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STATIC ANALYSIS OF CORROSSION RESISTANCE FRP FAN BLADE AND REVERSE ENGINEERING

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ABSTRACT:- *The static analysis of the radiator fan which is in the corrosion environment and at the outcome we analyze the failure of the entire blade taking into design consideration. The analysis of the FRP radiator fan is executed to check and evaluate the FRP material which withstands the dynamic and structural loads. The design of the blade is done through reverse engineering and the static analysis has been done using ANSYS where the 3D solid model of the FRP radiator fan is considered for structural analysis. The various loads and properties are applied through the entire length of the radiator fan. The FRP fan is coated with grey epoxy enamel and validating the FRP fan which withstands in corrosion environment. The maximum stress of the FRP coated with grey epoxy enamel is high.*

Keywords: *Reverse Engineering, FRP, ANSYS*

INTRODUCTION

In[1] explained a new methodology for surface reconstruction from sets of points for reverse engineering is described. The sets of points are obtained using stereovision techniques. Techniques for minimizing the number of images required for a complete object reconstruction are explored based on characterizing the shapes to be recovered in terms of visibility and number and nature of cavities. The ultimate goal of is to minimize the number of images when no prior information about the objects is available.

In[2] described about the technical challenges to automatically generate computer-aided design models of existing vehicle parts using laser range imaging techniques and a complete system that integrates data acquisition and model reconstruction. They discuss methods to resolve the occlusion problem and the associated registration problem. They also present the reconstruction algorithm and explain this range image-based, computer-aided reverse engineering system has a potential for faster model reconstruction over traditional reverse engineering technologies.

In[3] discussed about reverse engineering of mechanical parts requires extraction of information about an instance of a particular part sufficient to replicate the part using appropriate manufacturing techniques. This is important in a wide variety of situations, since functional CAD models are often unavailable or unusable for parts which must be duplicated or modified. Computer vision techniques applied to three-dimensional (3-D) data acquired using noncontact; 3-D position digitizers have the potential for significantly aiding the process. Serious challenges must be overcome, however, if sufficient accuracy is to be obtained and if models produced from sensed data are to be truly useful for manufacturing operations.

In[4] discussed that the automotive industry has an increasing need for the remanufacturing of spare parts through reverse engineering. In Laser Range Scanning, CCD camera captures the profile of the laser as it passes on an object. Structured light is the projection of a light pattern on an object also with the use of several cameras to obtain a profile of the object. The study was to generate part-to-CAD and CAD-to-part reconstruction of the original for future usage. These newly created 3D models could be added to the IRIS 3D Part Database.

In[5] detailed about analysis of the stress distribution in the various parts of the piston to know the stresses due to the gas pressure and thermal variations using with Ansys.

FAILURE ANALYSIS OF RADIATOR BLADE

Even though the number of failures of a particular component may be small, they are important because they may affect the reliability. In some cases, particularly when the failure results in personal injury or death, it will lead to expensive lawsuits. In any failure analysis it is important to get as much information as possible from the failed part itself along with an investigation of the conditions at the time of failure.

The possible causes of failures in case of radiator fan blades are as fallows.

- Improper heat treatment of the radiator fan blade.
- Pressure variations along the length of the blade.
- Other sundry causes

A. Improper heat treatment of the radiator fan blade

Proper heat treatment must be done after casting process i.e. precipitation hardening, so as to increase the strength of the material. The purpose of precipitation hardening is to increase strength and hardness of heat treatable aluminum alloys, and is achieved through a sequence of solution heat treatment, quenching and natural/artificial ageing. However, certain alloys, which are relatively insensitive to cooling rates during quenching, can be precipitation hardened either by air-cooling or by water quenching directly from the elevated temperature shaping process followed by a ageing treatment.

By conducting certain laboratory tests it is observed that heat treatment is not done properly and some defects such as

- Pin holes/porosities have been revealed(in clusters at the critical zones and in scattered pattern over other locations of the fan-blades)
- Notches/deep dents have been noticed at and nearby to the hub ends of the fan blades. One can notice that the fractured faces reveal two distinct zones having dull and bright in nature. Fractured faces of the broken blade are completely crystalline in nature.

B. Pressure variations along the length of the blade

As the fan is rotating past the fluid (air), this fluid exerts some pressure variation along the cross-section of the blade, due to this pressure changes lift and drag forces will be created, these forces depends upon the design and operating conditions. For the radiator fan, lift force has to be minimum; otherwise it may lead to the breakage of the blade.

