QUESTION BANK

EE6351- ELECTRICAL DRIVES AND CONTROLS

UNIT – I INTRODUCTION

1).What is an electrical drives?

A drive consists of various system combined together for the purpose of motion control or movement control. Especially the drives which employ electric motors for motion control are known as Electrical drives.

2).List the elements of an electric drive system.

- Group drive
- Individual drive
- Multimotor drive

3).State the some of the advantage of an electric drive system

- Control characteristic can be manipulated as per requirements
- Availability of simple and easy speed control methods
- Electric braking can be employed in easy manner
- The operation is pollution free
- The variety of electric drives with wide range of speed, power and torque ratings are available.
- The efficiency is higher as no load losses are less.
- They have short time overload capacity.

4).List the factors affecting the selection of electric drives.

Efficiency, Braking, Limits of speed range, starting requirements, power factor, load factor, availability of supply, effects of supply variations, economical aspects, reliability of operation, environmental effects.

5).State the selection of motor based on load variation

- Continuous or constant loads
- Continuous variable loads
- Pulsating loads
- Impact loads
- Short time loads

6).State the various classes of duty

- Continuous duty
- Continuous duty, variable loads
- Short time loads
- Intermittent periodic duty
- Intermittent periodic duty with starting
- Intermittent periodic duty with starting and braking

7).What are the elements of an electric drive system?
Electrical motors and load
Power modulator
Source
Control unit
Sensing unit

8).List the types of electrical drives?
DC drives
AC drives

9).Mention the application of electrical drives?
Paper mills
Electric traction
Cement mills
Steel mills

10).Define cooling time constant?

It is defined as the ratio between C and A. cooling time constant is denoted as ‘ ’

= C/A

Where C= amount of heat required to raise the temperature of the motor boby by 1 degree Celsius in / c

A= amount of heat dissipated by the motor per unit time per degree Celsius in J/S c

11).What are the three methods of operation for electrics drive?
Steady state
Acceleration including starting
Deceleration including stopping

12).Define four – quadrant operation?

A motor operate in two modes and braking. In motoring, it converts electrical energy into mechanical energy, which support its motion. In braking it works as a generator converting mathematical energy into electrical energy and thus, opposes the motion. Motor can provide motoring and braking operations for both forward and reverse directions.

13).Compare a.c. and d.c. drives.
S.No
DC Drives
AC Drives

14) Mention the necessity of power rating?

Power rating of electric drives for particular operation is important since, following reasons.

1.To get economy with realiability

2.To obtain the maximum efficiency on their full load without any damaging.

15).what is duty factor?

The ratio of ON time(Ton) of the drive to total time period(Ton +Toff) is called duty factor.

16) What is cooling curve?

When a machine is switched off from the mains or when the load on the motor is reduced, the machine cools. The curve obtained temperature drop Vs time when the drive is switched off or load on the drive is removed.

BIG QUESTIONS

1).What is electric drive? Explain the basic elements of an electric drive system.

2).Explain the classification of electric drives.

3).Explain the various classes of duty. How it affect the selection of rating of a motor for the drive?

4).Draw a typical temperature rise –time curve and derive equation for temperature rise in an electric drive

5).Write a note on cooling curve of an electric derives, stating its expression.

6) cooling curves problems

UNIT-I

Part - B

① Define electric drive & describe the classification of drive

System employed for motion control are called "Drives" and many employ any of prime mover [engines (or) motor] for supply mechanical energy for motion control. Drives employing electric motor are known as "Electrical drives".

Classification.

They are three types of industrial drives.

(i) group drive

(ii) individual drive

(iii) multimotor drive

Group - drive

It consists of a single motor which drives group of machines (or) mechanism may be operated. - It is also called shaft drive.

Advantage

- A single large motor can be used insted of a number of small motors.
- increasing efficieny & Power factor.

Dis advantage

- No Flexibility
- Addition of an extra machine to main shaft is difficult.
- any one machine are not working, losses are increased, efficieny & Power factor decreased.

