GTE Experiment

Regular slots on Monday

Week	Slot	Roll Numbers
5 Aug 2024	3	22B0002, 22b0048
	8	22b0030, 22b0055
	9	22b0074, 22B0054
12 Aug 2024	3	22b0068, 22b0019
	8	22b0001, 22b0039
	9	22B0076, 22b0034
19 Aug 2024	3	22b0003, 22b0021
	8	22b0059, 22b0075
	9	22b0028, 22b0007
26 Aug 2024	3	22b0077,22b4214
	8	22b0047,22b0053
	9	22b0052, 22b0071
2 Sep 2024	3	22b0049, 22b0057
	8	22b0045, 22B0067
	9	22B0015, 22B0035
9 Sep 2024	3	22B0006, 22B0073
	8	22b0069, 22b0042, 22b0041
	9	22b0012, 22B0051
23 Sep 2024	3	22B0004,22b0018
	8	22b0070,22b0032
	9	22b0046,22B0027
30 Sep 2024	3	210010020, 22b0020
	8	22B0040, 22b0063,22b0036
	9	22b0705, 22B0024
07 Oct 2024	3	22b2717,22b0013
	8	22B0672, 22B0043
	9	22b0025,22B2472

TA
3 – Chaturya (10:30-11:30 am)
8,9 – Mahesh (2:00 -4:55 pm)

Additional slots

Date	Slot	Roll Numbers
Aug 6	1	22b0064, 22b4215
Aug 7	7	22B0037, 200010002
Aug 13	1	22b0072, 22b0008

TA
1 – Chaturya (9:30-10:25 am)
7 – Mahesh (7:30-9:25 am)

ENGINE PERFORMANCE ANALYSIS OF GAS-TURBINE
AE 345

Date Performed: August 2, 2024

Objectives

To calculate different performance parameters with the help of data attained by operating a gas turbine engine.

Precautions

- Always follow basic safety precautions when using any laboratory equipment.
- Please remember: Protective hearing protection is required when operating equipment and appropriate footwear must be worn in the laboratory.
- Keep the windows open throughout the experiment.
- Do not operate the engine with any loose items near the engine inlet or exhaust at any time.
- Always stay clear of the engine inlet and exhaust. This applies to the operator and all observers.
- While the engine is running or after shutdown, do not touch its parts as some may be very hot and could cause severe burns.
- Do not try to adjust or override safety devices or controls to operate the engine beyond its limits. Do not operate the system above 74000 rpm.
- Remember, do not switch off the system until it is properly cooled. After taking measurements, return the system to its initial state and only power it off once it has been cooled down and screen shows 0 rpm on GSU.

Theory

Gas turbine engines convert fuel energy into mechanical work or thrust. They are widely used in aviation, power generation, and industry due to their high power-to-weight ratio and efficiency. The engine consists of a compressor, combustor, and turbine, operating on the Brayton cycle.

- Compression: Air is drawn into the engine and compressed by the compressor. This process increases the air's pressure and temperature.
- Combustion: The high-pressure air flows into the combustor, where it is mixed with fuel and ignited, initiating the combustion process that releases energy, significantly raising the temperature and expanding the air-fuel mixture.
- Expansion: The turbine extracts energy from the expanding gases, reducing their pressure and temperature.
- Exhaust and Thrust Generation: The remaining high-velocity exhaust gases are expelled through a nozzle, generating thrust.

Thermodynamic Analysis

The performance of gas turbine engines is evaluated using the principles of thermodynamics. Key performance parameters include (Hill and Peterson 1992):

- Thermal Efficiency: The ratio of useful work output to the heat input from the fuel.
- Specific Fuel Consumption (SFC): The fuel required to produce a unit of thrust or power. Lower SFC indicates higher engine efficiency.

Apparatus

Figure 1: Gas Turbine Engine

Specifications

Data Given:

- Ratio of specific heat of air, $\gamma_{air} = 1.4$;
- Ratio of specific heat of flue gas, $\gamma_{gas} = 1.33$;
- Calorific value, $Q_f = 42580$ kJ/kg;
- Density of air, $\rho_{air} = 1.29$ kg/m^3;
- Area of nozzle, $A_t = 0.00419$ m^2;
- Characteristic gas constant of gas, R = 287 J/kgK;

Methodology

Figure 2: Ground support unit

- Please ensure that precautions are being followed at all times.
- Turn on the Main switch. Turn on the Ground support unit (GSU) (Refer figure 2).

