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Thermal Properties of Jet Engines Used for Aircrafts: Mini Review

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***Abstract*—** This review paper is about the phenomenon of propulsion systems of Jet Engine. A detailed study has been made up on the gas turbine engines all parts and how that parts works. The effect of applying cooling process and also temperature variation of the chamber using axial and centrifugal stages airflow going the exhaust axially or radially are been studied. There are also some properties described such as- exhaust velocity, thermal conductivity and fuel efficiency.
***Keywords*— Jet engine parts, Chamber Temperature, Exhaust, Fuel Efficiency, Cooling and Burning Process.**

1. INTRODUCTION

Aerospace propulsion systems successfully applied to jet engines, rocket engines, and piston engines. Before applying its combustion pressure increase to improve system efficiency, and also reduce fuel consumption and emissions of CO_2. This injection system is stable and efficient combustion, its required to understand of fluid behavior and any desired conditions [11]. This first powered engine and flight were designed and built by the Wright brothers. After that this powered flight sparked and develop aviation in the world and made a mature industry. In past 100 years, aviation become a symbol of innovation and also many contributed by advance in engines or propulsion system. In this paper theoretically knows about technical advancements of turbofan and turbojet engines in US during the last 60 years. Aviation growth phase 1950 to 1969. When we look back in our aviation history, they provide many brief reviews of gas turbine engine control principle. Now a days maybe it's very helpful for us [12]. In this gas turbine engine, we applied SOFCs (Solid Oxide fuel cells), its work slimier to APU when it uses in heavy-duty trucks. It is the very important facility of the power generation system in the body. SOFC propulsion capacity is more, so it helps electric UAVs (unmanned aerial vehicle) attain more endurance and also high efficiency [3]. In gas turbine engine parts are air inlet, compressor section, diffuser, combustion section, turbine and exhaust [13]. In this paper we also mention fuel efficiency also. Now aircraft fleet are 70% more fuel efficient than 40 years ago [14].

II. LITERATURE REVIEW

Salvatore Corcione et.al (2023) demonstrates an experiment using aero-propulsive effects on a large turboprop aircraft with rear engine installation. This work mainly focused the horizontal tailplane aerodynamics, consequently and the characteristic of aircraft's static stability [1]. J. Schoenmaker et.al (2022) discusses on synthetic jet propulsion using thermal cycle. Perspective of jet propulsion and Thermoacoustic engine verified with Schlieren imaging regarding several relevant parameters as of geometric factors, frequency and power i.e., electromechanically and thermally produced. Use of tapered nozzle shows consistent behavior that of single- flat-screen configuration [2]. M. Rostami et.al (2022) mention about performance, stability and flight endurance. Study determines the use of Solid Oxide Fuel Cell (SOFC) to enhance thrust, low temperature, increases pressure ratio, maximum efficiency for hydrogen & methane fueled system and extra power [3]. Bolam et.al (2020) gives a detail discussion of aircraft electrical propulsion. As electrical motor configuration for aerospace application is to be required for future commercial aircraft design. It also defines the important of high TRV value, high efficiency, efflux velocities, high motor speed and increase in

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specific sustainability [4]. S. Manigandan et.al (2020) used Kay's and Grunberg- Nissan Mixing rule, fuel is being blended with various ratio of additives. Moreover, this enhances fuel effectiveness and less emission of harmful gasses. It can be utilized without physical changes in engine structure [5]. Seyed Jalal Mohammadi et.al (2020) provides references and practical aspects of Aero Engine control designs, with challenging technologies to be adopted by manufacturers [6]. Zifei Ji et.al (2019) demonstrate the Dual Duct Rotating Detonation Aero Turbine Engine (DRDATE) with arrangement of multi annular Rotating Detonation Combustor (RDC) which expands the stable operation range. It attains optimum efficiency, and improves fuel consumption performance. By preventing reverse flow of detonation wave, it increases the compressor stability and exfoliates the erratic characteristics [7]. Tomash P Stankowski et.al (2017) describes the sensitivity of aerodynamic Installation of overall engine parameters. Evaluation of throttle dependent on interference effects by lowering specific thrust shows cycle benefits in specific fuel consumption also leads to aerodynamic advantages [8]. D.Felix Finger et.al (2017) defines design of transitioning vertical take-off and landing (VTOL) aircraft. Also increase the energy of consumption in the take-off and landing phases and conventional wing-fuselage-stabilizer configuration [9]. Sergio CHIESA et.al (2016) studies the installation of a hybrid propulsion aircraft, electric motor and related Propeller. It is being considered as cost reduction in terms of weight, fuel and airport taxes. It is moreover able to recover energy during descent phase which relates general aviation advantages [10].

