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CONVERSION OF AUTOMOTIVE TURBOCHARGER TO GAS TURBINE

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Abstract- Gas turbines are prime movers with major technical advantages over the conventional internal combustion engine. It would be specifically for this, that they have been deployed in the aerospace industry for propulsion. A few differences from the reciprocating automotive engine is the absence of moving parts like the piston and valve mechanism which are a major cause of friction. The aero engines also have a high thrust to weight ratio – making them the natural choice for airborne transport vehicles. In this project the turbocharger unit used in the Mahindra XUV 500, vehicle was selected. All other components including the combustor and the fuel system were designed, fabricated and incorporated into the Gas turbine power plant. The tests yielded successful results opening further challenges to be resolved and pursued to wholly attain the objectives.

Keywords – Turbocharger, combustor, fuel injector, combustor liner, nozzle.

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I. INTRODUCTION

In an automobile turbocharger is a supplementary component which feeds in air at little higher pressure into the engine cylinders. This happens only when the turbocharger reaches its requisite rpm. Thus it is the part which is designed to optimise the overall performance and efficiency of the engine. The turbocharger supplies compressed air into engine cylinders. The exhaust from the engine is used to drive the turbine blades of the turbocharger. This in turn rotates the compressor of turbocharger as both the turbine and compressor are coupled together. The compressor blades suck in air from the ambient environment and pass through the casing of compressor which results in compression of the air. The compressed air is later fed to the cylinder. The turbocharger serves as an integrated compressor & turbine assembly which is suitably manipulated (carefully converted) in to an open cycle constant pressure gas turbine. The project mainly involves designing, fabrication and analysis of combustion chamber using software's like UniGraphics; and then complete fabrication of the same.

II. SYSTEM AND COMPONENT DESIGN

The major part of the design is similar to that carried out in [1] with the commonalties being the combustor design with the primary and secondary air holes. In this project a simplified fuel system and igniter were used. The entire block circuit of the engine has been divided into three major units for the sake of the simplicity of understanding. The three major sub units are listed below

1. The Turbocharger unit
2. The Hydrostatic lubrication unit and
3. The Combustion system

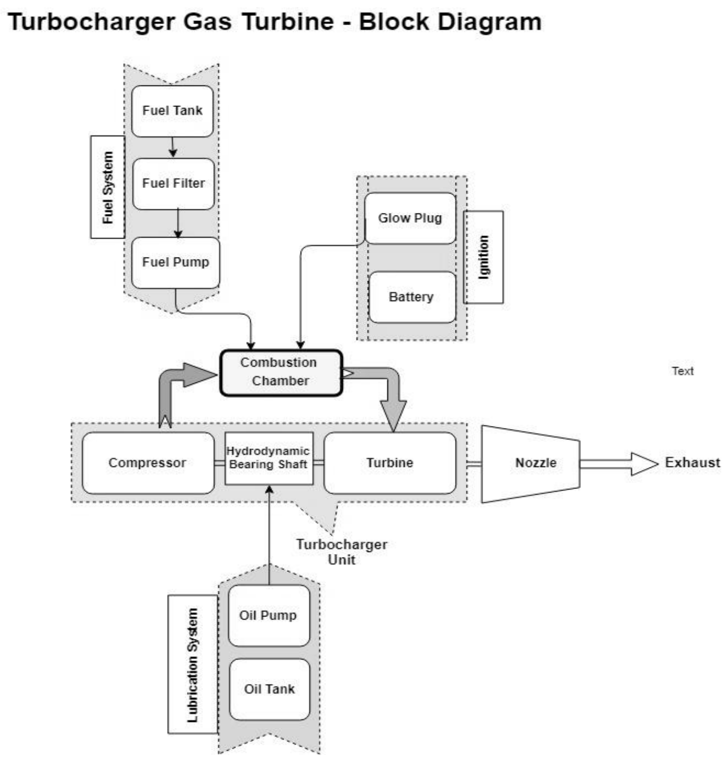

Fig 1. Layout of Turbocharger Gas Turbine

Each of these three units is further sub divided into sub units, brief description of which is given below:

1. Turbocharger

There are a number of factors, such as turbo lag, boost threshold, heat, back-pressure, low-end torque, and top-end power, that must be taken into account when selecting a turbo. A large turbo will suffer from turbo lag and may lack in producing low-end torque.

