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Design and Fabrication of Model Jet Engine using Recycled Turbocharger Parts

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Abstract: This is a capstone project that describes the idea on how to design and fabricate of a Model Turbojet Engine from scrap and recycled parts of an old turbocharger which is reliable and cheap. Turbine jet engine operates at an open cycle called a jet propulsion cycle. A small-scale turbine jet engine comprises of the same element as the gas-turbine engine but in a smaller scale. Both engines differ in utilization and purpose of its production. Turbine jet engines were constructed mainly for air transportation while the small-scale turbine jet engines are developed for a wider purpose, ranging for research activity to hobbyist enthusiastic. Hence, this thesis encompasses the design, fabrication, and testing a small-scale turbine jet engine. The engine assembly was mounted in a test setup. This project is replica of actual working of the jet engine on a small-scale level. The turbocharger serves as an integrated compressor & turbine assembly which is suitably manipulated (carefully converted) in to an open cycle constant pressure gas turbine.

Keywords: Model turbo jet, Turbo Charger, Design, Fabrication, Assembly

I. INTRODUCTION

The invention of the gas turbines around twentieth century during the era of Second World War led to a breakthrough in the field of prime movers. The absence of the reciprocating and rubbing members, few balancing problems, exceptionally low lubricating oil consumption coupled with high power to weight ratio made gas turbines highly reliable. These inherent advantages of the gas turbines were realized when they were first used for aircraft propulsion around mid-twentieth century; and ever since gas turbines have received a special attention by potential mass of engineers and scientists all around the globe. The gas turbines have been used as the source of power for variety of application most of which includes stationary power plant application, as propulsion device for marine, locomotives etc. but the vast portion of the application of gas turbines is found in aircraft industries. The introduction of the gas turbine as propulsion device in the airplanes have made air ways highly reliable source of transportation. It is not just the engineers and scientists who are thrilled by this new highly emerging and developing prime mover, but it has also attracted the attention of the general public who are fascinated by its inherent advantages, simplicity of construction and high reliability.

A typical turbojet is an air breathing jet engine as shown in Fig.1 which consists of a gas turbine and a guiding nozzle. The fresh atmospheric air enters into air inlet, compressor, combustion chamber, at last the turbine. The air gets compressed in the compressor which is heated in the combustion chamber and then allowed to expand in the turbine. The exhaust from the turbine is then expanded in the nozzle which provides thrust. These engines use high overall pressure ratio and high turbine entry temperature. These features combine to give a high efficiency relative to a turbojet. All practical engines are internal continuous combustion engines that directly heats the air by burning fuel, with the exhaust gases from the nozzle.

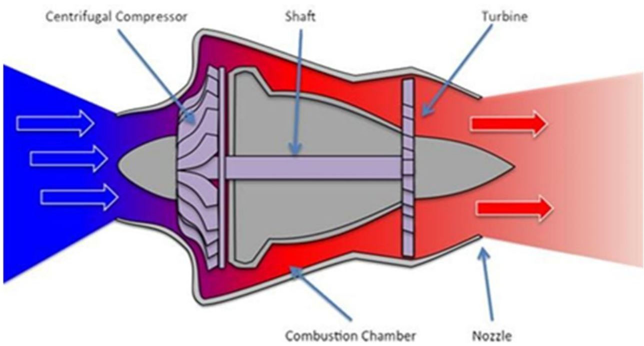

Fig. 1 A schematic view of turbojet engine

It mainly works on the principle of Brayton Cycle where various thermodynamic processes take place in stages. Ambient air is drawn into a compressor, where it is compressed; ideally an isentropic process. The compressed air then runs through a mixing chamber where fuel is added, an isobaric process. The pressurized air and fuel mixture are then ignited in an expansion cylinder and energy is released, causing the heated air and combustion products to expand through a turbine; another ideally isentropic process. Some of the work extracted is by the turbine to drive the compressor through a crankshaft. The rest of the power is used to propel the aircraft.

