Failure analysis and stress monitoring of TVS Shaft located on satellite vehicle of Reel Transport Vehicle (Gantry) used in Newspaper Industry

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Abstract **- TVS (Transport Vehicle System) Shaft is the most important part which is responsible for the movement of satellite vehicle with accurate distance and positioning. Satellite itself has 1600 kg weight and paper reel has maximum of 2000 kg weight. Hence the TVS Shaft has to work with total 3600 kg load. Therefore the design and material chosen for the TVS Shaft is having maximum strength and sustainability under maximum load. But even using toughest material failure accurse usually in TVS Shaft. Which creates many problems in reel transportation system used in newspaper printing industry. Misalignment and faulty positioning are the major problems arises due to the failure of TVS Shaft. Hence it becomes essential to find the reasons behind failure and its remedies. Available literature focuses on design and toughest material used. But there is a more need to focus on stress concentration and loading capacity. In this paper failure analysis is discussed which is performed on FEA Tool ANSYS to find stress concentrating areas. Also the deformation obtained due to loading condition is studied and discussed. CAD model is developed on CATIA software which is further converted into IGES file. Conclusion is drawn on the basis of obtained results.**

keywords **- TVS Shaft, Failure Analysis, FEA Tool, CAD Model**

I. INTRODUCTION TO TVS SHAFT

TVS shaft is an important component in Transport Vehicle System. It mainly guides the satellite vehicle which is able to move in both X and Y direction. It also become a crucial member in guiding system as it is a part on which the wheels are located. Hence the failure of this shaft may create the problem in reel positioning and placing. Fig. 1.1 shows the TVS shaft assembly which has failed shaft from the bottom.

Fig. 1.1: TVS Shaft Assembly

Helical spring is attached to absorb the shocks during travel. Wheels are attached for the proper movement in X direction. One more wheel is attached on the shaft itself for the movement in Y direction. This assembly is located on satellite vehicle of Reel Transport Vehicle.

1.1 Reel Transport Vehicle.

Reel Transport Vehicle is divided into two vehicles.

1) **Gantry**

Movement of gantry is always parallel to the printing press. Its movement is indicated with illuminating lamp with strict indication. Supply rail is used to transmit power and data. Axels are driven smoothly. Data exchange is done with the AURO log computer by radio. The distance measuring system consists of a bar code band and bar code scanner which calculate the location of the gantry. The electrical components are located in the switchboxes. The switchboxes are cooled by ventilation. The ventilation system features a filter mat. The satellite is conveyed with the gantry.

2) Satellite

The satellite moves in both X and Y direction along with gantry. The flashing lights illuminate when the satellite moves. The siren sounds before the satellite starts and if the protection field malfunctions. When the satellite has left the gantry, it moves on rails. A guide roller engages with the guide groove in the rail. The wheel axles are driven synchronously. Lifting forks move the reel vertically. A transmitter with cable pull monitors the vertical position of the lifting fork. The lifting fork points can be extended and retracted. Position switches monitor the lifting fork points. A light scanner checks the space within the satellite. The light scanner detects reels which have a diameter larger than 200 mm. Two light barriers check the space within the satellite. Each light barrier checks the space in front of the satellite in the direction of travel. There is a cable connection between the gantry and satellite. A motor-driven cable drum winds up the cable. A position switch monitors the cable drum.