- Increment the RPM (press the INC button continuously 3-4 times) till the GSU display shows ready on the top portion of the GSU display.
- Slide throttle from I to F and back to I immediately, and then the rpm of the gas turbine starts increasing. Wait until the Engine reaches Idle rpm (i.e., the rpm does not increase after a particular rpm but the engine continues to run) ranging from 34000-35500 rpm.
- Once the idle speed is achieved, gradually increase the throttle from I slowly and gradually until a speed of 70000 rpm is reached. Record the readings in the LabView Interface.
- Bring the throttle back to I and wait till it gets back to the idle speed then Press the Decrement button (dec button below the trim value) 3-4 times continuously till the system shows cooling on GSU Display.
- Wait till cooling is completed (0 rpm is read on GSU Display). Only after cooling, turn off the GSU and MAIN switch.

Temperature and pressure readings will be recorded from different points as shown in the figure 3. These readings will be used to calculate the performance parameters of the gas turbine engine.

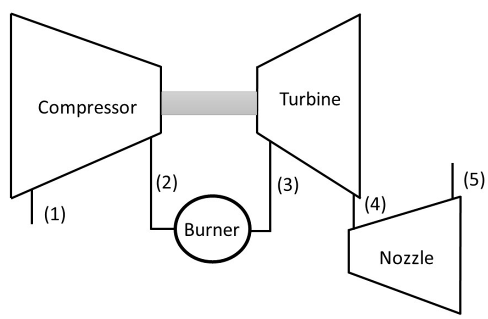

Figure 3: Measurement points

Results to be Calculated *

- Air fuel ratio
- Compressor efficiency
- Heat energy supplied
- Compressor pressure ratio
- Specific fuel combustion
- Thermal efficiency of the engine
- Thrust

*Make reasonable assumptions wherever you need to and indicate it clearly in your report. Compare your results with the experimental result and explain the error if any.

Observations

Sl No.	Time (s)	N (rpm)	h (mm WC)	(V_f) (LPH)	F(N)	$T_a(^0C)$	$T_1(^0C)$	$T_2(^0C)$	$T_3(^0C)$	$T_4(^0C)$	$T_5(^0C)$	P_1 (bar)	P_2 (bar)	P_3 (bar)	P_4 (bar)

Table 1: Observation Table

Calculation

Sl. No.	Time (s)	N (rpm)	m_a (kg/sec)	m_f (kg/sec)	AF	η_c (%)	Q (W)	rp	η_{th} (%)	sfc

Table 2: Calculation Table

Sample Calculation Sl No:

Rotational speed, N (rpm)	=
Head, h (mm WC)	=
Flow rate of the fluid, V (LPH)	=
Force, F (N)	=
Ambient temperature, T_a (°C)	=
Temperature at point 1, T_1 (°C)	=
Temperature at point 2, T_2 (°C)	=
Temperature at point 3, T_3 (°C)	=
Temperature at point 4, T_4 (°C)	=
Temperature at point 5, T_5 (°C)	=
Pressure at point 1, P_1 (bar)	=
Pressure at point 2, P_2 (bar)	=
Pressure at point 3, P_3 (bar)	=
Pressure at point 4, P_4 (bar)	=
Mass flow rate of air, $\dot{m}_a$ (kg/s)	=
Mass flow rate of fuel, $\dot{m}_f$ (kg/s)	=
Specific heat capacity of the fuel, C_{pf} (J/kg),	=
Density of the fuel, ρ_f (kg/m^3)	=
The density of the air, ρ_a (kg/m^3)	=
Specific heat ratio of air, γ_a	=
Specific heat ratio of the gas, γ_g	=
Area of the inlet, A_i (m^2)	=
Characteristic gas constant, R (J/(kg·K))	=
Air to fuel Ratio ($\dot{m}_f/\dot{m}_a$)	=
Compressor pressure Ratio (π_c)=P_2/P_1	=
Isentropic Efficiency of compressor, η_c (%)	=
Heat Energy Supplied (Q_{IN})=$\dot{m}_f$*C_{pf}	=
Specific Fuel Consumption ($\dot{m}_f$/Thrust)	=
Thermal Efficiency, η_t (%)	=

Conclusion

Inference

References

Hill, Philip G and Carl R Peterson (1992). *Mechanics and thermodynamics of propulsion*. Pearson Education.