Reverse Engineering & Stable Analysis of Corrosion Protective Fibre Reinforced Plastic Fan Blade

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Abstract. The radiator fan blades is manufactured using various materials and we have chosen FRP has the material because it provides excellent corrosion resistance. The heat from the radiator is reduced by circulating cooling water and the fan supplies the air required for cooling. The design of entire blade is taken into consideration for analysing the failure of the blade as the radiator fan is analysed under static condition as the fan blade is in corrosive environment. The Fibre reinforced plastic radiator fan blade analysis is conducted to test the Fibre reinforced plastic object that is able to withstand dynamic as well as structural loads. For this paper the blade design is achieved by reverse engineering, static analysis is achieved using ANSYS where the FRP radiator fan's 3D rigid model is used for structure stability (analysis). The weight acting and external properties were implied to the radiator fan throughout its entire length. The FRP radiator fan is brushed with a coat of enamel based epoxy of grey in colour and validates the Fibre reinforced plastic radiator fan which can withstand the property of corroding by environment.

1. Introduction
The blade radiator fan is a system that lowers working temperature by transmitting engine heat to the atmosphere by allowing the atmospheric air to cool the engine through the radiator panels, leaving it in the atmosphere. At the rear end of the locomotive is fitted the radiator fan assembly, which in turn receives drive from the engine. A rubber-cushioned flexible, rigid coupling attaches the vehicle air blower to the radiator ventilator drive shaft. This consists of a rigid portion, placed on the shaft of the fan drive, consisting of an internal and external member using vibration damper between the two members.

The object moves in a fluid medium and the velocity of the object varies with the surface of the object. This movement of the object in the fluid medium creates a centrifugal force on the object. The force on the upper side of the blade is the centrifugal force and the force of the fluid particles, creates a convex shape which keeps the object away from its own surface. Under the free stream pressure the static pressure on this side has a suction effect which is known as the suction side. On the lower side we can see the concave side of the blade, this centrifugal force pushes the fluid tighter on the surface of the blade, thereby directly increase the pressure higher to that of the flux. The pressure side is the side of the blade, the combined impact is the upward force on the blade if the pressure side is balanced positively, negatively to that of suction side. The lift force and drag force are created due to pressure created.
2. Literature review

The designer has to perform various important tasks in the design process, such as brainstorming, role analysis, morphological map, synectics, and integrated decision area analysis of design ideas. Meanwhile, a few researchers have proposed theories for automatically producing product shapes. They were all focused on describing the surface blending method, however, and rarely considered a reverse engineering connection. Generally a parametric type blending method was used for an automated product configuration generation. Li and Hui (2011) proposed a 2D curve blending process, which was used to synthesize 3D configuration by considering 2D curve outlines.

In another approach proposed for shape generation by Wang (1999), the required points have been set to calculate the corresponding relationships between the points on different sections were established before the product structure generation. To determine relation between any two points, the corresponding relationships between points, Chen and Brown (2000) established a way to find out the easiest way of known two points and physical property dependent approach during which the crisscrossing of the created curves was avoided throughout the shape blending process. In Reverse Engineering the primary step is to achieve data points by calculating the points on associate object's surface. The health and accuracy of the info greatly affects the consistency of each the ultimate CAD model and therefore machined piece of work.

The data got from the scan is considered a strong immovable motion problem and the three dimensional point subset registration approach has been used for solution of the problem. Rapid prototyping is used in manufacturing processes for production of layer to layer type object making of different shape and size as per the requirement. This methods is not a traditional method of material removal. The fully automated Rapid prototyping method has a number of advantages over conventional methods of manufacturing. The idea of rapid prototyping solves the challenge in the manufacturing processes of complex features. The impossible machining operations where done through RP manufacturing methods. Reverse engineering concepts is used to retrieve knowledge for the replication or remanufacture of identical objects from the actual one. Discussed the mechanical contact and optical non-contact approaches for extracting geometric details, i.e. exact measurements of the object component.

In addition, data stored with output of available points in the planar region makes the device less accuracy and thus the removal of any data does not affect the efficiency of rapid prototyping machines. A broad trade-off value shows sparse representation strongly desired at the cost of weakening the suit. Ronfard and Rossignace (1996) have suggested a merging algorithm to automatically measure the information on edge collapsing with the triangular approximation. The edges are lined up according to the cost functions which determines the error due to edge collapse and the approximation rates are regulated by the geometric tolerances.

3. Structural Failure Analysis of Radiator Blade

The major loss of any vehicle or the object depends on the failure of the object. If the object tens to have continuous failure it may effect in the market of the business of the producing company or the individual who owns the business may also lead to the loss of the business. If the failure directly affect the customer it may lead to the loss for the customer and it in turn it may lead to the demise of the customer or accidental situation to the customer. It is necessary to get as much information as possible from the failed component itself in any failure study, along with a data of the circumstances at the exact time of the failure when occurred.

In the case of radiator fan blades, the extensive causes of failures are as follows.

- Incorrect heat treatment methods used on production of radiator fan blade.
- Pressure fluctuation along the length of the blade.
- Sundry causes

3.1. Incorrect heat treatment methods used on production of radiator fan blade
The heat treatment of the material during the casting increases the strength of the material. The process of hardening is required to increase the strength of the material and the strength of the material is in turn obtained by continuous heat treatment procedures followed by quenching processes. Ageing is the process used in heat treatment. Some of the materials which are formed or named as alloys are quenched and aged application is done during the heat treatment processes. The temperature of the heat treatment process will be from lower temperature to higher temperature. Defects are formed in the material after heat treatment due to non-technical handling of heat treatment methods

- Pin holes
- Porosities (looks like uneven surface)
- Notches
- Deep dents

3.2. **Entire length of the blade undergoes pressure fluctuations**
Fluctuations in pressure along the section of the blade during the rotation of the fan past air lift forces and drag forces are generated due to the pressure changes, these lift and drag forces depend on the actual working conditions. Lift force has to be contained or reduced for the radiator fan because it can lead to blade breakage.

