Design And Analysis of Aircraft Cooling Fan

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Abstract—An internal combustion engine produces power by burning fuel within the cylinders; therefore, it is often referred to as a heat engine. Engines that produce their energy by heat and combustion have a problem of maintaining safe operating temperatures. Thirty to thirty five percent of the heat produced in the combustion chambers by the burning fuel is dissipated by the cooling system along with the lubrication and fuel systems The necessity for cooling may be emphasized by considering the total heat developed by an ordinary six-cylinder engine. It is estimated that such an engine operating at ordinary speeds generates enough heat to warm a six-room house in freezing weather.
Air cooling is a method of dissipating
It works by expanding the surface area or increasing the flow of air over the object to be cooled, or both. An example of the former is to add to the surface of the object, either by making them integral or by attaching them tightly to the object's surface (to ensure efficient heat transfer).
Engine cooling fans are an essential component of the engine cooling system which is used to dissipate the excess heat generated by the combustion of fuels inside the engine. This project consists of designing the fan in CREO 3.0 parametric software.
Cooling fan model developed for speed of 2000, 2500 & 3000 rpm to study the interaction between the fluid and solid of cooling fan. The speed is the input for CFD analysis and the pressure obtained from the CFD analysis is taken as input for structural and modal analysis.
Computational fluid dynamics (CFD) and fluid structure interaction (FSI) will be done in ANSYS.

Indexed Terms—internal combustion engine, heat engine, CREO 3.0 parametric software, Computational fluid dynamics (CFD) etc.

I. INTRODUCTION

An aircraft engine is the component of the propulsion system for an aircraft that generates mechanical power. Aircraft engines are almost always either lightweight piston engines or gas turbines, except for small multi copter UAVs which are almost always electric aircraft.

Shaft Engines
In this entry, for clarity, the term "inline engine" refers only to engines with a single row of cylinders, as used in automotive language, but in aviation terms, the phrase "inline engine" also covers V-type and opposed engines (as described below), and is not limited to engines with a single row of cylinders.

V-TYPE ENGINE
A Rolls-Royce Merlin V-12 Engine
Cylinders in this engine are arranged in two in-line banks, typically tilted 60-90 degrees apart from each other and driving a common crankshaft. The vast majority of V engines are water- cooled. The V design provides a higher power-to-weight ratio than an inline engine, while still providing a small frontal area.

Horizontally opposed engine
A horizontally opposed engine, also called a flat or boxer engine, has two banks of cylinders on opposite sides of a centrally located crankcase. The engine is either air-cooled or liquid- cooled, but air-cooled versions predominate. Opposed engines are mounted with the crankshaft horizontal in airplanes, but may be mounted with the crankshaft vertical in helicopters.

H configuration engine
An H configuration engine is essentially a pair of horizontally opposed engines placed together, with the two crankshafts geared together.

Radial engine
This type of engine has one or more rows of cylinders arranged around a centrally located crankcase. Each row generally has an odd number of cylinders to produce smooth operation. A radial engine has only one crank throw per row and a relatively small crankcase, resulting in a favorable power-to-weight ratio. Because the cylinder arrangement exposes a large amount of the engine's heat-radiating surfaces to

the air and tends to cancel reciprocating forces, radials tend to cool evenly and run smoothly.

- CoolingFan

- Early turbofans

Rolls-Royce Conway low bypass turbofan from a Boeing 707. The bypass air exits from the fins whilst the exhaust from the core exits from the central nozzle. This fluted jetpipe design is a noise-reducing method devised by Frederick Greatorex at Rolls-Royce

General Electric GEnx-2B turbofan engine from a Boeing 747-8. View into the outer (propelling or "cold") nozzle.

II. MODELLING AND ANALYSIS

- INTRODUCTION TO CAD

Computer-aided design (CAD) is the use of computer systems (or workstations) to aid in the creation, modification, analysis, or optimization of a design. CAD software is used to increase the productivity of the designer, improve the quality of design, improve communications through documentation, and to create a database for manufacturing. CAD output is often in the form of electronic files for print, machining, or other manufacturing operations. The term CADD (for Computer Aided Design and Drafting) is also used.