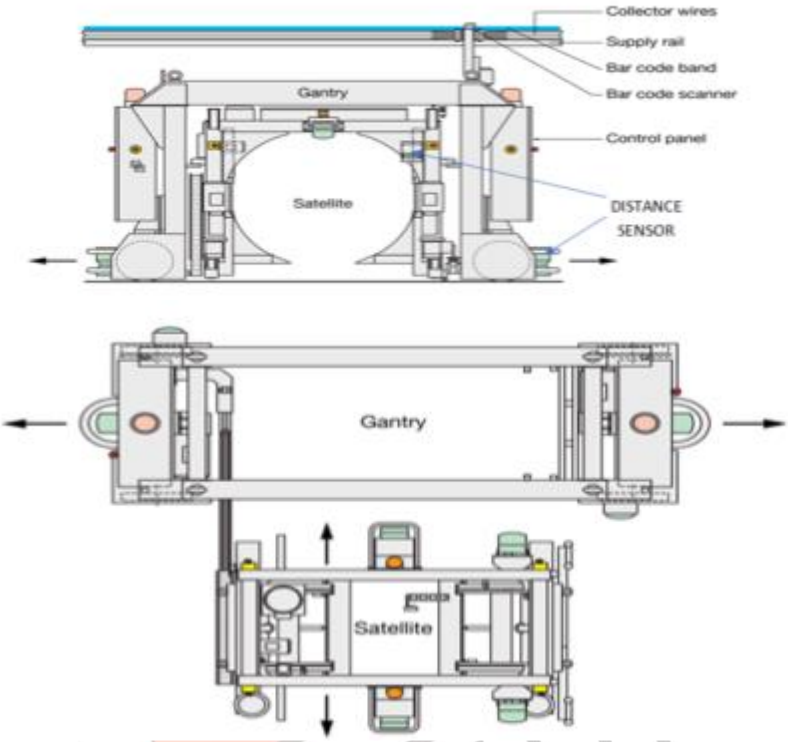

Fig. 1.2: Front and Top View of Gantry and Satellite.

1.2 Problems Associated with TVS Shaft

During the travel of RTV it is found that the TVS shaft fails rapidly and positioning of satellite goes wrong. Also it is noted that the guiding path is not followed well. Mainly failure accurse at the end where diameter of shaft is less as compare to the remaining body. Even after using though material failure accurse which is too costly and requires more maintenance. It is also found that the vibrations during working of gantry and satellite affect the performance of TVS shaft.

Total load carried by TVS shaft is 3600kg which is too high and TVS shaft have to perform movement with this load. Loading condition may be a one of the reason behind failure.

1.3 Aims and Objectives of Study

The primary aim of this study is to perform failure analysis in case of shaft structure. remaining are listed below.

1) Study of deformation obtained through structural analysis.
2) Study of stresses developed in TVS Shaft.
3) Study of Loading condition and its effect.

To perform entire study following objectives are decided.

1) CAD Modeling of TVS shaft.
2) Reverse Engineering Process for accurate dimensions.
3) Structural Analysis of TVS shaft.
4) Result Synthesis.

II. LITERATURE SURVEY

Very less literature is available with this specific topic. Some literature available have focused on shaft like components. Pravin R. Ahire1, Prof. K. H. Munde2 have done the study on "Design and analysis of front axle for heavy commercial vehicle". Their study is also based on shaft like structure in which they explored results obtained. [1]

Nikola VUČETIĆ have worked on topic "STATIC ANALYSIS OF GEARBOX DRIVE SHAFT" where deformation and stresses obtained are discussed. [2] "The Miller Park Crane Collapse –Analysis of the King Pin Failure" is the topic on which Matthew T. Kenner, P.E., John A. Wilkinson, P.E., and Charles R. Morin, P.E. have studied and conclusion drawn on the basis of obtained result. [3]

A Review was done on "Fundamental Shaft Failure Analysis" by Hariom1, Prof. Vijoy Kumar 2, Dr. Chandrababu D.3. They found the methods of performing failure analysis of shaft and possible reasons of failure.[4] An Investigation was done on "Failure of Automotive Components in Cars" by Paul Gregory F1, Durkesh Karthik P2, Gokul C2, Hiran N K3 in which they have discussed various reasons of failure of automobile components like clutch assembly and transmission system. [5] Design Improvement is done by Yaseen Khan, Vibhay Kumar and Satpal S Saini for "Kingpin Stub Axle Assembly" used in tractor using FEA. [6]

2.1 Outcomes from Literature Survey

1) No direct literature is available on TVS shaft.
2) Structural analysis is to be performed for knowing failure reasons.
3) No literature is available in case of Vibration effects on shaft.

Complete failure analysis can be done with structural analysis of shaft by using CAE softwares

III. CAD MODELING OF TVS SHAFT

CAD modeling of TVS shaft is done on CATIA V5R19 software. Commands like revolve, pad, chamfer, fillet etc. are used to create the TVS shaft. All dimensions are taken from the reverse engineering process and detailed sheets available. Figure 3.1 shows the CAD model of TVS shaft which is developed by taking all the dimensions.

Fig. 3.1: CAD Model of TVS shaft developed in CATIA V5R19.