Individual drive

- each individual machine is driven by a separate motor.

Ex - single spindle drilling machines, lathes

Dis advantage

- losses are increased.
- efficiency decreased.

Multimotor drive.

A group of electric motor that are interconnected by a common control system

Ex rolling mill, Paper making machines

2 Discuss in detail the various factor which affect the selection of electrical drive. For

(i) Steady state operation requirement.

Speed - torque characteristics

(Ex) Speed regulation

Speed range

efficiency

duty cycle.

(ii) Transient operation requirements

acceleration & deceleration.

starting, braking & reversing.

(iii) Requirements related to source

Type of source

magnitude

Power factor

(iv) capital & running cost, maintenance

(v) space & weight restriction.

(vi) Environment & location.

(vii) Reliability.

(3) Explain Heating & Cooling of an electric motor.

Heating curve

let us assume

The machine is considered as homogeneous body

- No heat is radiated
- rate of dissipation of heat is constant for all conditions.

let us assume

heat developed is proportional to the losses, we have the standard balance equation.

Total heat Generated = heat dissipated to surround medium + Heat stored in body

$$W\,dt = A\lambda\theta\,dt + ms\,d\theta$$

$$w\,dt - A\lambda\theta\,dt = Gs\,d\theta.$$

$$\frac{dt}{\frac{Gs}{A\lambda}} = \frac{d\theta}{\frac{w}{A\lambda} - \theta} \quad \text{— (2)}$$

Temperature rise reaches its maximum value then the body is said to have reached the maxi temp rise θm.

$\therefore$ (1) becomes

Generated heat = heat dissipated

$$w\,dt = A\lambda\,\theta m\,dt.$$

$$\theta m = \frac{w}{A\lambda} \quad \text{— (3)}$$

(3) in (2)

$$\frac{dt}{\frac{Gs}{A\lambda}} = \frac{d\theta}{\theta m - \theta}$$

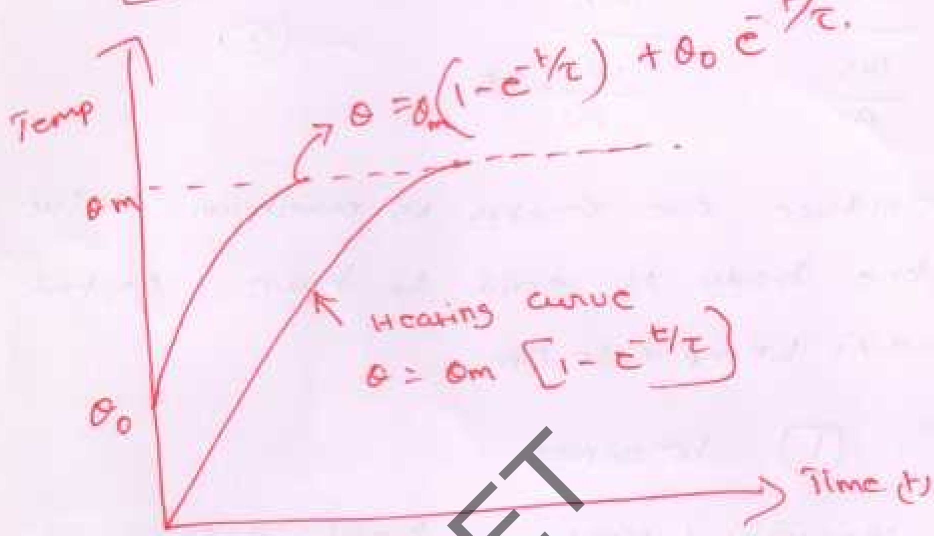
$$\theta = \theta m - (\theta m - \theta_0)\,e^{-\left(\frac{A\lambda}{Gs}\right)t} \quad \left[\frac{Gs}{A\lambda} = \tau\right]$$

$$\boxed{\theta = \theta m\left\{1 - e^{-t/\tau}\right\} + \theta_0 e^{-t/\tau}}$$

a) motor starts from cold condition.

