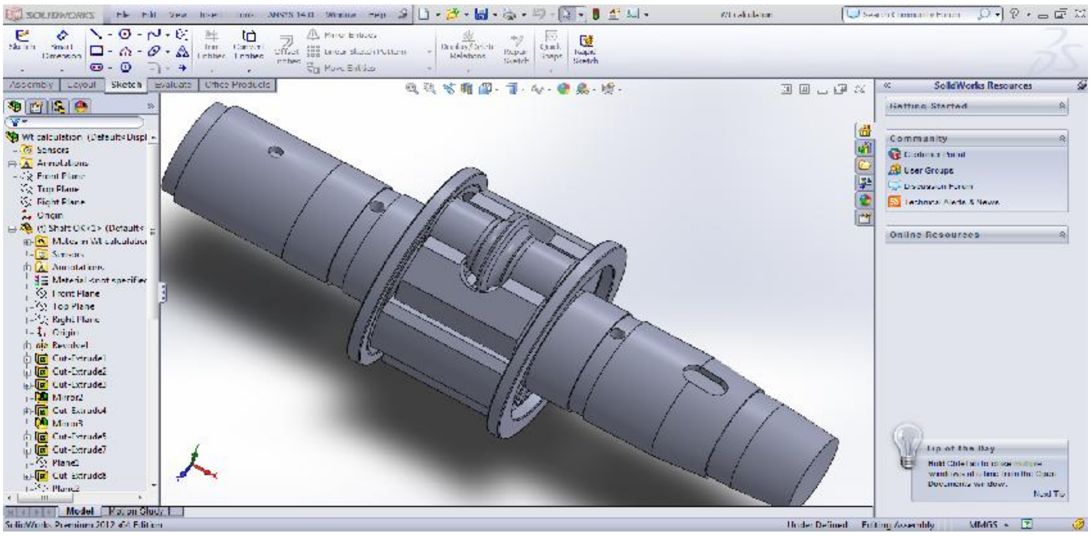

Fig. 1 3D model of the assembly used for analysis

Figure 2 shows an exploded view of the assembly with the associated parts:

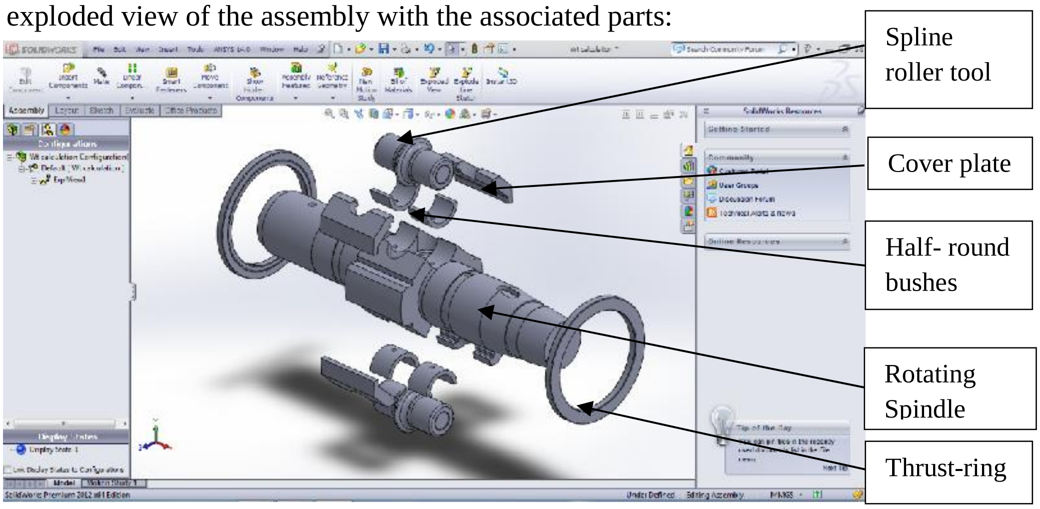

Fig. 2 Exploded view of the assembly

THEORETICAL CALCULATIONS

Mass of the rotating spindle unit, m = 5.77 kg,

$Fc = m \times \omega^2 \times r$ ---(1)

$= 5.77 \times 302 \times 36 \times 10^{-3}$

$= 187$ N

$F_f = 0.5 \times$ Normal force exerted on the spindle---(2)

Normal force exerted on the spindle = compressive strength $\times A_{tc}$

$= 700 \times 48$

$= 33600$ N

Therefore, force exerted during the cold forming

F_f = 0.5 × (Normal force exerted on the spindle + Centrifugal force)--------------------------(3)

= 0.5 × (33600 + 187)

= 16894 N

Considering the force of 16894 N to be acting on the four sides of the two roller tools, we can calculate the force acting on each side of the roller.

