

Design Aspects & Manufacturing of Blade Types in Aero Engine

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ABSTRACT: In any airplane engine, the blades play a very important role in providing forward thrust. The first factor that determines an engine's efficiency is the efficiency of each and every single vane profile. It is the design of a blade that decides the engine efficiency apart from all other secondary parameters. This paper presents the design aspects and considerations of vane (or blade) profile along with the manufacturing methods, assembly and testing. In addition to this, the paper also discusses the design features, construction and requirements that are necessary before designing and manufacturing any vane or blade profile.

The designing of blades of an airplane engine to meet the engines thrust requirement is of complicated task and requires creative thinking as well as understanding of existing systems. Designing is done keeping in mind that the design profile should offer possible less drag and avoid surging and choking phenomenon. The designed profile throws a challenge to manufacturing phase in which every process has to be carried out according to design requirement. It is the manufacturing phase where some special processes are carried out so as to make the blade capable of resisting high loads and high temperatures. This paper presents all such special processes and respective advantages which give fine strength, hardness, temperature resistive capability and surface finish to the profile.

KEYWORDS: Blade profile, Airplane engine, Thrust, Design & manufacturing, Strength, Hardness, Temperature resistive capability and surface finish

I. INTRODUCTION

From the past few decades, there has been growing importance for gas turbine engines being used in different types of airplanes. Gas turbines satisfy all the customer requirements to maximum extent starting from its size to its efficiency. There has been huge development from engine design to its performance characteristics. After analysing the requirements of the task to be performed, the next step is to analyse the problem and understand its context. The first activity in this phase is studying the existing system and other is to understand the requirements of the new system. Both the activities are equally important but the first activity serves as a basis of giving the functional specifications and then any further changes or requirements are employed in the design of proposed system. However, our paper deals with the study of existing system and its requirements. Improper understanding of the system can lead diversion from solution. It is obvious to say that the development of every part of the engine will be contributing for this, but it is the primary design of a blade on which the complete engine's performance mainly depends. This paper discusses those main aspects and analyses the design features, requirements and problems in practical point of view. Analysing of the existing and new design requirements while calculating blade profile parameters for designing is done.

II. BACKGROUND

From the past few decades, there has been growing importance for gas turbine engines being used in different types of airplanes. Gas turbines satisfy all the customer requirements to maximum extent starting from its size to its efficiency. There has been huge development from engine design to its performance characteristics. It is obvious to say that the development of every part of the engine will be contributing for this. Although every individual component has a key role in contributing to its development, it is the blades of the engines that come to designers mind before solving the problems.

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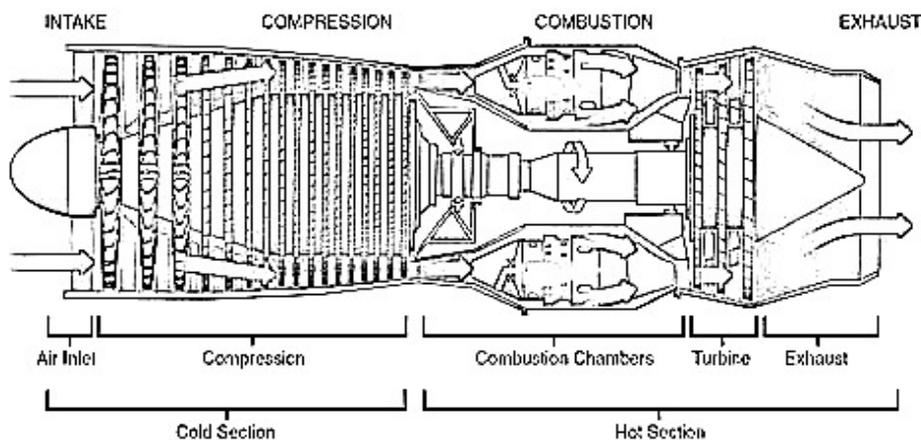


Impulse Turbine Blades

Gas, steam and water turbines have a casing around the blades that contains and controls the working fluid. It is the primary design of a blade on which the complete engine's performance mainly depends. Every single blade will contribute towards this and so the blades designing and its manufacturing are the two main aspects which decide the engine's final output. The failure of one blade during the flight will lead to the damage of others. So manufacturing and assembly of the blades is of very important task. This paper discusses those main aspects and analyses the design features, requirements and problems in practical point of view. All the ideas presented in this paper are the result of practical approach to blade design and manufacturing

III. SCOPE OF RESEARCH

Understanding the basic working in components of the engine with the study of existing design types and systems is the scope of this research. Analysing the existing and new design requirements This Procedure describes the general requirements for designing and manufacturing of aero turbine blades. Design and analysis were considered based on impulse turbine blades turbofan engine operation. To manufacture a low-pressure turbine rotor (LPTR) blade and sent for checking of its dimension, profile, cracks etc and the whole engine depends on its functioning.