The cyclic process consists of a isentropic compression, expansion and followed by a isobaric heat addition and heat rejection. There should be no loss of pressure in the combustion chamber and also the power developed by the turbine is just sufficient to drive the compressor the following p-v and t-s diagrams are shown in the Fig. 2.

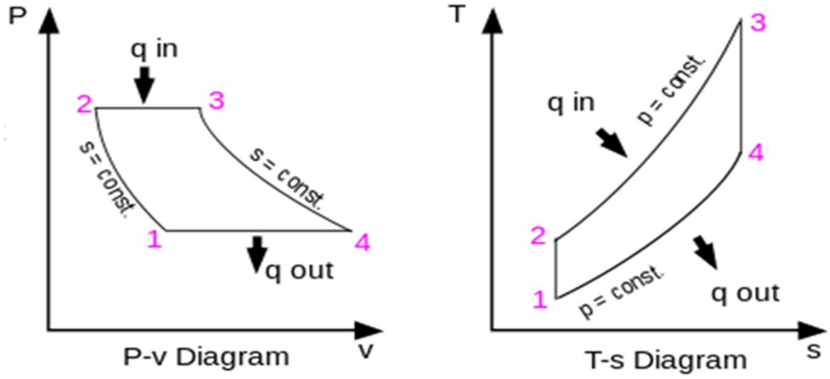

Fig. 2 P-V and T-S diagram for Brayton cycle

II. MAIN COMPONENTS OF JET ENGINE

The complete engine consists of many parts which are necessary for its effective functioning. Some, of the most basic components are shown in Fig.3.

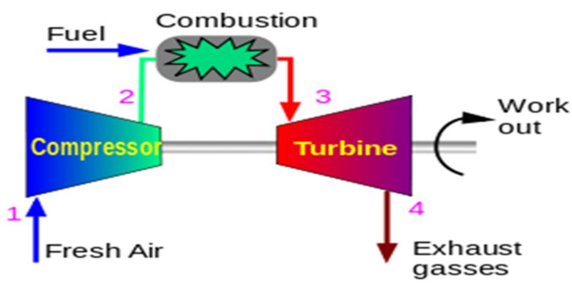

Fig. 3 Major components and working

Each of the parts has its own significance and the roles played to achieve an desired output. The function of each component is explained below.

A. Compressor

Centrifugal compressors, sometimes called radial compressors, are a sub-class of dynamic axisymmetric work-absorbing turbomachinery. They achieve a pressure rise by adding kinetic energy/velocity to a continuous flow of fluid through the rotor or impeller. This kinetic energy is then converted to an increase in potential energy/static pressure by slowing the flow through a diffuser. The pressure rise in the impeller is in most cases almost equal to the rise in the diffuser. This usual casting that increases that increase in area from the entry towards exit slows down the velocity of the air increases the pressure of the air. The compressor blades are made usually from the investment casting of aluminum alloy. The blades should all be intact and not bent excessively. The curved portion of the blades near the center are called the inducer vanes and are used to draw air into the compressor where the blades accelerates it.

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Volume 7 Issue IV, Apr 2019- Available at www.ijraset.com

B. Combustion Chamber

The combustion chamber shows in is the key element of the engine. This is where fuel is mixed with compressed air and burned, causing the air to expand and drive the turbine wheel. A shield called a "combustion liner" is designed to allow some air to mix with the fuel and burn, while the remainder of the air is used to cool the steel parts. The holes in the combustion liner are adjusted to allow the right amount of air to mix with the fuel so that combustion can occur. If the holes are too large, the incoming pressurized air will blow out the flame. If the holes are too small, there will not be enough oxygen to support combustion. If the holes at the fuel inlet end are too small, the flame will have to travel down the combustion liner until enough oxygen has entered to support combustion. This will cause the combustion to occur in the inlet to the turbine and overheat the turbine.