Its use in designing electronic systems is known as electronic design automation, or EDA. In mechanical design it is known as mechanical design automation (MDA) or computer- aided drafting (CAD), which includes the process of creating a technical drawing with the use of computer software.

CAD software for mechanical design uses either vector-based graphics to depict the objects of traditional drafting, or may also produce raster graphics showing the overall appearance of designed objects. However, it involves more than just shapes. As in the manual drafting of technical and engineering drawings, the output of CAD must convey information, such as materials, processes, dimensions, and tolerances, according to application- specific conventions.

CAD may be used to design curves and figures in two-dimensional (2D) space; or curves, surfaces, and solids in three-dimensional (3D) space.

CAD is an important industrial art extensively used in many applications, including automotive, shipbuilding, and aerospace industries, industrial and architectural design, prosthetics, and many more. CAD is also widely used to produce computer animation for special effects in movies, advertising and technical manuals, often called DCC digital content creation. The modern ubiquity and power of computers means that even perfume bottles and shampoo dispensers are designed using techniques unheard of by engineers of the 1960s. Because of its enormous economic importance, CAD has been a major driving force for research in computational geometry, computer graphics (both hardware and software), and discrete differential geometry.

- CAD/CAM Software

Software allows the human user to turn a hardware configuration into a powerful design and manufacturing system. CAD/CAM software falls into two broad categories,2-D and 3-D, based on the number of dimensions are called 2-D representations of 3-D objects is inherently confusing. Equally problem has been the inability of manufacturing personnel to properly read and interpret complicated 2-D representations of objects. 3-D software permits the parts to be viewed with the 3-D planes-height, width, and depth-visible. The trend in CAD/CAM is toward representation of graphic images. Such representation approximates the actual shape and appearance of the object to be produced; therefore, they are easier to read and understand.

- APPLICATIONS OF CAD/CAM

The emergence of CAD/CAM has had a major impact on manufacturing, by standardizing product development and by reducing design effort, tryout, and prototype work; it has made possible significantly reduced costs and improved productivity.

Some typical applications of CAD/CAM are as follows:

Programming for NC, CNC, and industrial robots;

Design of dies and molds for casting, in which, for example, shrinkage allowances are preprogrammed;

Design of tools and fixtures and EDM electrodes;

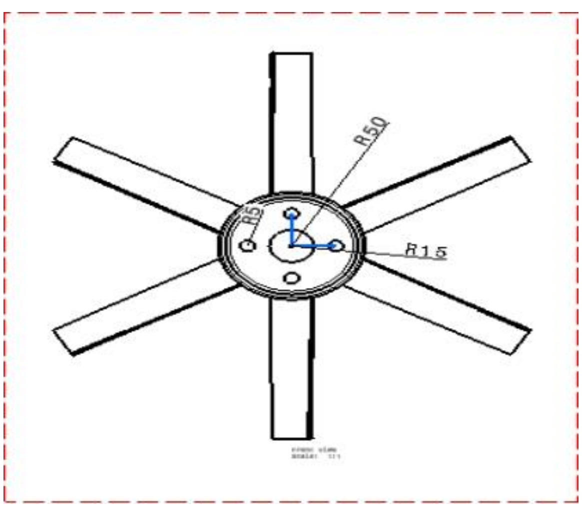
Quality control and inspection--- for instance, coordinate-measuring machines programmed on a CAD/CAM workstation;