$\theta_0 = 0°C$.

$$\theta = \theta_m \left[1 - e^{-t/\tau}\right]$$



Heating Curve

Cooling Curve

If the machine is switched off from main supply (or) when load on machine is reduced. the machine cools.

Heat generated in body	+	Heat stored in body	=	Heat dissipated to surrounding medium.

$$w\,dt + v s\,d\theta = A \lambda \theta\,dt.$$

$$\frac{ms}{A\lambda'} d\theta = \left[\theta - \frac{w}{A\lambda'}\right] dt \quad -2$$

$d\theta \rightarrow$ temperature decrease. $(-)$

$$\frac{-ms}{A\lambda'} d\theta = \left(\theta - \frac{w}{A\lambda'}\right) dt.$$

$$\frac{-d\theta}{\left[\theta - \frac{w}{A\lambda'}\right]} = \frac{dt}{\left(\frac{ms}{A\lambda'}\right)} \quad -3$$

Final temperature is reached θ_f is

heat generated = heat dissipated.

$$w\,dt = A\lambda' \theta_f\, dt$$

$$\theta_f = \frac{w}{A\lambda'} \quad -(4)$$

(4) in (3)

$$\frac{-d\theta}{\theta - \theta_f} = \frac{dt}{\left(\frac{ms}{A\lambda'}\right)}$$

$$\ln(\theta - \theta_f) = -\frac{A\lambda'}{ms} t + k_1.$$

At $t = 0$ $\theta = \theta m$

$$\ln(\theta_m - \theta_f) = K_1 \quad -⑥$$

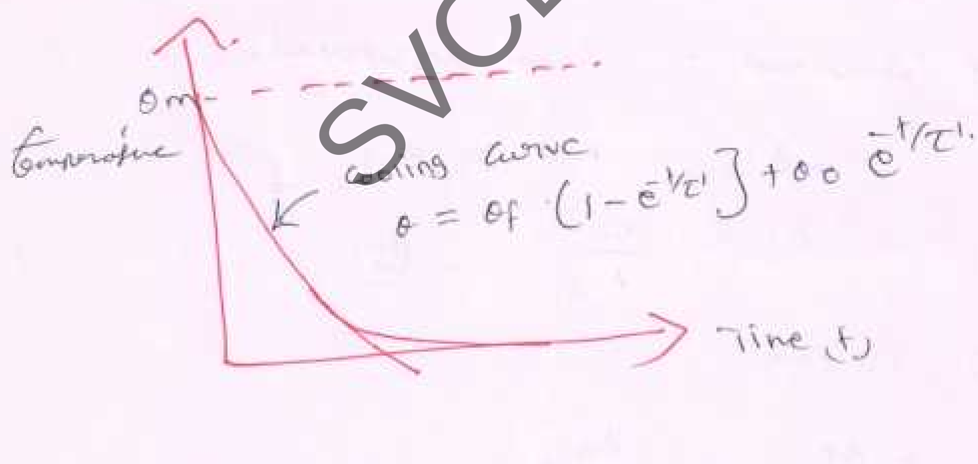
⑥ in ⑤

$$\theta - \theta_f = (\theta_m - \theta_f)\, e^{-\frac{A\lambda'}{ms} t}$$

$$\frac{ms}{A\lambda'} = \tau'$$

$$\theta = \theta_f + (\theta_m - \theta_f)\, e^{-t/\tau'}$$ → load is reduced

$$\theta = \theta_m\, e^{-\frac{t}{\tau'}}$$ → machine is switched off.



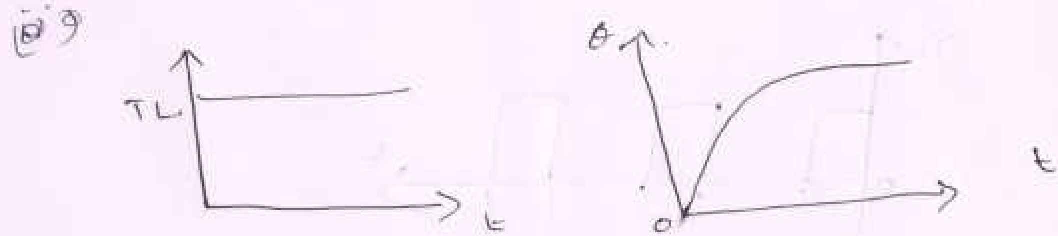
(4) Explain different classes of motor duty.