Failure Analysis of TVS shaft is performed on ANSYS Workbench 14.5 software. It is the tool used to carry out FEA analysis of engineering components. Directly CAD file cannot be imported into the ANSYS software. For this purpose .igs i.e. IGES (Initial Graphics Exchange Specification) file is prepared and the it is imported into ANSYS software. To know the failure regions we have to perform structural analysis which can give the possible deformation and various stresses. But to perform structural analysis material properties and boundary conditions must be known.

IV. FAILURE ANALYSIS OF TVS SHAFT USING ANSYS SOFTWARE.

Failure Analysis of TVS shaft is performed on ANSYS Workbench 14.5 software. It is the tool used to carry out FEA analysis of engineering components. Directly CAD file cannot be imported into the ANSYS software. For this purpose .igs i.e. IGES (Initial Graphics Exchange Specification) file is prepared and the it is imported into ANSYS software. To know the failure regions we have to perform structural analysis which can give the possible deformation and various stresses. But to perform structural analysis material properties and boundary conditions must be known.

4.1 Material Properties Required

As we know that to perform structural analysis material properties should be known. EN 24 is the material used for existing TVS shaft which is one of the toughest material. Following are the material properties of EN 24 which are required to perform structural analysis.

Table 4.1: Properties of EN 24 material for Structural Analysis.

Property	Value
Young's Modulus (E)	2.07e5 MPA
Poisson's Ratio	0.3
Density	7840 kg/m3

4.2 Boundary Conditions Applied

As per the actual loading conditions on TVS shaft loads and fixed constraints are assigned. Total load during working is 3600kg (1600kg weight of satellite + 2000kg weight of paper reel). Hence the equivalent force is applied on shaft at position B as shown in Fig. 4.1. The shaft is fixed at the end where the driven wheel is attached. Entire boundary conditions are applied as shown in Fig. 4.1.

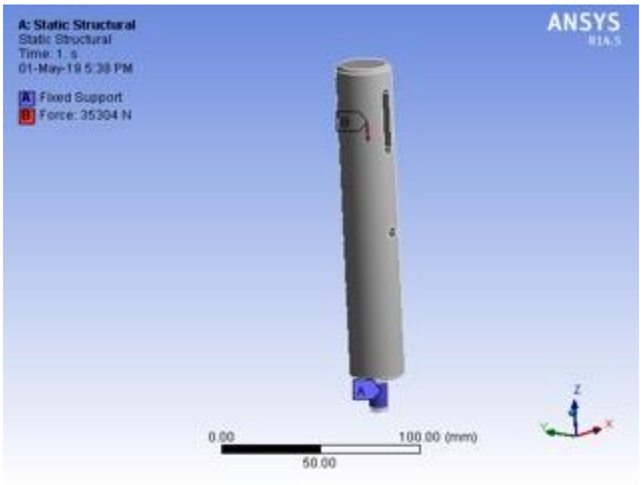

Fig. 4.1: Boundary conditions applied on TVS shaft.

4.3 Result Obtained

By performing structural analysis of TVS shaft we have obtained following results. These results are in the form of deformation due to loading and number of stresses.

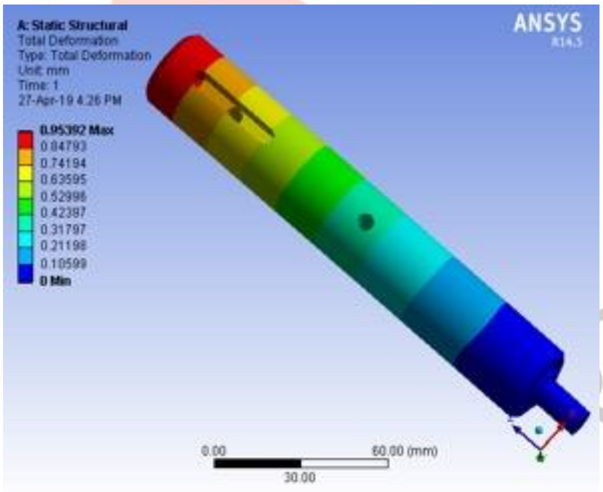

Fig. 4.2: Total Deformation

Fig. 4.2 shows the total deformation obtained due to loading. Maximum value of deformation is 0.95 mm ≈ 1 mm which is considerably higher. But maximum deformation is at top portion of shaft and failure accurse at the bottom. Hence could not be a reason of failure.