3.3. **Sundry (Several) causes**
The vehicle radiator fan has to be operated in drastic conditions such as dust, water, pollution etc. It may be exposed to dust from environment or fiber from various organic materials, such as tar, silica powder, copper, carbon black, calcium carbonate, locomotive brake shoe dust, fiber of different organic materials, gasoline, etc.

4. **Procedure in Reverse Engineering**
When a part without design is available in one quantity the procedure must be done with suitable care for validation. The geometric character of the component has to be analyzed and the functions of the component has to be calculated or estimated depends on its characteristics. These features include various prismatic shapes. All such characteristics such as free forming structures and 3D structures can be measured using other techniques such as scanning methods. All measurements that can be manually measured with tools such as vernier calipers etc. Standard reverse engineering cycle can be sequentially summarized as in

- Any model that needs to be revamped or used as base for new product.
- Use various scanners to get the point cloud through physical model
- Points cloud processing involves combining of the component which is scanned through iteration of several settings.
- Build a polygon model and plan rapid prototyping of STL data.
- Prepare the surface model for analysis.
- Import tool path in CAM software in a CNC computer.

5. **Digitization of Fan Blade**
More section numbers were rendered between the embossed area and the bent portion. Scanning is performed with the specified parts to get the cloud data from the point. The steps for obtaining the point data through coordination are:

- Straight 0.25 mm diameter probe is used depending on the complex geometry of the blade.
- Lock the blade so as to restrict the degree of freedom.
- Pick the Item option to check the blade root edge coordinates
- Measure at different points along the blade segment.
- The output file contains measured points along the length of the blade. The fixed point of reference gives the coordinates.
6. Actual Fan Blade Modelling
Radiator blades structural model is developed using the following methods: ANSYS. Key point data from RE process for blade obtained. The detailed list of key points is obtained through the structured basic outline. Various areas (Fig.2) are created using the splines and lines as boundaries.

7. Design of the Sections of the Blade
7.1. The blade has different areas of force concentration
The axial $\Delta F_x$ and tangential $\Delta F_y$ forces acting on the blade are also shown, ($\Delta FR$) is the resultant force is inclined to the direction of lift at an angle of $\Phi$.

Solving the forces

\[
\Delta F_x = \Delta l \sin \beta - \Delta d \cos \beta \quad \text{.................. (1)}
\]

\[
\Delta F_y = \Delta l \cos \beta + \Delta d \sin \beta \quad \text{.................. (2)}
\]

The equation of lift force and drag force can be written as follows

\[
\Delta l = \frac{1}{2} C_a \rho \omega^2 (ldr)
\]

\[
\Delta d = \frac{1}{2} C_a \rho \omega^2 (ldr)
\]

From these $\Delta l$ and $\Delta d$ values the $\Delta F_x$ and $\Delta F_y$ are calculated from the Equ 1 and Equ 2:
Table 1. Different radii of the blade with axial thrust and torque forces

| R (mm) | △l(N)  | △d(N)  | △F_x(N) | △F_y(N) |
|--------|--------|--------|---------|---------|
| 550    | 1416.567 | 196.241 | 296.531 | 1402.398 |
| 450    | 1614.345 | 201.547 | 401.257 | 1596.571 |
| 350    | 2045.287 | 298.357 | 602.942 | 1907.651 |
| 250    | 2354.257 | 314.278 | 852.621 | 2257.124 |

7.2. Fan blade methodology through Analysis
The Ansys is used for analysis of the fan blade in required format for present-day research. The blades undergoing heat and stability changes are noted. The meshed blade with the thermal elements of a three-dimensional 10-node tetrahedron. The meshed blade output is like shown in Figure 3. Consideration of the blades structural examination as an unknown cantilever beam. The loads i.e. the lifting and drag forces that are resolved in △F_x and △F_y directions are applied at specific sections of the obtained blades (Table 1).

![Figure 3. Mesh output](image-url)

![Figure 4. Maximum deformation](image-url)
The result obtained is administered with the Fibre reinforced plastic blade material. Fibre reinforced plastic radiator fan shall be materialized by RTM (resin transfer moulding) or compression moulding process using selected resin reinforced with a mixture of E-glass single directional roving, woven roving either and chopped strand mat. The selected resin has been specified to get high tension and flexibility strength, in sight of the very fact that the quality deviation of properties in FRP is extremely high. However the mechanical properties laid out in this specification are attained. Fig. 4 and Fig. 5 shows the maximum deformation and von-mises stress for the Fiber reinforced plastic (FRP).

8. Conclusion
The stresses obtained are tabulated in Table 2. In the case of FRP the slight increase in von misses stress and deformations is observed. Yet there are acceptable limits for the values. Consideration is given to preventing blade failure due to environmental and other sundry causes. FRP is considered the substance that is able to withstand corrosion and stress caused.

| Material under Consideration | Von-mises stress in N/mm² | Principal stress in N/mm² |
|------------------------------|---------------------------|---------------------------|
| Fibre reinforced Plastic with Grey epoxy enamel coated | 61.279 | 58.354 |

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