(i) continuous duty
(ii) short time duty
(iii) Intermittent periodic duty
(iv) intermittent periodic with starting
(v) " " " " & braking
(vi) continuous duty with intermittent periodic loading
(vii) continuous duty with starting & braking
(viii) continuous duty with periodic speed changes.

(i) Continuous Duty

It denotes the motor operation at a constant load torque for long duration [The motor temperature to reach steady state value]

Ex: papermill, compressor, fans & conveyers

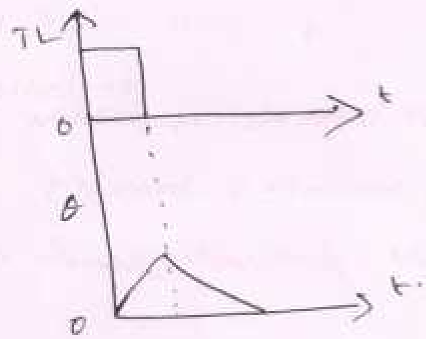


(ii) Short time duty

This operation is less than the heating time constant. and machine is allowed to

means surrounding
Cool off to ambient temperature before the motor is operate again.

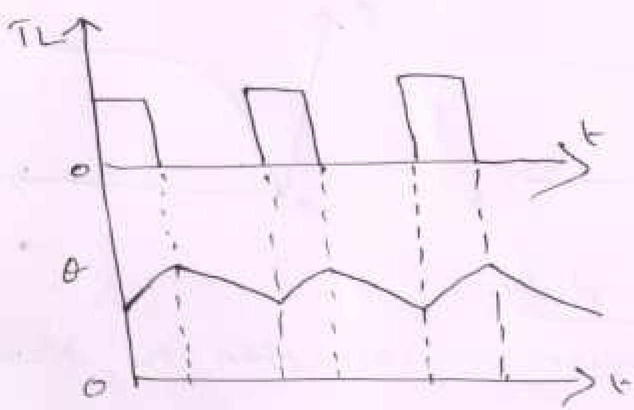
Ex
crane, turning bridge, valve drives



3 Intermittent Periodic Duty

This duty consist of running of a constant load and a rest period.

- on period → Temperature reachs to steady state value
- Off period → To cool off to ambient temperature

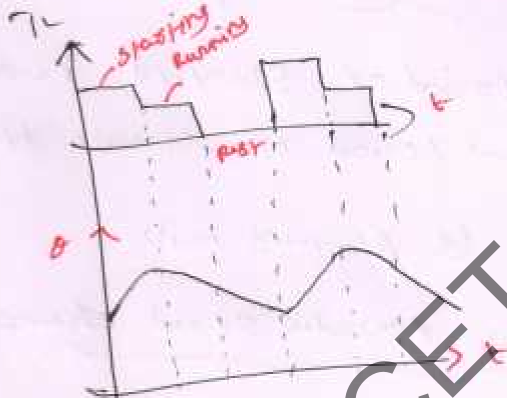


Ex pressing cutting & drilling

4 Intermittent period duty with starting

It consist of a period of starting, a period of running (constant load) and a rest period. [during starting & braking → heat loss is ignored]

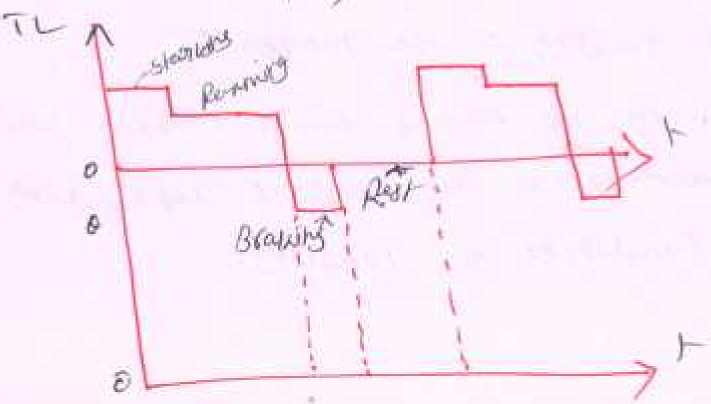
Ex
metal cutting, drilling tool drives.