III. OVERVIEW ON JET ENGINE

The jet engine mainly made of a compressor, a combustion chamber, turbine and an exhaust. When ambient air comes in the compressor through the air intake, then this air compressed to a higher pressure. Then heat is provided in the combustion chamber to increase the ambient air temperature. We can assume that 40% of air is primary air, it used for burning. During the burning another 40% air is secondary air it used for cooling the upper surface and inner valve. And extra 20% for dilution, its used to reduce the temperature, was transferred into the combustor. Fuel and air mixed and burned in this process [13]. In there we used flow meter to measure the fuel consumption [5]. In combustion chamber having some holes its helps to burning and cooling also. If it's not there then for excessive heat this chamber melt. When this air goes through the nozzle and increase the gasses speed [13]. In exhaust we used K-type off thermocouple to measure the exhaust gas temperature, the compressor outlet temperature (COT), and turbine inlet temperature (TIT) [5].

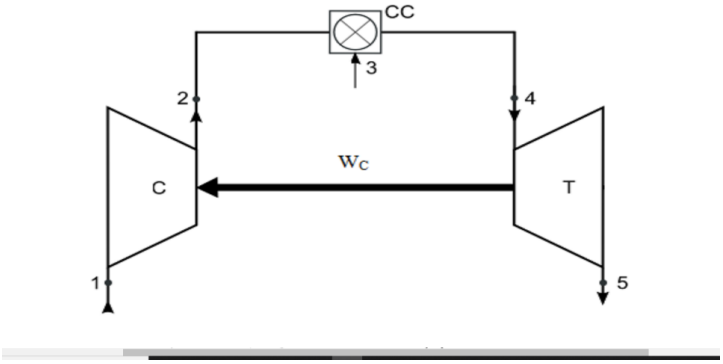

Figure 1. Open gas turbine system [13]

In this process many components of a gas turbine engine and its blades (fan blades, turbine blades, etc.) are mainly important. In this blade each blade having number and blade weight also. These blades help to reduce the air speed for the Swirler effect. This part is the most valuable part of the engine. It generates more thrust force, for more air in engine increase the mass of air flowing and also increase the fan diameter [15]. In gas turbine engine we used different type of stage centrifugal compressor, axial and combination of both (centrifugal and axial). In centrifugal compressor air

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entries axially then compressed and rotate radially and goes bake axially and in axial flow is direct exhaust. One another instrument digital tachometer was attached to the engine shaft for observe the engine RPM.

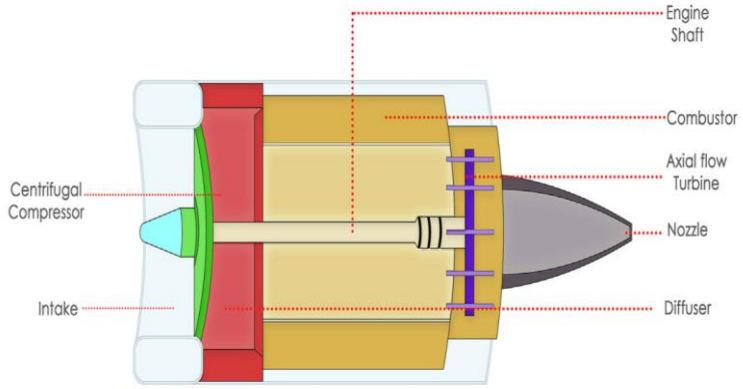

Figure 2. Gas turbine engine flow diagram [5]

We know that this gas turbine engine we used is jet fuel (kerosene) in the jet A, jet A1, jet B. Jet B fuel (gasoline 70% + kerosene 30%) fuel is JP-4, JP-5. But this Jet B fuel is mostly used in low temperature condition [5].

IV. THERMAL PROPERTIES OF JET ENGINE

In this section, we will be discussing about different properties that are relatable for jet engines. Some of major properties based on propulsion configuration are described below.

Chamber Temperature and Pressure - We know jet engine divided in 6 parts- Air intake, compressor, diffuser, combustion chamber, turbine and exhaust. Atmospheric air enters through air intake and its compressed. After that compressed air entire in combustion chamber, in that time velocity up to 500 feet per second, and air speed also increase [18]. Where fuel is sprayed into it, mixture of Oxygen (O_2) and fuel ignited and burned in constant pressure. After that create energy [16] and turns into high pressure & high temperature that pressure and temperature expend to producing more power in the turbine [17]. In combustion chamber having 16 stages combustion chamber (stater & rotor), stater and rotor construction is divergent duct so here pressure increase and velocity decrease. If in chamber air temperature is rise up to 1600 ˚C then turbine blade maybe melt, so we need cooling process [17].