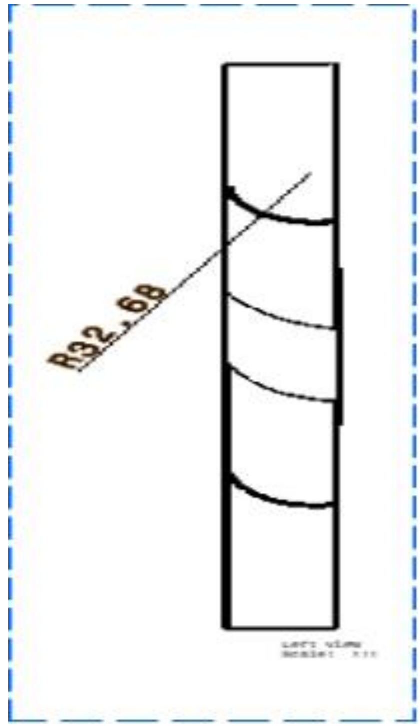
Process planning and scheduling.

INTRODUCTION TO CREO

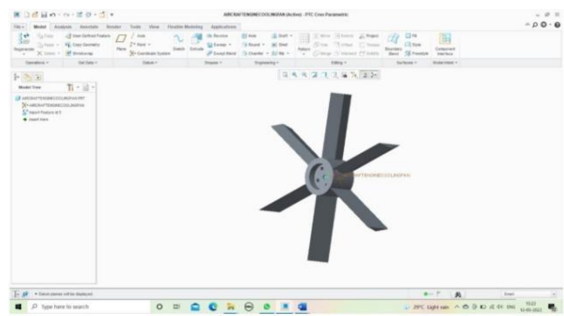
PTC CREO, formerly known as Pro/ENGINEER, is 3D modeling software used in mechanical engineering, design, manufacturing, and in CAD drafting service firms. It was one of the first 3D CAD modeling applications that used a rule-based parametric system. Using parameters, dimensions and features to capture the behavior of the product, it can optimize the development product as well as the design itself.

The name was changed in 2010 from Pro/ENGINEER Wildfire to CREO. It was announced by the company who developed it, Parametric Technology Company (PTC), during the launch of its suite of design products that includes applications such as assembly modeling, 2D orthographic views for technical drawing, finite element analysis and more.





2d model



3D model

III. ANSYS

ANSYS Autodyn is computer simulation tool for simulating the response of materials to short duration severe loadings from impact, high pressure or explosions.

- ANSYS Mechanical

ANSYS Mechanical is a finite element analysis tool for structural analysis, including linear, nonlinear and dynamic studies. This computer simulation product provides finite elements to model behavior, and supports material models and equation solvers for a wide range of mechanical design problems. ANSYS Mechanical also includes thermal analysis and coupled-physics capabilities involving acoustics, piezoelectric, thermal–structural and thermo-electric analysis.

- Introduction To CFD

Computational fluid dynamics, usually abbreviated as CFD, is a branch of fluid mechanics that uses numerical methods and algorithms to solve and analyze problems that involve fluid flows. Computers are used to perform the calculations required to simulate the interaction of liquids and gases with surfaces defined by boundary conditions. With high-speed supercomputers, better solutions can be achieved. Ongoing research yields software that improves the accuracy and speed of complex simulation scenarios such as transonic or turbulent flows. Initial experimental validation of such software is performed using a wind tunnel with the final validation coming in full-scale testing, e.g. flight tests.

- Structural analysis

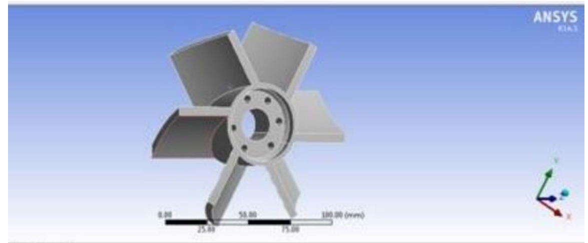
Structured analysis is a software engineering technique that uses graphical diagrams to develop and portray system specifications that are easily understood by users. These diagrams describe the steps that need to occur and the data required to meet the design function of a particular software.

This type of analysis mainly focuses on logical systems and functions, and aims to convert business requirements into computer programs and hardware specifications. Structured analysis is a fundamental aspect of system analysis.

