Program: B. Sc. (ME) / B. Sc. (IPE)/ B. Sc. (TE)
Semester: 8th /8th/4th

Date: 15 May 2024 (Wednesday)
Time: 10:00 am – 1:00 pm

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)
ORGANISATION OF ISLAMIC COOPERATION (OIC)
DEPARTMENT OF MECHANICAL AND PRODUCTION ENGINEERING

Final Semester Examination
Course Number: IPE 4821
Course Title: Machine Tools

Summer Semester: 2022 – 2023
Full Marks: 150
Time: 3 Hours

There are **six** questions. Answer **all the** questions. The symbols have their usual meanings. Marks of each question are mentioned with the questions and corresponding CO and PO, and the total marks are written on the right side. Data tables and some formulas (not all) are provided at the end of the question. Assume reasonable values of missing data.

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1. a) State the features of a DNC machine and explain the working principle of the DNC machine with a schematic diagram. — 10+5+10 (CO1) (PO1)

   b) Differentiate between NC and CNC machines.

   c) i. State the advantages and disadvantages associated with gear-shaping technology.
   ii. Illustrate the mechanism of the horizontal hobbing machine.

2. a) Explain the resultant cutting motion in cylindrical turning. Use necessary illustrations and equations to represent it. — 8+5+12 (CO1) (PO1)

   b) Illustrate traverse grinding and plunge grinding and mention the direction of rotation of grinding wheel, worktable rotation, reciprocation of worktable and infeed.

   c) i. Define and classify different methods of machine tool maintenance.
   ii. Discuss the importance of preventive maintenance in ensuring the reliability and longevity of machine tools. How does preventive maintenance contribute to minimizing unplanned downtime, improving production efficiency, and reducing overall production costs in a manufacturing environment?

3. a) i. Suppose an operator of a machine tool having a hydraulic transmission system. During the operation, the fluid line experienced a sudden surge in pressure level and exploded. This resulted in production downtime and overall economic loss. Analyzing the cause of the accident, identify the component that was missing from the fluid line that may have prevented the — 15+10 (CO3) (PO3)

incident. Explain the working principle of the component in short through an illustration of a simple figure.

ii. Classify the pump based on displacement. Identify the type used in the hydraulic transmission of machine tools. Provide one example through illustration along with the working principle in short.

b) i. List different elementary transmission systems that transfer rotary motion in the mechanical transmission system of machine tools. Among them identify the transmission method most suitable for precise speed control. Justify your point of view.

ii. How can the issue of axial thrust in helical gears be effectively mitigated or resolved, considering the gear's inherent design characteristics? Justify the answer with simple force analysis.

4. A design specification of a machine tool shows that it will operate under variable loading conditions. The expected load variation based on process analysis is shown in Figure 1. The overall efficiency of the transmission system is 85.6%. A load variation graph of the system is provided in Figure 1. The machine tool utilizes a gearbox to generate different spindle speeds. The minimum spindle speed of the system is 50 RPM. The gearbox has a range ratio of 12. The gearbox is designed using a geometric progression step ratio of φ_{10}. The motor driving the gearbox has a torque of 127.528 N-m and is connected with the input shaft via a flat belt drive which generates a speed reduction of 2:1. 25 (CO3) (PO3) (K1, K3,K5)

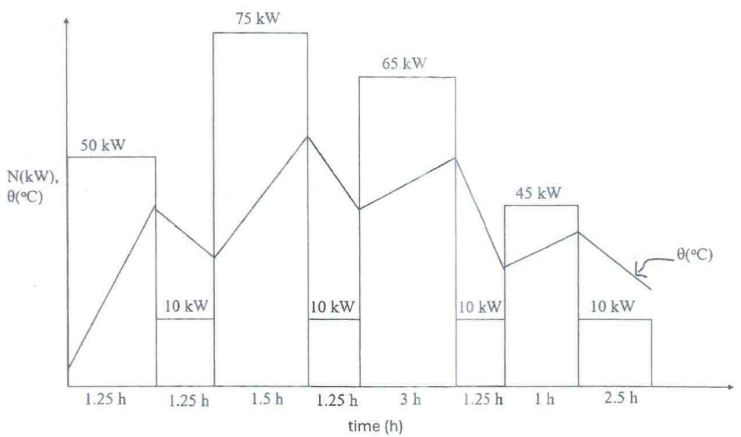

Figure 1: Variable Loading Condition of Designed Machine Tool of question 4(a).