C. Shaft

The turbine drives the compressor by means of a drive shaft; usually a very short, small diameter shaft that is friction welded to the turbine wheel and bolted to the compressor. The shaft runs through an aluminum bearing Most modern turbochargers use hydrodynamic. This is an alloy sleeve bearing with design tolerances that allow a layer of oil between the shaft and the bearing. When the turbocharger is running, the oil supply is under pressure and the shaft rides on a layer of oil and does not touch the alloy bearing. The shaft is suspended on a layer of oil. The thrust bearing on the turbine end rides on a layer of oil and is cooled by oil.

D. Turbine

The turbine is located at the rear of the turbocharger inside a snail housing. The turbine is a radial inflow design. The snail housing is designed to increase the velocity of the inflowing air so that it strikes the turbine blades, at high velocity. The inflowing high-speed air strikes the tips of the turbine blades causing the turbine to rotate at very high speed. The turbine wheel has angled blades near the outlet and is designed to exhaust the hot gases to the rear. Turbine extracts energy from the hot air so, that the air gets expanded and the pressure drops, and the kinetic energy rises.

E. Nozzle

A propelling nozzle is a nozzle that converts the internal energy of a working gas into propulsive force; it is the nozzle, which forms a jet, that separates a gas turbine, being gas generator, from a jet engine. Propelling nozzles accelerate the available gas to subsonic, transonic, or supersonic velocities depending on the power setting of the engine, their internal shape and the pressures at entry to, and exit from, the nozzle. The internal shape may be convergent or convergent-divergent (C-D). C-D nozzles can accelerate the jet to supersonic velocities within the divergent section, whereas a convergent nozzle cannot accelerate the jet beyond sonic speed.

III. DESIGN AND FABRICATION

A. Cycle Calculations

The jet Engine cycle is also known as "Brayton cycle". The typical temperature and the pressure ratio at each stage are calculated as shown in Fig. 4

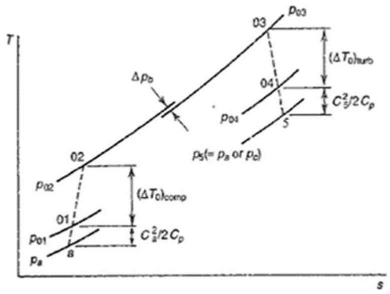

Fig. 4 The Simple Turbojet Cycle Conditions

1) The Initial condition for model Jet engine,

Ta = 288.15k

Pa = 1.01325bar

T3 = 873k

Ca = 340.29 m/s

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The assumed parameters are,
Compressor Ratio: 1.023
Compressor Efficiency $n_c = 0.74$
Turbine Efficiency = $n_t = 0.75$
Intake = $n_i = 0.90$
Nozzle = $n_j = 0.95$
Mechanical Efficiency = $n_m = 0.99$
Combustion Efficiency = $n_b = 0.98$
combustion pressure loss = $\Delta P_b = 0.06$
Formulas and values obtained,

2) The stagnation conditions after the intake may be obtained as follows:

a) $T_{01} = T_{0a} + \frac{C_a^2}{2c_p} = 345.76K$

b) $\frac{P_{01}}{P_a} = \left[1 + n_i\left(\frac{C_a^2}{2c_p}\right)\right]^{K/K-1} = 1.7844$

c) $T_{02}-T_{01} = \frac{T_{01}}{n_c}\left[\left(\frac{P_{02}}{P_{01}}\right)^{\frac{k-1}{k}} - 1\right] = 3.045K$

d) Work done by the compressor:

$$\frac{W_c}{\dot{m}} = C_{pa}(T_{02}-T_{01}) = 3.060W$$

e) Work done by the turbine:

$$\frac{W_t}{\dot{m}} = \frac{\frac{W_c}{\dot{m}}}{n_m} = 3.0911W$$

3) The stagnation conditions at combustion chamber

a) $T_{03} - T_{04} = \frac{C_{pa}(T_{02} - T_{01})}{C_{pg}\, n_m} = 26.94K$

b) $P_{03} = P_{02}\left(1 - \frac{\Delta P_b}{P_{02}}\right) = 1.775616bar$

c) The actual temperature is given as

$T'_{04} = T_{03} -- \frac{1}{n_t}(T_{04} - T_{03}) = 837.08K$

d) $P_{04} = P_{03}\left(\frac{T'_{04}}{T_{03}}\right)^{\frac{K}{K-1}} = 1.532bar$ (here , K = 1.333)

e) The nozzle pressure ratio is therefore,

$$\frac{P_{04}}{P_a} = 1.512657bar$$

f) The critical pressure ratio

$$\frac{P_{04}}{P_c} = \frac{1}{\left(1-\frac{1}{n_j}\left(\frac{k-1}{k}\right)\right)^{\frac{k}{k-1}}} = 1.9179bar$$