Turbofan Engine Operation

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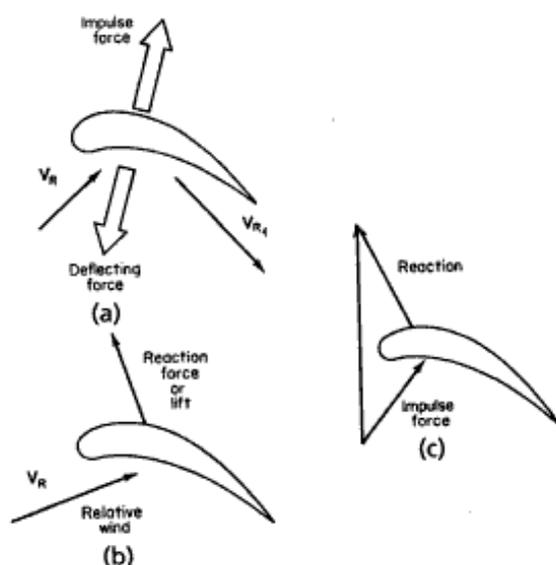
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IV. DESIGN REQUIREMENTS & ANALYSIS

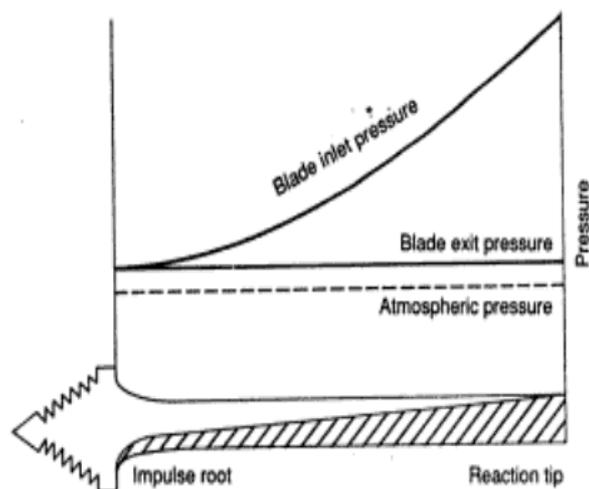
- i. Engine thrust can be high only if the inlet duct supplies the engine with the required airflow at the highest possible pressure. For subsonic aircraft, the nacelle/duct should not produce strong shock waves or flow separations and should be of minimum weight for both subsonic and supersonic designs.
- ii. Present day compressors have a compression ratios over 25:1, efficiencies over 90 percent, and airflows up to approximately 350lb/s [158 kg/s]. With addition of fan, total pressure ratios of more than 25:1 and mass airflows of 1000 lb/s [453 kg/s] have been achieved.
- iii. Operation of the compressor must take into account both aerodynamic and thermodynamic considerations since it is impossible to compress air without incurring a temperature rise. The temperature rise is a result of the work being done by the rotor blades and the temperature rise in a substance (in this case, air) is always proportional to the energy or work expended.
- iv. Stall indications may be a rapid EGT increase or fluctuation, rpm fluctuation, EPR decrease or fluctuation, vibration caused by compressor pulsations, and poor engine response to power-lever movements. Such stalls influence engine reliability and durability.
- v. In order to furnish the drive power to compress the air, the turbine must develop as much as 100,000 hp or more for the larger jet engines. One blade or bucket of a turbine can extract about 250 to 300 hp from the moving gas stream. It is important to distribute the power load evenly from the base to tip of the blade. An uneven distribution of the work will cause the gases to exit from the blade at different velocities and pressures. The turbine blading is a blending of the impulse type at the roots and the reaction type at the tips.

V. RESEARCH & EXPERIMENTAL RESULT

In an axial flow machine (compressor in particular) the energy is carried from the shaft to the flow by an impeller consisting of cantilever vanes fixed on the hub. Since the rotating impeller of the machine is prevented from shifting in an axial direction and its vanes are fixed at an angle to the plane of rotation, the impeller moves gas along the direction of axis. The performance and design of axial flow machine is considered using the theory of cascade profiles.