Force acting on each side of the roller = $\frac{16897}{4}$

= 4223.5 N

Therefore stress developed on each side of the roller = $\frac{\text{Force}}{\text{Area of contact}}$

= $\frac{4223.5}{198.87}$

= 21.237 N/mm^2 or 21.237 MPa

Permissible stress = $\frac{\text{Ultimate stress}}{\text{Factor of safety}}$ --(4)

= $\frac{430}{8}$

= 53.75 N/mm^2

We can observe that the developed stress of 21.237 MPa is lesser than the permissible stress of 53.75 MPa. Hence we can conclude that the thrust ring is safe from failure.

ANALYSIS USING WORKBENCH

Stress analysis has been performed using ANSYS WORKBENCH 17 using the following boundary conditions:

1. Rotational velocity of 1800 rpm given to both thrust rings along their axes,
2. A force of 4223.5 N has been given on each side of the spline roller tool at the ends that are in contact with the thrust ring.

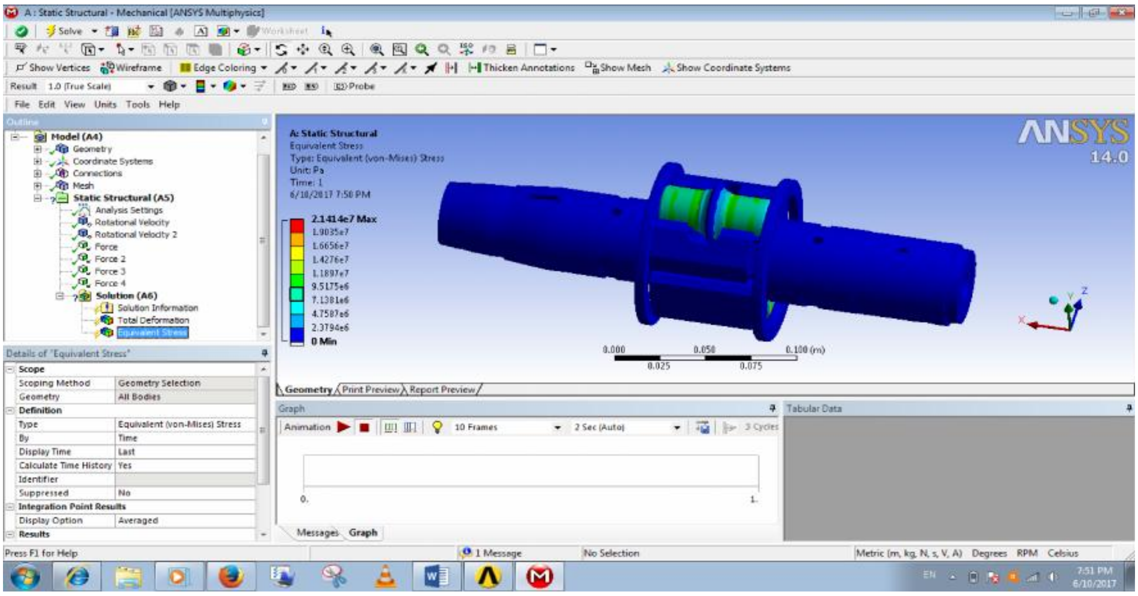

Fig. 3 Stress analysis using ANSYS WORKBENCH 17.

The values of stress calculated using workbench gives us a value of 21.414 MPa for a coefficient of friction equal to 0.15.

CONCLUSION

The equivalent stress developed in the component is 21.414 MPa for a value of coefficient equal to 0.15. This value is very much close to the stress calculated in the theoretical calculations which is equal to 21.237 MPa. From the analysis carried out above we have come to know that the stress developed on the thrust rings is acceptable under normal working conditions. In order to improve the performance of the thrust ring and the machine as a whole, the thrust rings may be manufactured by materials whose permissible stress is more than that of the EN 32 which is presently used for the manufacture of the rings. Also, care has to be taken for the material selection such that value of permissible stress should be lesser than that of the spline roller tool in order to avoid any damage to the tool.

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