4) Since, here $\frac{P_{04}}{P_c} > \frac{P_{04}}{P_a}$ the nozzle is unchoked

a) $T_{05} = T_c = \left(\frac{2}{k+1}\right)T_{04} = 725.2046K$

b) $P_{05} = P_c = P_{04}\ x\ \frac{1}{\frac{P_{04}}{P_c}} = 0.7991bar$

c) $\rho_{05} = \frac{P_c}{RT_c} = 0.3839\frac{kg}{m^3}$

d) $C_5 = (kRT_c)^{0.5} = 526.72$ m/s

e) Mass flow rate at exit

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$$\frac{A_{05}}{\dot{m}} = \frac{1}{\rho_{05}\, c_5} = 0.004945 \text{ m}^3/\text{kg}$$

f) The specific Thrust:

$$F_s = (C_{05} - C_{0a}) + \frac{A_5}{\dot{m}} (P_c - P_a) = 186.43 \text{ Ns/kg}$$

B. 3-D CAD Drawings

The modelling software's used to design the components are Solid works and the Auto Cad. Some of the drawings are shown below All dimensions are in "MM"

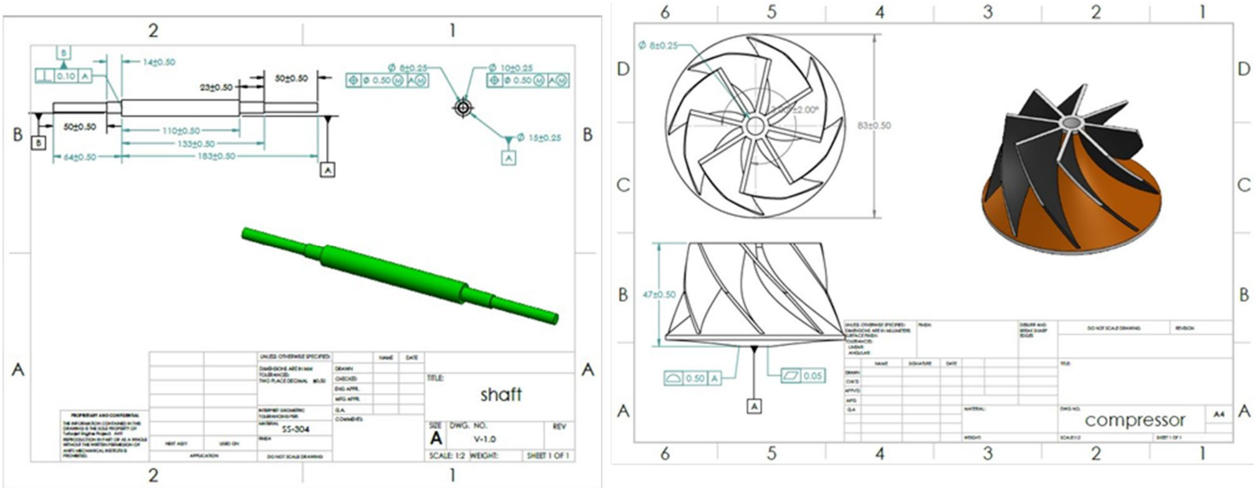

Fig. 5 CAD design of shaft and the compressor

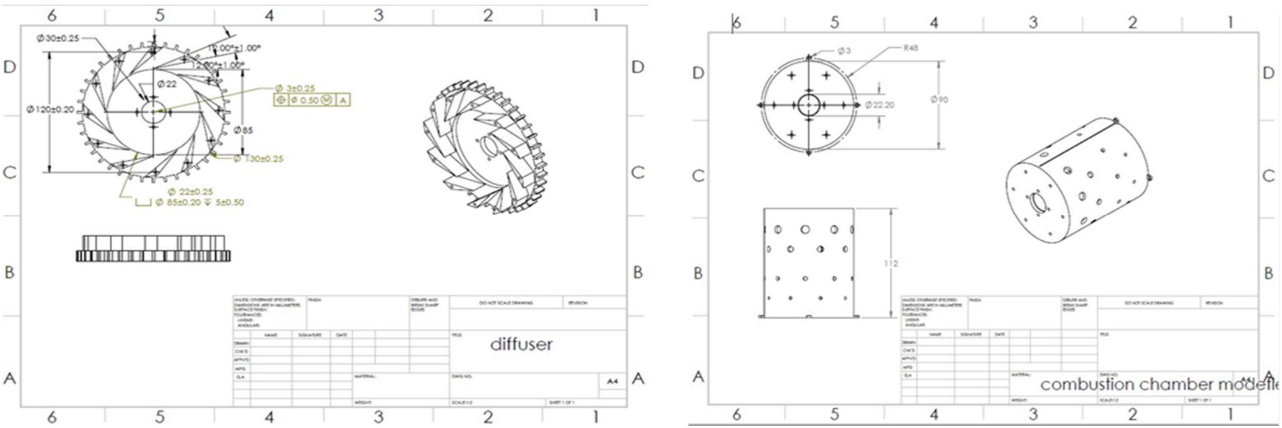

Fig.6 CAD designs of diffuser and combustion chamber

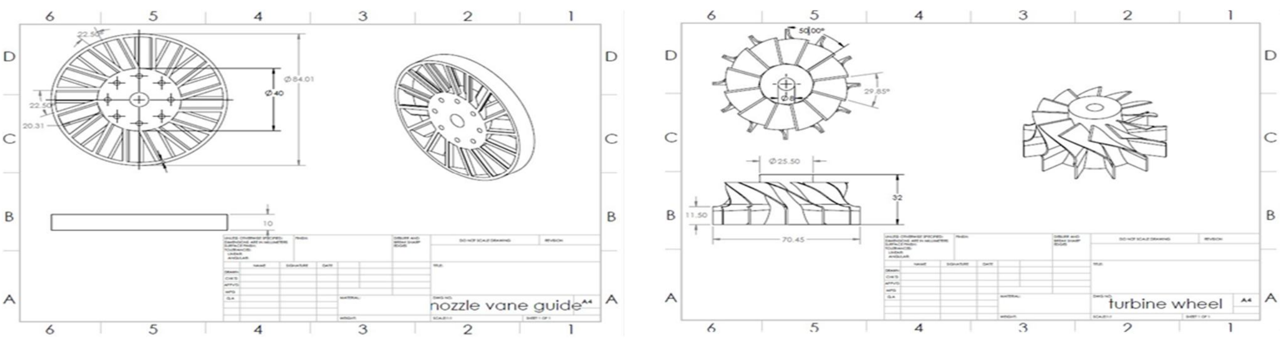

Fig. 7 CAD design of guide vanes and the turbine wheel

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C. Fabrication

1) *Compressor and Turbine:* The components for the fabrication of model turbo jet engine are taken form and old turbocharger as shown in Fig. 8. The two main components of the jet engine are compressor and turbine were obtained from the turbocharger the rest of the components are from scrap which are machined to obtain the desired function.