Determine/answer the following parameters/tasks:

a) Power rating of the motor.
b) Maximum RPM of the motor and input shaft speed of the gearbox.
c) Maximum spindle speed provided by the gearbox.
d) Total number of speed steps of the gearbox.

e) Find the structural formula and total number of gears in the gearbox if the second stage has 3-speed steps.
f) Based on the structural formula develop the speed diagram.
g) Design the simplified kinematic/gearing diagram of the gearbox showing the motor and spindle connections.

5. a) i. Identify the locator that is used as side stops under light side loads of shallow parts and illustrate how it is used as side stop using one simple figure. 12+13 (CO2) (PO1)

ii. Explain the principle that ensures a minimum number of locating points in three mutually perpendicular planes through the illustration of simple figures. Discuss how 9 out of 12 degrees of freedom are restricted through this principle.

iii. Explain the measures that can be implemented to secure the remaining degrees of freedom of a workpiece following its initial locating.

b) State the four key requirements of clamping. "In a strap clamp the distance between fastener and workpiece should always be less than that between the fastener and heel pin." Justify the above statement with proper reasoning and illustrations.

6. a) Explain different types of loads and motions associated with bearings and State the requirements of bearing while designing machine tools. 10+7+8 (CO2) (PO1)

b) Illustrate different parts of a bearing used in conveyor belts which can withstand very high radial loads.

c) Differentiate between jigs and fixtures and state the advantages and purposes of jigs and fixtures.

Tables and Some Formulas

ϕ_{40}	= R =	$\sqrt[40]{10}$	= 1.06
ϕ_{20}	= R =	$\sqrt[20]{10}$	= 1.12
ϕ_{10}	= R =	$\sqrt[10]{10}$	= 1.26
$\phi_{20/3}$	= R =	$\sqrt[20/3]{10}$	= 1.41
ϕ_{5}	= R =	$\sqrt[5]{10}$	= 1.58
ϕ_{4}	= R =	$\sqrt[4]{10}$	= 1.78
$\phi_{10/3}$	= R =	$\sqrt[10/3]{10}$	= 2.0

Preferred Number Series of Geometric Progresison

$$N_{eq} = \frac{1}{\eta}\sqrt{\sum_{i=1}^{n}\frac{N_i^2 t_i}{t_c}}$$

Equivalent Power Rating based on the consideration of heating.

N_{eq} = equivalent power rating
N_i = power required for ith sequence of the variable loading cycle
t_i = duration of the ith sequence of the variable loading cycle
t_c = cycle time
n = total number of sequences in the cycle
η = coefficient of efficiency of the drive

$$N_m = \frac{N_{max}}{\eta \cdot \lambda}$$

Equivalent Power Rating based on the consideration of overloading.

N_{max} = maximum power required in the whole cycle (N_1, in the example of Fig. 1.18)
λ = permissible overloading coefficient for the given type of motor
η = coefficient of efficiency of the drive

Active time ratio (cutting time: total time)

$$\varepsilon_a = \frac{t_c}{t_c + t_i}$$

Generally, standard motors are manufactured for ε values of 15, 25, 40, and 60%.

$$N_m = \frac{1}{\eta} N_a \sqrt{\frac{\varepsilon_a}{\varepsilon_{st}}}$$

Power rating based on active time ratio.

where $N_a = N_{eq}/\sqrt{\varepsilon_a}$; N_{eq} being the equivalent power rating calculated for the given cycle from the consideration of heating as discussed above.

$$N_m = \frac{N_c}{\eta}\ \text{kW}$$

where N_m = power rating of the electric motor, kW
N_c = total power required for removing metal, kW
η = coefficient of efficiency of the drive

$$N_c = \frac{P_z \cdot v}{60 \times 75 \times 1.36} + \frac{P_y \cdot s_y \cdot n}{60 \times 75 \times 1.36 \times 1000} + \frac{P_x \cdot s_x \cdot n}{60 \times 75 \times 1.36 \times 1000}\ \text{kW}$$

$$P = T\frac{2\pi N}{60}$$

Where,
P = Power Rating of Motor, W
T = Torque Generated in Motor, N-m
N = Maximum RPM of the Motor

Table 1.1 *Values of coefficient of efficiency for various transmission and supports*[1]

Type of Transmission or Support	*Coefficient of Efficiency*
Belt drive with flat belt	0.98
Belt drive with V-belt	0.96
Spur gear drive	0.98
Helical gear drive	0.97
Bevel gear drive	0.96
Ball or roller bearing	0.995
Crank and slider mechanism	0.90
Jaw clutch	0.95
Multiple-disc friction clutch operating in oil	0.90