MANUFACTURER: Turbo Energy Private Ltd (TEL)

COUNTRY: INDIA

TYPE: BV43-007 M&M, WATERGATE TYPE

SERIAL: 12 112 1072

APPLICATION: XUV 5OO, MAHINDRA AND MAHINDRA

Inducer diameter of the turbocharger, I = 3.5cm or 35mm

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2. Combustor Design

This section deals with the detailed design of the combustion chamber of the modelled turbojet engine. The design includes deciding the dimension of the combustion chamber

Approach towards combustor design

1. Study of the existing jet aircraft combustion chamber.
2. Deriving empirical relations based of the study.
3. Manipulation of the empirical relations suited for our application.
4. Calculation of the combustor dimensions and other design details based on manipulated empirical relations.
5. Initial combustor model based on calculations.
6. Incorporation of necessary changes to the initial design to suit practicality and construction feasibility of the combustor.
7. Final model of combustor.

Construction of combustion chamber

The construction of the combustor consists of two main parts the outer casing and the flame tube with other parts added to their assembly. The seamless tubing of SS304 which will be used for the construction of outer casing of the combustor. The tubing is cut to the required length. The casing consists of the taper at the end. An angle of 300 is given for the taper. The combustion of the fuel and air in the proper ratio occurs in the combustion chamber and therefore large amount of heat is generated in this chamber. Ideas for the conical part of the combustor was adapted from [3].

Figure 2: Fabricated Combustion Chamber Casing

The above figures show the completed combustor casing.

Fuel Supply System :

The fuel system comprises of Fuel Injector, Heater Plug, Fuel Pump & Gear Pump **.**

To pump lubricating oil, a gear pump is coupled with an AC motor for lubrication and cooling the turbo charger specifications

RPM:- 1440

Maximum Pressure=12 Kg/cm2

Capacity=20 LPM

DESIGN PARAMETERS OF COMBUSTION LINER

Total area of combustion Liner Holes =4*I=14cm2

I is the inducer diameter of compressor

Size of a hole =0.3 cm^2

No of Holes =48 (approximately)

Combustion Liner Dimension

Internal Diameter =7cm

Length =25cm

Thickness =3mm

Outer Diameter =7.6cm

III. FABRICATION

Jet engine test stand:

The turbocharger mounting is designed to take up the weight of the turbocharger and combustion chamber assembly as well as to withstand the thrust produced while the engine operation. The turbo must be secured so that it will not move when running. The mounting at the turbine end is secured by means of MS bolts and the other mounting is welded to the engine frame.

Mounting combustion chamber on Turbocharger

The image below shows the mounting of the entire combustor on the turbocharger. The image clearly illustrates the simplicity of the mounting procedure. The SS304 pipe goes inside the compressor outlet; on the other hand, combustor's flange is matched with the turbine flange, both the flanges are bolted together by means of SS 10mm bolts.

Figure 3: Mounting of combustor on The Turbocharger

Final assembly:

The completed engine assembly is depicted below

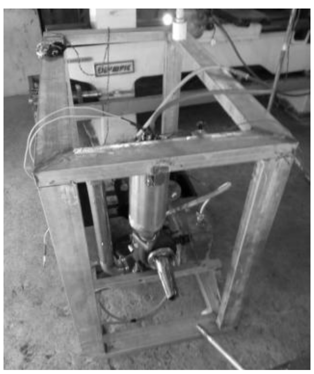

Figure 4:Completed Turbojet Engine Test Rig

IV. RESULTS & CONCLUSION

The design and fabrication of turbojet was done successfully. The combustion of air- fuel mixture occurred for the given air-fuel ratio. The whole setup was made within the expected estimate. The vibration of the complete setup was under control. The calculations made for providing mass flow rate and pressure for discharge of oil and fuel was sufficient for the test to be successful. The setup was completely leak-proof.

V.FUTURE SCOPE

The turbojet engine could self-sustain for a very limited period. It might be due to the assumptions made in designing the combustion chamber and liner. The design of thrust nozzle couldn't produce the expected thrust to displace the setup. The weight of the turbojet engine test frame has drastically affected in producing the required thrust.

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