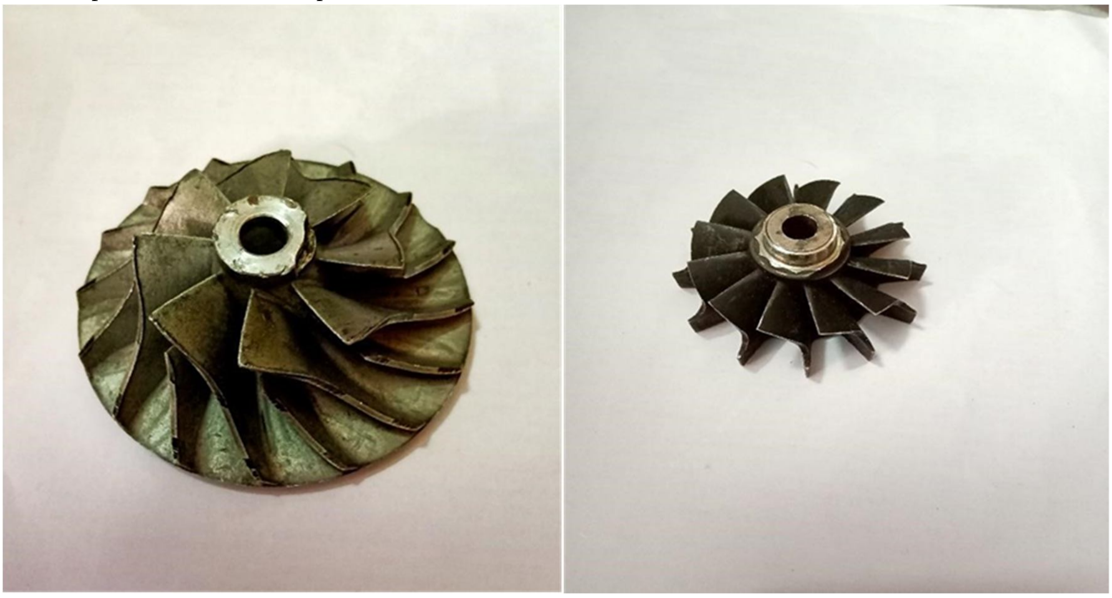

Fig. 8 Compressor And Turbine parts from the turbocharger

2) *Diffuser and Guide vanes:* This part is made from a scrap aluminium alloy shaft which after machined in CNC 3- axis machine as shown in Fig. 9. The machined component requires high degree of accuracy. So, the component is first designed in solid woks then the G-code is generated by the Siemens Nx8 software the final components are shown in Fig 10.

Fig. 9 3 xis CNC machine (AGNI BFW)

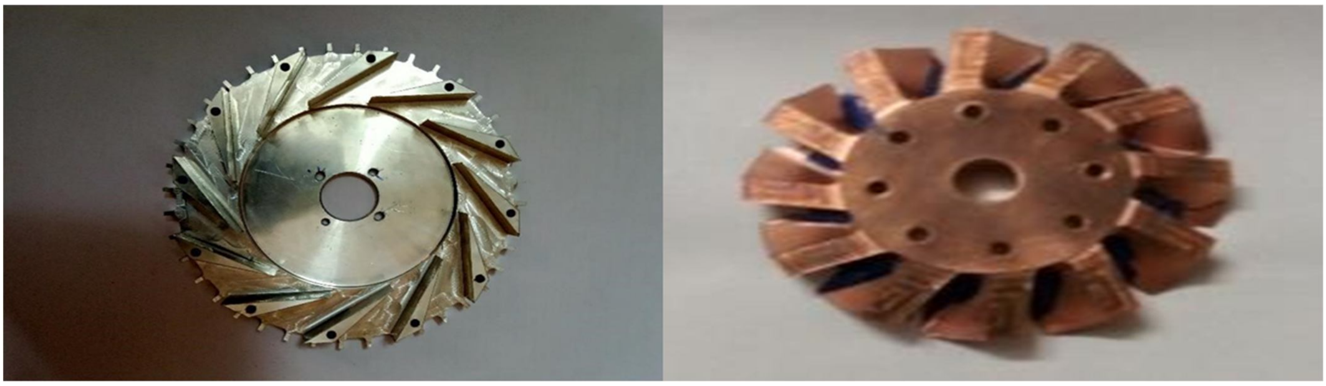

Fig. 10 The machined diffuser and guide vanes

3) *Other components*: Components such as shaft, housing, compressor and turbine covers are also made from the scrap material such as SS, MS and are machined using lathe machine to the desired functional level are shown in Fig 11

Fig. 11 The components which are produced on lathe

D. Assembly of Model Jet Engine

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 rigidly into the shaft housing. The shaft housing 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.