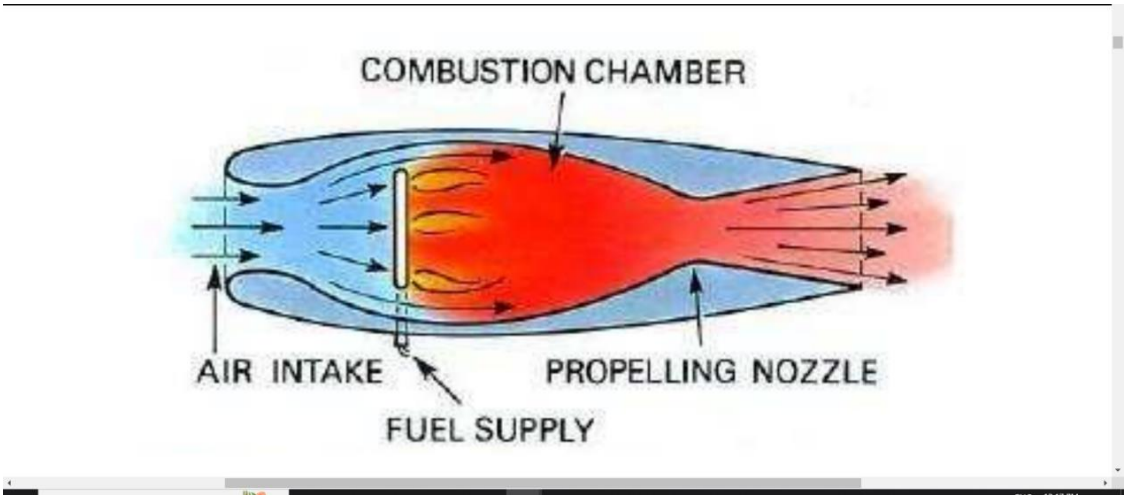

Figure 3. Representation of jet propulsion engine [17]

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Exhaust velocity: Gas turbine engine produce thrust by accelerating mass and throughout in atmosphere through exhaust nozzle. Exhaust assembly is a convergent type, so their velocity increases [20]. The speed of sound then the pressure decreases rapidly [17]. Thermocouple is situated in exhaust panel like rear of all the turbines, then its measurement is called Exhaust Gas Turbine (EGT). So, thermocouple mainly used for measure the different location temperature in the engine. And also measured fuel flow rate, thrust, RPM, and the oil fuel and air pressure. It is measured the temperature in every 120 seconds [21]. Exhaust gas temperature maximum value is 720 deg C (1300 deg F) [23]. Combustion chamber burn the fuel and thrown out in the atmosphere through exhaust panel. And we also used alternative fuels to reducing emission of pollutants, its present in exhaust gasses [22]. When gases exiting from turbine then it's converted to kinetic energy in the exhaust gas panel, in that time exhaust gas flow in high speed. Speed of That gas which is exiting from the exhaust nozzle was calculated as 408.61 m/s [13].

Thermal conductivity: Thermal conductivity is the ability of material to conduct heat. It is divided into two parts High and Low thermal conductivity. Both materials are very essential. High thermal conductor mainly transfers the heat rapidly and also in this material efficiency is very high. If this material used in turbine engine, then this part efficiency is increase then no need cooling system. At the opposite side, low thermal conductivity materials are also crucial. For example, if gas turbine engine blades increase their efficiency and output power, then in low thermal conductivity its needed multifunctional materials and chemical stability to protect the turbine blade at high temperature [24]. This thermal conductivity area most important is smoothness. For help to reducing the conductivity used coatings. Thickness is also important in thermal conductivity [25].

Fuel efficiency: One of the main performances of an aircraft is Fuel efficiency, its help from the financial crisis. Here air transport increases faster more then another transport. In world aircraft use 5.8% oil per day. Before already projected to grow in jet fuel around 38% from 2008 to 2025 [26]. In jet engine primarily used Kerosene fuel. This fuel divided in three parts - JET-A, JET-A1, JET-B, AVGAS 100 LL. If ethanol is added in Jet-A fuel then its burning rate is improved and also enhance the combustion efficiency. If in gas turbine engine RPM is 30000 then it produces thrust 21.2 N, like higher than low heating rate. And also, we increase the engine RPM value like 70000 then Jet-A fuel produce more thrust approx. 42.5 N. So, if gas turbine gas produces more thrust then fuel consumption is reduced. Jet-A fuel is also known as JP-8 [27]. Jet engine fuel must be having low freezing points for jet-A (-40 deg C), jet-A1 (-50 deg C), jet B (-60 deg C) (28). When temperature is very low in that time, we use Jet B fuel. This fuel helps to increase the efficiency and reduced emission [29]. It's another name is JP-4, its freezing point and flash point are very less compared to Jet- A fuel [27].

V. CONCLUSION

In this review, the propulsion of gas turbine engine was briefly discussed, and also observed all parts work of the engine. For example, it was noted that when ambient air after compressed its going for burn, there in between 100% only burn 40% air and another used for cooling purpose. The review also examines the variation of engine temperature, when the chamber temperature cross 1600 ◦C then the turbine blade is melted, for that reason used cooling process. Overall, the review highlighted the importance of some parameters like temperature and pressure variation, exhaust panel in there one more instrument fitted thermocouple, it calculates the engine temperature and another important thing are thermal conductivity and fuel efficiency. The study of the propulsion of gas turbine engine has significantly expanded our understanding of the engine and has the potential to upgrade the engine power, fuel efficiency and also structure which is more helpful in our future generation.

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