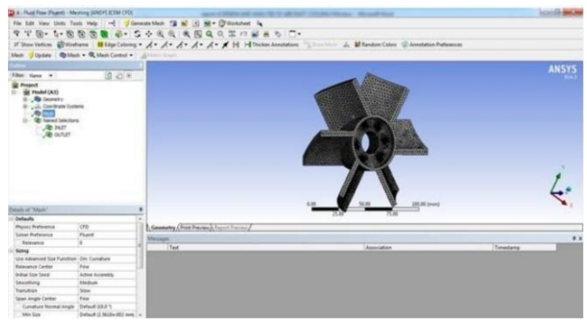
- Finite Element Method

Finite Element Method (FEM) is also called as Finite Element Analysis (FEA). Finite Element Method is a basic analysis technique for resolving and substituting complicated problems by simpler ones, obtaining approximate solutions Finite element method being a flexible tool is used in various industries to solve several practical engineering problems. In finite element method it is feasible to generate the relative results.

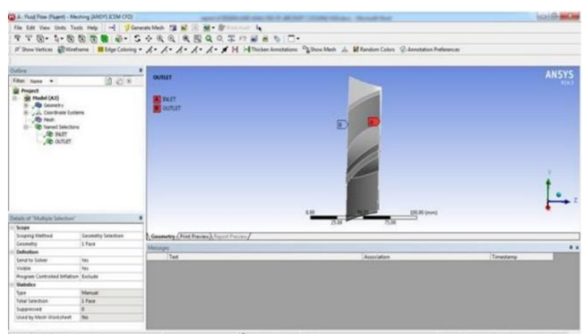
In the present day, finite element method is one of the most effective and widely used tools. By doing more computational analysis the approximate solution can be improved or refined in Finite element method. In Finite element method, matrices play an important role in handling large number of equations. The procedure for FEM is a Variation approach where this concept has contributed substantially in formulating the method.



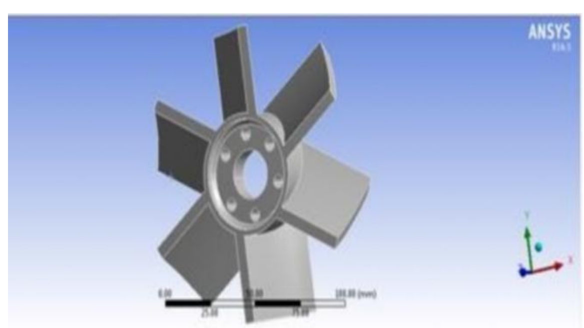
At speed 2000 rpm



Meshed Model



Air inlet & outlet



Static analysis of colling fan

IV. RESULTS

STATIC ANALYSIS RESULTS

SPEED	Deformation (mm)	Stress (MPa)	Strain
2000	0.078003	83.206	0.00041674
2500	0.1902	116.49	0.00058343
3000	0.15601	166.41	0.00083348

V. CONCLUSION

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Cooling fan model developed for speed of 2000, 2500 & 3000 rpm to study the interaction between the fluid and solid of cooling fan.

The speed is the input for CFD analysis and the pressure obtained from the CFD analysis is taken as input for structural and modal analysis.

By observing the CFD analysis results the pressure, velocity, heat transfer coefficient and mass flow rate values are increases by increasing the speed.

By observing the static analysis results the stress values are increases by increasing the speed of the cooling fan.

By observing the modal analysis the deformation maximum value at mode shape 6.

By radial engines have the cylinders arranged evenly around the crankshaft, although some early engines, sometimes called semi-radials or fan configuration engines, had an uneven arrangement.

The best known engine of this type is the Anzani engine, which was fitted to the Bleriot XI used for the first flight across the English Channel in 1909.

This arrangement had the drawback of needing a heavy counterbalance for the crankshaft, but was used to avoid the spark plugs oiling up.

In military aircraft designs, the large frontal area of the engine acted as an extra layer of armor for the pilot.

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