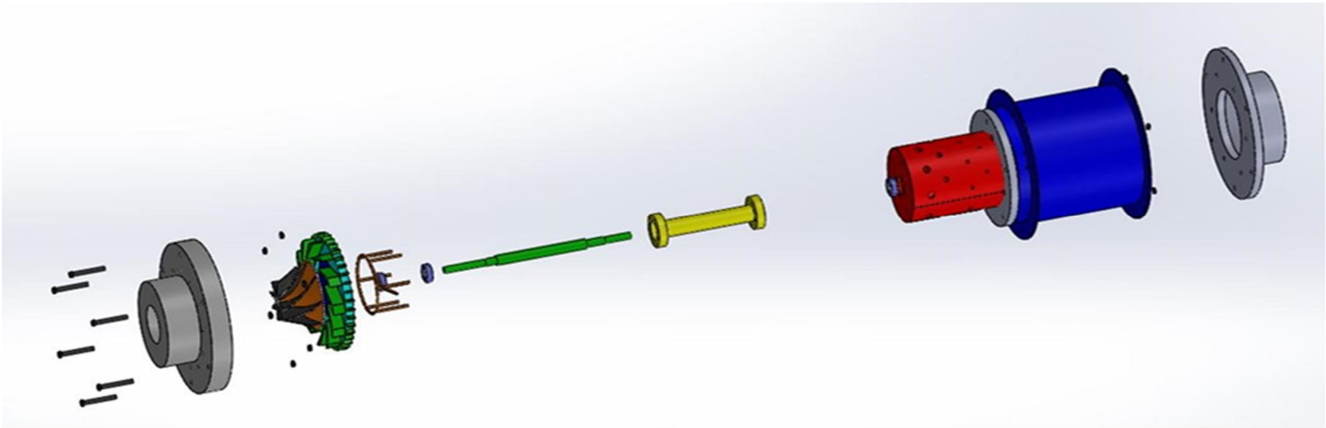

Fig. 12 Assembly of Jet engine using Solid Works

Fig. 17 Model Jet Engine

IV.CONCLUSIONS

Final assembly is done by mounting the model jet engine to the platform which consists of fuel pump, lubricating system. Going through this project was a learning experience for both the supervisor and the team, everything was done according to the procedure and a good understanding was also developed both in the fields of designing and manufacturing.

The aim of this project was not just only designing but also to manufacture it with such detailed designing and a good idea about the manufacturing techniques we were able to manufacture all the components locally with in a budget of Rs. 25,000/- which is 4 times lesser than the proposed budget for this project. The assembly is going on as this report is getting submitted and a detailed testing for every component will also be performed in order to make sure the proper working of the engine.