C. Other Sundry Causes

- The radiator fan of diesel locomotives is required to work in a very hazardous environment with increase of oil dust and rain. It can be exposed to the roadside dust or fiber of various organic materials that can be in the environment of the locomotive operation such as, calcium carbonate, silica sand, aluminum, carbon black, fiber of various organic materials, oil, locomotives brake shoe dust, etc.
- Failure may occur due to cracks generated with the impact of tools, machinery items like clamps, pipes etc during engine overhauling.

REVERSE ENGINEERING PROCESS

If only one original part is available, it has to be handled with utmost care during the process as the original part is crucial for validation. The component must be thoroughly examined and the prominent geometric feature affecting the working of that component must be extracted and the feature which can be measured manually is also estimated. Such features encompass prismatic, geometric shapes. All other features such as free-formed surfaces, complex contours and 3D surfaces are to be measured through other techniques like scanning, acoustics and optical methods. All the dimensions which can be measured manually are taken with the help of available measuring devices like vernier calipers, height gauge, etc. The features which cannot be measured manually can be obtained through available digitization techniques.

The typical Reverse engineering process can be summarized in sequence as under

- Physical model which needs to be redesigned or to be used as the base for new product.
- Scanning the physical model using various scanners to get the point cloud.
- Processing the points cloud includes merging of points cloud if the part is scanned in several settings. The outlines and noise are eliminated. If too many points are collected then sampling of the points should be possible.
- Create the polygon model and prepare Stl files for rapid prototyping.
- Prepare the surface model to be sent to CAD/CAM packages for analysis.
- Tool path generation with CAM package for the manufacture of final part on the CNC machine.

DIGITIZTION OF RADIATOR BLADE

First the blade is divided into sections to identify the features for digitizing. More number of sections is made at the vicinity of the embossed region and the bent region. Along with the identified sections, the probing is done to get the point cloud data. The entire outer edge of the blade is digitized to get the size of the point cloud data.
The steps to obtain the coordinate point data are:

- Select suitable probe depending on the complex geometry of blade. Here straight probe of 0.5mm diameter is used.
- Clamp the blade to restrict the degrees of freedom.
- Selecting the Element option in the main menu of Usoft to probe the edge coordinate of the blade root.
- Probe at different point along the aero foil section of blade.

Figure 1.Digitizing of Fan blade

- The output file gives the coordinates of probed points along the blade length. These coordinates are taken from fixed reference point.

The point cloud data obtained from Digitizing technique imported in IGES format into FEA package like ANSYS and solid modeling is done.

MODELING OF FAN BLADE

The geometric model of radiator blade is generated using ANSYS as follows. The key point data for blade collected from Reverse Engineering process. The list of key points through the basic outline of the structure is obtained. Using splines and lines as boundaries different areas (Figure2) are generated.

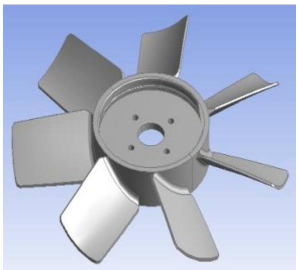


Figure 2.Modelling of Fan blade

DESIGN AND ANALYSIS

The radiator fan blade with the existing material is analyzed first to verify the induced stresses are within the safe limits or not. Further a better alternative material is studied with the same input parameters. The material is chosen in such a way that it is least effected to the above said causes of failure. The first part of analysis is to calculate the various forces acting on the blade at different cross sections. Then the blade model is created and analyzed in ANSYS.

Assumptions for the design

- The fluid (air) is considered to be incompressible.
- The turbulent effect i.e. stall conditions are neglected.

The profile geometry calculations of aerofoil section for different radii of the fan and tabulated.

A. Forces acting on the different sections of the blade

On account of considerable variation in the flow conditions and the blade section along the span, it is divided into a number of infinitesimal sections of small, radial thickness. The flow through such a section is assumed to be independent of the flow through other elements.

Velocities and blade forces for the flow through an elemental section are shown in Figure4. The flow has a mean velocity W and direction β (from the axial direction). The lift force ΔL is normal to the direction of mean flow and the drag ΔD parallel to this. The axial (ΔF_x) and tangential (ΔF_y) forces acting on the element are also shown, (ΔF_R) is the resultant force inclined at an angle Φ to the direction of lift.

Resolving the forces in the axial and tangential directions

$\Delta F_x=\Delta L \sin\beta-\Delta D \cos\beta$ --------(1)

$\Delta F_y=\Delta L \cos\beta+\Delta D \sin\beta$ --------(2)

By definition lift and drag forces from the eq.