5 Intermittent periodic duty with starting & braking

It consist of a period of starting, a period of operation with a constant load, a braking (electric) & rest period.

Ex
mine hoist, electric trains



6 Continuous Duty with intermittent Periodic loading

This cycle consist of a period of running at constant load ; a period of running at no load.,

Ex cutting , drilling

7 Continuous duty with starting & braking

It consist of a period of starting, running at constant load and period of electric braking. (no rest period) Ex Blooming mill

(8) Continuous Duty with Periodic speed changes

It consist of period of running at one load & speed and another period running at different speed and load

(5) Explain the Selection of motor Power rating.

- horse power rating of a motor to drive a particular load is selected on the basis of thermal loading of the motor.
- capacity of motor must match the requirement of the load & depending upon the condition of loading.

The proper selection of motor power rating is important from the point of view of economy & maintenance.

(i) Continuous duty load.

The selection of motor power rating is simple, particularly if the magnitude of load is also constant.

kW rating of motor can be found.

$$P = \frac{NT}{975} \eta \text{ kW}$$

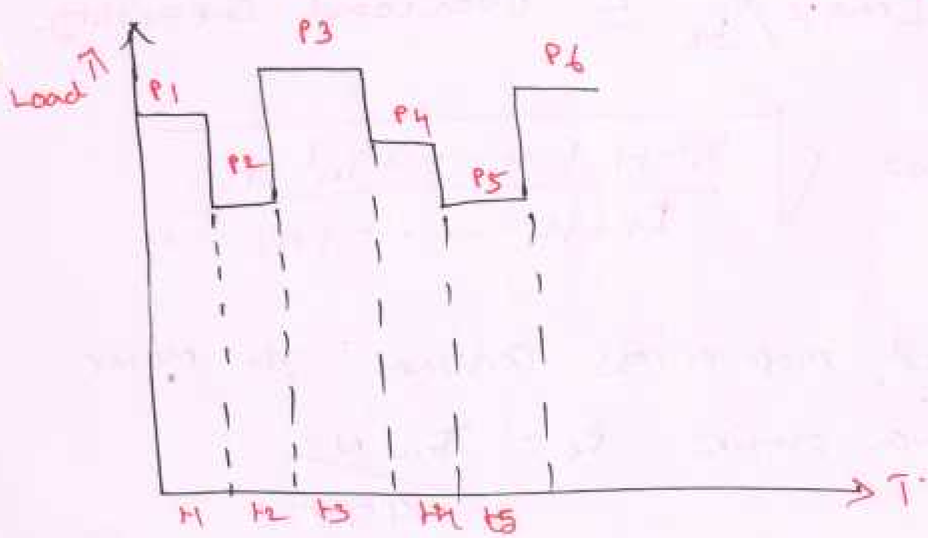
If the motor is to drive a fan.

$$P = \frac{Qh}{102\eta} \text{ kW}$$

Q - volume

h - pressure

η - efficiency



For the motor with variable loading for calculation of average losses W_{av}.

$$W_{av} = \frac{W_{L1} t_1 + W_{L2} t_2 + \cdots + W_{Ln} t_n}{t_1 + t_2 + \cdots + t_n}$$

For selection of motor rating the average current that will produce the same losses as variable current during different load condition as follows

$$I_{eq}^2 = \frac{I_1^2 t_1 + I_2^2 t_2 + \cdots + I_n^2 t_n}{t_1 + t_2 + \cdots + t_n}$$

$$I_{max} / I_r \leq \text{overload capability.}$$

$$T_{eq} = \sqrt{\frac{T_1^2 t_1 + \cdots + T_n^2 t_n}{t_1 + t_2 + \cdots + t_n}}$$