V. ACKNOWLEDGMENT

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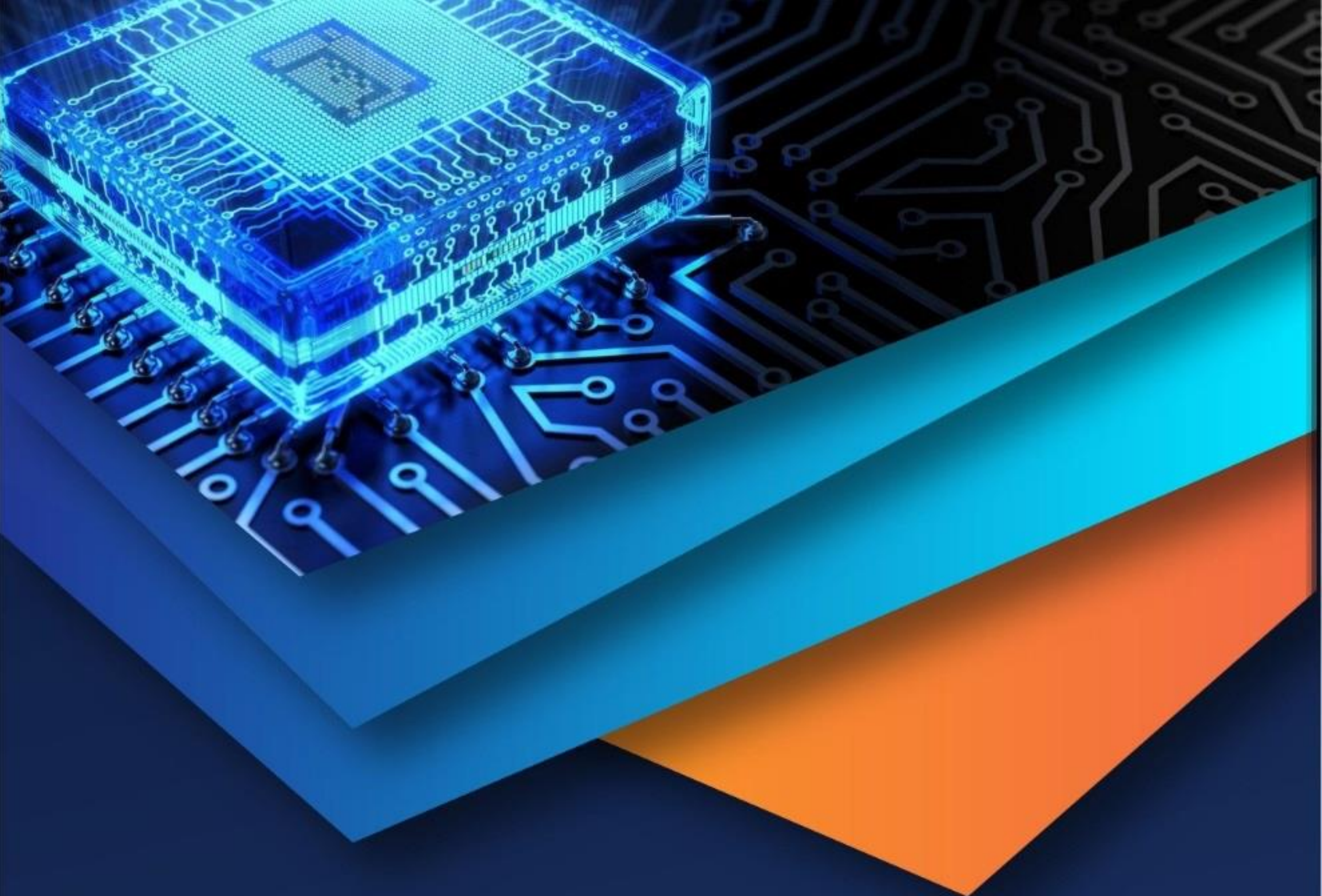
REFERENCES

[1] Gas turbines by V. Ganesan Tata McGraw-Hill Education, 01-Apr-2010
[2] Gas turbine Theory by HIH Saravanmutto Pearson,Fifth Edition-2011
[3] Turbomachinery Design and theory by Rama S.R. Garla , First Edition
[4] en.wikipedia.org
[5] Model Jet Engines (Modeller's World) by Thomas Kamp ,2005 published
[6] Gas Turbine Engines For Model Aircraft by Kurt Schreck ling,2003 reprinted
[7] Prabjot SinghVirdi,Mohammed Saahil Khan, "Design and fabrication of Major components of Turbojet Engine"DOI: 10.5923/j.ep.20170705.02
[8] Onkar patel, Prakash Kumar Sen, " A Review On Turbo Jet Engine", International journal of Mechanical engineering (IIJME), Volume 3, Issue 11, November 2015.
[9] Edwin Cyril, B Shobin Mathew," A Study on Mini Jet Engine", International Journal of Innovative Research in Science, Engineering and Technology.
[10] Dr. Jassin M., Abdulkarim Jaff, " Contribution in Development of Design and Performance of Turbine Jet Engine"Journal of Mechanical and Civil engineering (IOSR-JMCE)



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