| UNIVERSITY OF MANSOURA | FIRST TERM | DESIGN OF POWER MACHINES |
| FACULTY OF ENGINEERING | EXAMINATION | 4$^{\underline{th}}$ Year Mech. |
| Dept. of Mech. Power Eng. | 17 January 2012 | Time allowed: THREE hours |

OPEN BOOK EXAMINATION - ANSWER ALL QUESTIONS

QUESTION NO. (1) [20 marks]

A. Explain why the brake mean effective pressure of a naturally aspirated diesel engine is lower than of a naturally aspirated spark ignition engine. Explain why the bmep is lower at the maximum rated power for a given engine than the bmep at the maximum torque. **[5 marks]**

B. The power per unit piston area P/Ap (often called the specific power) is a measure of the designer's success in using the available piston area regardless of size.   Derive an expression for P/Ap in terms of mean effective pressure and mean piston speed for two-stroke and four-stroke engine cycles. **[5 marks]**

C. The diesel system shown in Fig. A consists of a multi cylinder reciprocating diesel engine, a turbocharger (with a compressor C and turbine T_T mechanically connected to each other), an intercooler (I), and a power turbine (T_P) which is geared to the engine drive shaft. The gas and fuel flow paths and the gas states at the numbered points are shown. You can assume that the specific Heat at constant pressure C_p of the gas throughout the entire system is 1.2 KJ / Kg. K and $\gamma = C_P / C_v$ = 1.333. The engine operates at 2000 rev/min. The fuel has a lower heating value of 42 MJ /Kg of fuel. **[10 marks]**

(a) Calculate the power (in Kilowatts) which the turbocharger (T_T) must produce? What is the gas temperature at exit to the turbocharger turbine?

(b) Calculate the power turbine power output?

(c) Find the engine power output, the total system power output, and the total system brake fuel conversion efficiency, if the heat losses in the engine are 15 % of the fuel's chemical energy (m $_f$ Q$_{LHV}$). Friction effects in the engine and power turbine are internal to these devices and don't need to be explicitly evaluated.

(d) Compute the typical maximum value of P/Ap for the engine.
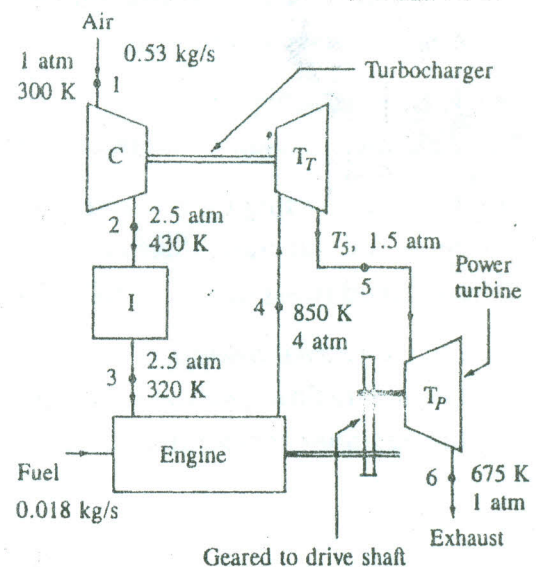
Figure A

QUESTION NO. (2) [10 marks]

A hydraulic cylinder is made of an aluminum alloy of an outside diameter of 80 mm and 10 mm thickness. For an internal pressure of 2 MPa and zero external pressure, calculate the values and locations of both maximum radial and tangential stresses. If this cylinder is made of two shrink fitted cylinders with the same material and the same inner and outer diameters and 5 mm thickness for each cylinder, calculate the maximum internal pressure can be applied for 0.05 mm interference.

QUESTION NO. (3)   [20 marks]

A. Draw neat sketches showing the details of (a) Axial Clutch and (b) Automatic disk brake.   Explain briefly the operating characteristics of each type. **[12 marks]**

B. A band brake is needed to exert a braking torque of 350 N.m on a drum with 254 mm diameter. The actuating force exerted by the operator's foot should not have to exceed 110 N. Limit the maximum contact pressure to 0.404 MPa . The value for f is 0.31± 0.03. **(1)** Make sure the brake will not be self-locking for an f value 30 percent above the maximum value. **(2)** Calculate the bandwidth to limit the contact pressure. **(3)** Find the length for the operating lever. **(4)** For the same actuating force, what is the braking torque if the drum rotation is reversed? **[8 marks]**

QUESTION NO. (4)   [40 marks]

A 2000 cc **four cylinders** four stroke spark ignition engine operates at speed of 5000 r.p.m. and develops a maximum brake power of 85 KW. The compression ratio is 8.2, the cylinder bore is 86 mm, the stroke is 90 mm, and the maximum in-cylinder gas pressure is 3.8 MPa.   Assuming any necessary data, you are required to make detailed design calculations of the following:

a. The piston head thickness, the piston barrel and skirt dimensions, the piston pin diameter, the axial thickness and the radial width of the compression rings. **[8 Marks]**

b. The forces acting on the connecting rod, the resultant stresses, and the connecting rod section dimensions. Assume that the maximum combined stress occurs at 30° crank angle. **[12 Marks]**

c. The forces acting on the crank shaft, the resultant stresses, and the dimensions of crank arm, crank pin, and crank shaft journal. Consider the case of side crank and assume that the maximum combined stress occurs at $30°$ crank angle. **[12 Marks]**

d. For the journal bearing of this crank shaft, find the minimum oil film thickness, the power loss, the oil side flow, and the maximum film pressure for 0.04 mm clearance and SAE 30 lubricant and the operating temperature is 60 °C. **[8 Marks]**

GOOD LUCK

Dr. Hamdi Abdel-Salam