$\Delta L=1/2C_a\rho\omega^2(ldr)$

$\Delta D=1/2C_a\rho\omega^2(ldr)$

From these ΔL andΔD values the ΔF_x andΔF_y are calculated from the Eq. (1) & (2) as;

Table1. Axial thrust and torque forces at different radii of the blade

R (mm)	**ΔL (N)**	**ΔD (N)**	**ΔF_x (N)**	**ΔF_y (N)**
500	1369.624	136.524	257.214	1357.258
400	1524.548	168.546	360.523	1538.241
300	1935.526	248.958	545.658	1852.567
200	2221.515	298.457	806.156	2157.856

B. Analysis of radiator blade

For present analysis a single blade is imported to ANSYS in IGES format. The blades are subjected to both thermal and structural loads. The blade is meshed with 3D 10-node tetrahedron thermal elements. The meshed model is as shown in Figure 3. In structural analysis the blade is considered as a cantilever beam (flange end fixed to hub). The loads i.e. the lift and drag forces which are resolved in F_x and F_y directions are applied at various cross sections of the blade obtained (Table1).

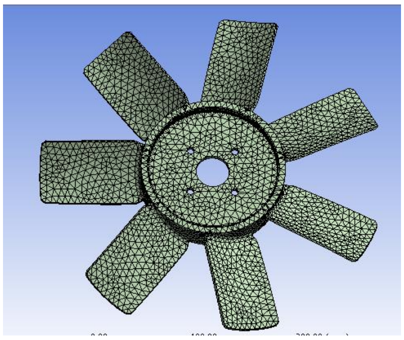
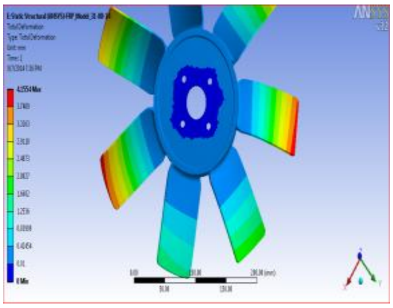


Figure 3.Meshed model of Fan blade



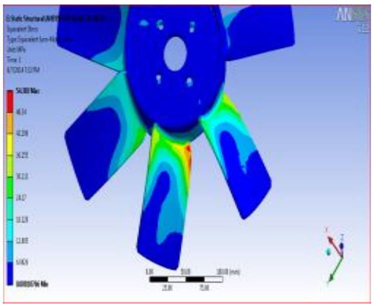


Figure 4.Maximum deformation of FRP

Figure 5.Von-mises stress of FRP

The analysis is first carried out with the FRP blade material. FRP radiator fan shall be manufactured from isopthalic resin reinforced with a combination of E-glass unidirectional roving, chopped strand mat and woven roving either by RTM (resin transfer moulding) or compression moulding process. Continuous-strand roving is used in the chopper guns for spray-molding of non-moving parts such as housings, inlet cones, inlet boxes, damper frames, and outlet transitions.The above resin has been specified to obtain high tensile and flexural strength, in view of the fact that the standard deviation of tensile strength in FRP is very high. However the resin and reinforcement had to be chosen such that the mechanical properties specified in this specification are met. Figures 4 and 5 represent maximum deformation and von-mises stress contour plots for the Fiber reinforced plastic (FRP).

RESULTS AND CONCLUSION

The induced stresses are tabulated in Table 2. The marginal rise in stresses as well as deformations is observed in case of FRP. But the values are within the safe limits. To prevent the failure of blades due to environmental and other sundry reasons are considered. FRP is considered as the material that withstands corrosion and induced stresses.

Table 2. Maximum stress in the material

Material	Maximum stress in N/mm^2	
	Von-mises	Principal stress
FRP (Grey epoxy enamel coated)	**55.784**	**55.219**

REFERENCES

[1] Zetu D,Akgunduz A, “Shape recovery and viewpoint planning for reverse engineering”, The International Journal of Advanced Manufacturing Technology, 2005, 26(11), pp. 1370-78.

[2] Page D, Koschan A, Sun Y, Abidi M, “Laser-based imaging for reverse engineering”, Sensor Review, 2006, 23(3), pp. 223-29.

[3] Thompson W B, Owen J C, James de St.GermainH J, Stark S R, Henderson T C, “Feature-Based Reverse Engineering of Mechanical Parts”, IEEE Transactions on Robotics and Automation, 1999, 15(1), pp. 57-66.

[4] Ali N S, “Reverse Engineering of Automotive Parts Applying Laser Scanning and Structured Light Techniques”, 2005.

[5] VenkataRajam C,Murthy P V K,Murali Krishna M V S,PrasadaRao G M, **“**Design Analysis and Optimization of Piston using CATIA and ANSYS”, International Journal of Innovative Research in Engineering Science, 2013, 1(2), pp. 41-51.