Forces exerted on a reaction blade



Pressure changes across the impulse and reaction sections

In the figure, the required drop for “reaction” is present at the tip and gradually changes to the “no pressure loss” condition required for “impulse” at the root. In addition, the higher pressures at the tip will tend to make the gases flow toward the base of the blade, which counteracts the centrifugal forces trying to throw the air toward the tip. If the

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impeller is sectioned by a cylinder of radius r , the development of the latter together with the vane sections will give a plane cascade of vane profiles for the axial flow machine. The manufacturing of blades involves various types of processes. Every stage in a compressor or turbine consists of blades with varying size, strength and manufacturing material that is used. Hence the process of manufacturing is different for different stages of blades. The machining processes remain same with a change in the order of operations. The compressor blades are manufactured from forging whereas turbine blades from casting. As the turbine blades consists of hollow section inside for cooling purpose, casting process is preferred. Compressor blades will be having a dove-tail root which is fixed into the rotor rub, whereas turbine blades will be having a fir-tree root as its holding strength is more.

DIFFERENCE & COMPARISON OF VARIOUS TYPES OF ENGINES (Manufactured in HAL, Koraput)

Sr No	Parameter	R11F2S	R25	R29B	RD33	AL31FP
1	Aircraft	MIG-21	MIG-21BIS	MIG-27/23BN	MIG-29	SU-MKI
2	LP Compressor Stage	3	3	5	4	4
3	HP Compressor Stage	3	5	6	9	9
4	Compression Ratio	8.9	9.2-9.5	12.2	20-22	LP 3.5 HP 6.6 (23)
5	Air Mass Flow (Kg/sec)	66.2	68.5	105	76+1.5	112
6	Rotor Speed (rpm)					
	N1 (100%)	11,150	11,156	8,482	11,000	10,098
	N2 (100%)	11,412	11,362	8,772	15,511	13,300
7	Combustion Chamber	Can Annular	Can Annular	Annular	Annular	Annular
8	TET (T3) Deg. C Max	936	1040	1130	1257	1392
9	JPT (T4) Deg. C Max	730	850	840	800	765

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Difference and comparison of various types of engines manufactured in HAL

A low-pressure turbine rotor (*LPTR*) blade is manufactured in several sequences of operations. In operation, AL-31 FP engine is a fighter aircraft which travels at a speed of Mach 1.8 – 2.2. This aircraft consists of 13 compressor stages (4LPCR + 9HPCR) and 2 turbine stages (HPTR+LPTR). After the manufacturing of blades is completed, the blades are sent for testing where they are tested using various non destructive tests and specific available rigs. The tested blades are then sent for assembly. So it has to undergo different types for checking of its dimension, profile, cracks etc. Being the power generating part, the whole engine depends on its functioning. Modern steam turbines frequently employ both reaction and impulse in the same unit, typically varying the degree of reaction and impulse from the blade root to its periphery.

VI. CONCLUSION

After performing a study on designing and manufacturing of Aero turbine blades, concepts covered were:

- Understanding basic theory and operation of engines manufactured
- Different types of blades used in turbines, compressor and nozzle guide vanes
- Various parts of Engines and their functions.
- Design aspects and construction features of Blades
- Various machining processes and studied the customized instruments used specifically to check the profiles of the blade.

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BIOGRAPHY



Hepsiba Seeli, post graduate of Andhra University (AU) 2011, Mechanical Engineering with specialization in (CAD/CAM).

I am currently working as Assistant Professor at Pydah Kaushik College teaching Mechanical Engineering courses and facilitating laboratory. In the past, I worked as a Research Assistant in the E-Foundry Lab at IIT Bombay. This was funded by National Knowledge Network Mission of Government of India, New Delhi. I also worked as a Research Assistant in the Biomedical Engineering and Technology centre (BETiC) at IIT Engineering Bombay (funded by the Rajiv Gandhi Science and Technology Commission of the Government of Maharashtra, Mumbai, along with the Department of Science and Technology, New Delhi. After completing my Bachelors degree, I started my career as an Engineering Design team member for Tipton Intellectual Property Operation PVT. LTD. Hyderabad, A.P, India. It is my passion for problem solving skills and creative thinking that motivated me to continue my education, teaching and research career.

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I am Joel P. John pursuing IV B.tech. I have chosen mechanical engineering as a passion. My professional ability in terms of technical and analytical skills helped me in broadening and enhancing my knowledge in writing technical papers, attending seminars and conferences, I have bagged few awards for paper presentations in various engineering colleges.