Speed more or less constant. The motor power rating $P_r = \frac{T_{eq} N}{975}$

equivalent power

$$P_{eq} = \sqrt{\frac{P_1^2 t_1 + \cdots P_n^2 t_n}{t_1 + \cdots + t_n}}$$

rated power of motor

$$P_r = (1.1 \text{ to } 1.3) * P_{eq}$$

Short time duty load

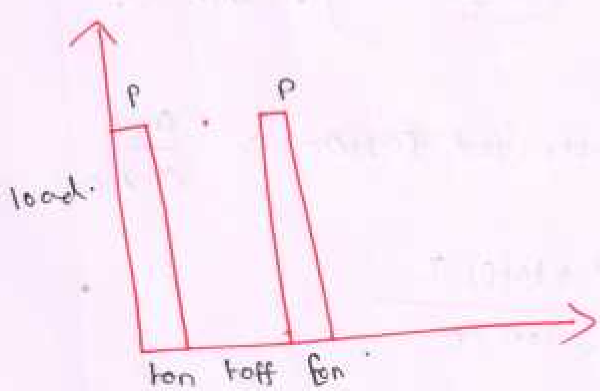
→ machine operated at short time only such motor small power rating may be selected.

temperature rise

$$\theta = \theta_m \left(1 - e^{-t/\tau}\right) + \theta_0 e^{-t/\tau}$$

$$\theta_0 = 0$$

$$\theta_m = \theta_m \left(1 - e^{-t/\tau}\right)$$



$$\theta_{op} = \theta_m' \left(1 - e^{-t/\tau}\right)$$

$$P_n = \frac{\theta_m'}{\theta_{op}} = \frac{1}{1 - e^{-t/\tau}}$$

$$P_m = \sqrt{P_n}$$

Intermittent duty load.

certain load are run for small period & off for small period.

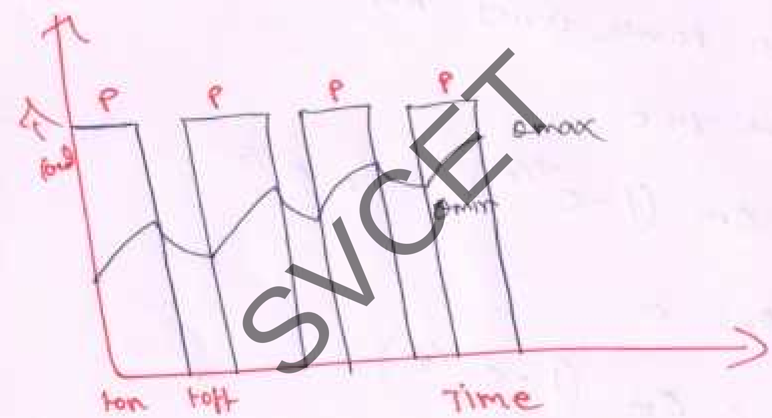
duration ON -> constant load P is applied.

off -> switched off.

motor temperature rise (fluctuate) θ_{max} to θ_{min}.

$$\theta_{max} = \theta_m \left(1 - e^{-t/\tau}\right) + \theta_{min}\, e^{-t/\tau}$$

$$\theta_{min} = \theta_{max}\, e^{-t/\tau'}$$



$$\theta_{max} = \left\{1 - e^{-\left(\frac{t_{on} + t_{off}}{\tau}\right)}\right\} \rightarrow \theta_m \left(1 - e^{t_{on}/\tau}\right)$$

(P_h) heating overload ration -> $\frac{\theta_m}{\theta_{max}}$

$$P_h = \frac{1 - e^{(t_{on} + t_{off})\,\tau}}{1 - e^{-t_{on}/\tau}}$$

$P_m = \sqrt{P_h}$ -> mechanical overload ratio