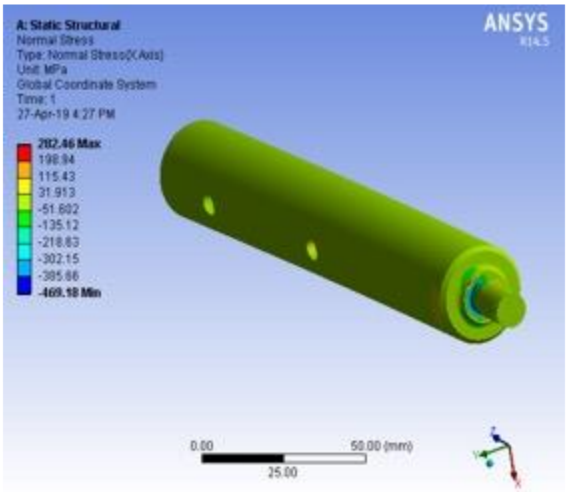

Fig. 4.3: Normal Stress

The maximum normal stresses obtained by performing structural analysis is 282.46 MPA. Normal stresses are less at bottom neck portion of TVS shaft, but higher at just adjacent to the less diameter shaft. Due to such condition shaft may fail in such loading condition which is applied several times.

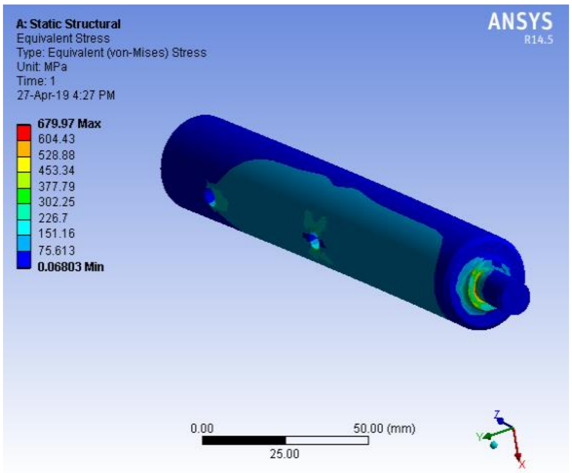

Fig. 4.4: Equivalent Stress

Equivalent stresses are the important parameter to study failure. In this study we found the maximum value of equivalent stresses is 680 MPA which shown in Fig. 4.4. By observing the stress concentration area, it is clearly displayed that these stresses are at the region from which shaft fails. Hence this may be the one of the reason of rapid failure of TVS shaft.

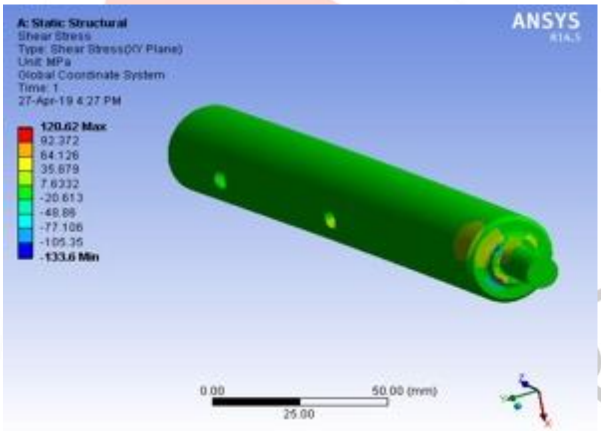

Fig. 4.5: Shear Stress

The value of shear stress obtained is only 120.62 MPA which is too less as compare to other stress values. It is also found that the maximum and minimum shear stress value is concentrated on bottom side of TVS shaft where the diameter is less. It may be a one of the reason of failure.

All results are indicating the maximum stress value is concentrated at the bottom of the TVS shaft where it fails. Hence the chances of failure from bottom portion is maximum.

V. CONCLUSION

By observing the results generated by structural analysis we can conclude that the major reason of failure of shaft is stresses induced due to loading and working at the bottom of TVS shaft. To avoid failure we can change shaft material or improve the design at the bottom.

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