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Design and Manufacturing of Mini Jet Engine

Vinayak Pawar[1], Kedar Kini[2], Umesh Kolge[3], Shivraj Mhetre[4], Sanjay Nikhade[5]
[1,2,3,4]*B.E. Student, Dept. of Automobile Engineering, Dr. D. Y. Patil School of Engg. & Technology, Pune, India*
[5]*Professor & HoD, Dept. of Automobile Engineering, Dr. D. Y. Patil School of Engg. & Technology, Pune, India*

***Abstract*: The content of this publication deals with design and manufacturing a small gas turbine engine. The manufactured components included: axial turbine, stator, diffuser, compressor inlet, shaft, outer casing, combustion chamber, fuel distributer, exhaust nozzle, and inlet flange. We reviewed literature regarding gas turbine engine components, designed each component, and manufactured them accordingly. We then assembled our engine and planned for testing.**

***Keywords*: Gas Turbine, Mini Jet Engine, Modelling of mini jet engine, Turbojet Engine**

1. Introduction

The mini jet engine is a machine that, according to the thermodynamic Brayton Cycle, does work by harnessing energy from a working fluid and converting the energy into a useable form. Various types of gas turbines are designed to perform a range of tasks but all operate on similar principles. Air enters the engine, is compressed, mixed with fuel, combusted, and then expanded through a rotating turbine. The goal of this project is to call on the literature available regarding small gas turbines in order to design and manufacture an engine that is self-sustaining. In order to expedite the design process, efficiency and thrust production are not prioritized. Due to budget and time restrictions we are unable to complete multiple iterations of a new engine. Therefore, we rely on engine designs currently developed to aid in the design of our major components. Subjects such as new aerofoil design for turbine blades, nozzle efficiency, and combustor efficiency can be the subject of years of research and investment. For this reason, we drew on industry standards and recommendations of modelers to design some of our components. We realized early that two crucial components, the centrifugal compressor and ball bearings, would be impossible to design and manufacture given the time frame. We made the decision to purchase these components in order to make our project more feasible given the restrictions.

This project consists of manufacturing of twelve major components:
Compressor, Diffuser, Power transmitting shaft, Shaft housing, Annular Combustion chamber, Fuel Supply System, Stator, Stator/turbine housing, Axial Turbine, Exhaust nozzle, Outer casing, Inlet flange. Each component listed above was first modelled with SOLIDWORKS software and then manufactured with the material processing capabilities available in Dr. D.Y. Patil School of Engineering & Technology workshop. Throughout the experience, our team furthered our design and manufacturing skills through manual and CNC milling and turning, TIG welding, sheet metal forming, and regular engineering troubleshooting.

2. Scope

The scope of this project is based on the following:

1. To design a Mini Jet Engine.
2. To fabricate the Mini Jet Engine.
3. To use LPG as fuel.
4. To test run the turbine jet engine and measure its performances in terms of thrust.
5. Produced, fuel flow rate and combustion and exhaust temperature.

3. Jet engine

A turbine jet engine is widely used in commercial aircraft and jet fighters. It comprises of four main parts, which are a compressor, a combustion chamber, a turbine and a nozzle. The compressor increases the pressure and temperature of air before entering the combustion chamber. The high pressure and high-temperature air then entered the combustion chamber where it is mixed with fuel and ignited, in a constant pressure process. The combustion gasses afterward flow through a turbine which connected to a compressor by a common shaft. The turbine extracts energy from the gasses resulting in a reduction of pressure and temperature of the gas. The remaining gasses, flows through a nozzle where it is accelerated to produce thrust. These processes of compression, combustion, extraction and exhaustion are continuous and self-sustaining.

4. Components

In order to better understand how a small turbojet engine operates, one must understand the purpose for each component.

A. *Compressor*

Compressor is the stage of the engine which creates high enough pressure to achieve combustion. Axial and centrifugal are the two types of compressors commonly used in turbojet engines. The axial compressor directs the air flow parallel to the rotational axis whereas the centrifugal design directs the flow radially outward, perpendicular to the rotational axis. Small gas turbines, that produce less than 5MW, are often designed around centrifugal compressors. The basic principle of all compressors is the same it converts kinetic energy into pressure energy. To achieve this air drawn into the compressor is first accelerated to high speed and then decelerated. This action converts the speed of the gas into pressure. If radial compressor is used, centrifugal force provides a further increase in air pressure.

Fig. 1. Compressor

B. Diffuser

The diffuser is the divergent section of the engine after the compressor and before the combustion section. It has the all-important function of reducing high-velocity compressor discharge air to increased pressure at a slower velocity. This prepares the air for entry into the flame burning area of the combustion section at a lower velocity so that the flame of combustion can burn continuously. If the air passed through the flame area at a high velocity, it could extinguish the flame.

C. Combustion chamber

The combustion chamber in gas turbines and jet engines is called the combustor. The combustor is fed with high pressure air by the compression system, adds fuel and burns the mix and feeds the hot, high pressure exhaust into the turbine components of the engine or out the exhaust nozzle. Three types of combustors namely: Can, Cannular and Annular type. Annular chamber can be employed quite effectively in a mini jet engine while being conducive to minimizing weight, cost and complexity of design. Our research focuses on small, annular combustion chambers that can be utilized in mini jet engines.

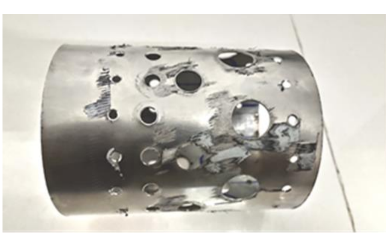

Fig. 2. Combustion chamber

D. Fuel supply system

The purpose of the fuel supply system is to transport fuel from an outside source into the vaporization tubes of the combustion chamber. We chose a simple distributor designed similar to those seen in many small gas turbines. Fuel is supplied by an annular fuel distributor at the back end of the combustion chamber. Divided in small tubes the fuel is injected with negligible overpressure in each tubular stick. Here the fuel is atomized, mixed with air and vaporized by contact with the hot surface inside the stick. Air mass flow transports the atomized and vaporized fuel to the diffuser shaped end of the stick. With the addition of excess air mass flow in the primary zone a well flammable fuel-air mixture is generated. In this zone the flame is stabilized and a continuous combustion over a wide range of operation is possible.

E. Shaft

The shaft of a jet engine connects the fan section, compressor and turbines together, transferring energy from the back of the engine to drive the front. Acting as the backbone of the engine, a shaft experiences different forces and temperatures along its length as it runs from the cool lower pressure fan section, driving the high-pressure warm compressor, passing through the hot combustor, then is turned by the high temperature fast rotating turbines. This means the shaft needs to be strong to transfer the force from the turbines all the way down its length to power the fan and compressor. It also needs to be able to cope with warm conditions as even with a cooling system, it is hot inside a jet engine. After reviewing various shaft designs used in similar engines, such as the KJ66 and SR30, we decided to use a design very similar to the KJ 66. Our engine is slightly larger than the KJ 66 therefore, we scaled up the shaft design while maintaining the overall style.

Fig. 3. Shaft assembly

F. Casing & inlet flange

Casing is used to hold all components together. It acts as the outer shell of the combustor, and is a simple structure that is protected from thermal loads by the air flowing in it, so thermal performance is of limited concern. However, the casing serves as a pressure vessel that must withstand the difference between the high pressures inside the combustor and the lower pressure outside. That mechanical (rather than thermal) load is a driving design factor in the case.

Fig. 4. Casing & Inlet flange

5. Construction & working

The assembly of the parts are as follows. The compressor and the turbine are connected to the shaft and rotates with it. The shaft is supported on bearings which fit neatly into the shaft tunnel. The tunnel is attached to the diffuser at the inlet and to the nozzle guide vane at the exit end. The diffuser is in turn attached to the housing by means of screws. The compressor cover protecting the compressor is attached to the housing. At the exit end the shaft tunnel is attached to the NGV which in turn is connected to the housing and the exhaust nozzle. Sufficient clearance is given between the rotary components to ensure smooth operation.

A. Working principle and operation

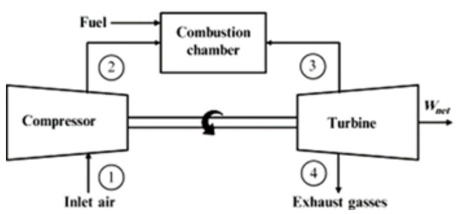

Fig. 5. Brayton cycle

To understand the working of the jet engine model one has to know the principle of working of the gas turbine. The jet engine works by the principle of Brayton's cycle. The air from the atmosphere is taken and compressed and then sent to the combustion chamber. Where the fuel is mixed along with the air and ignited. The large amount of energy is released which is used to run the turbine and the work done by the turbine is used to run the compressor as well thus the cycle continues. In this cycle the heat addition is at a constant pressure. This represents the gas turbine or internal combustion turbine in its simplest form. If working concept of a simple gas turbine is clear than understanding the working of the jet engine project shouldn't be difficult because the working cycle of the model is same as that of simple gas turbine.

6. Limitation

The limitations to carry out this project are as follows:

1. The availability of material.
2. The availabilities of components cost limitation.
3. Time limitation

7. Conclusion

Over the course of this project we successfully designed and manufactured all twelve of the components outlined that constitute our jet engine. The volume of research and information regarding gas turbines is simply immense and often difficult to navigate. Considering these factors, it becomes evident that our project was quite ambitious. However, through our struggles, we gained first-hand knowledge gas turbines and the challenges faced during their design and manufacturing.

References

[1] Edwin Cyril, B Shobin Mathew, Akhil Mathew, Gino Sunny, "A Study on Mini Jet Engine" IJIRSET, Volume 6, Special Issue 4, March 2017.
[2] Simon Fahlström, Rikard Pihl-Roos, "Design and construction of a simple turbojet engine", Uppsala Universitet, September 2016.
[3] V. Raviteja, T. Kashi Vishwanath, V. Ashok Kumar, N. Venugopal, R. Pavan Kumar, "Design and Fabrication of a Model Jet Engine (Sivani 150)" IJMER, Vol. 5, Issue 12, December 2015.
[4] R. Amirante, L.A. Catalano, A. Dadone and V.S.E. Daloiso "Design Optimization of the Intake of a Small-Scale Turbojet Engine", CMES, vol.18, no.1, pp.17-30, 2007
[5] Onkar Patel, Prakash Kumar Sen, Gopal Sahu, Ritesh Sharma, Shailendra Bohidar, "A Review on Turbo Jet Engine", IIJME, Volume 3, Issue 11, November 2015.