SNS COLLEGE OF TECHNOLOGY

(An Autonomous Institution)

COIMBATORE-35

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DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

COURSE NAME: 23EEB210 / Electrical Machines and Drives

II YEAR / IV SEMESTER

Unit I – OVERVIEW OF ELECTRICAL DRIVE

Topic : HEATING AND COOLING CURVES

HEATING AND COOLING CURVES

- A machine can be considered as a homogeneous body developing heat internally at uniform rate and dissipating heat proportionately to its temperature rise,

RELATION SHIP BETWEEN TEMPERATURE RISE AND TIME

let

P =heat developed, joules/sec or watts
G =weight of active parts of machine, kg
h =specific heat per kg per deg cell
S = cooling surface, m2
λ = specific heat dissipation (or) emissivity, J per sec per m^2 of Surface per deg cell difference between surface and ambient cooling medium
θ = temperature rise, deg cell
θ_m =final steady temperature rise, deg cell
t =time, sec
τ =heating time constant, seconds
τ' =cooling time constant, seconds

HEATING AND COOLING CURVES

Assume that a machine attains a temperature rise after the lapse of time t seconds.

In an element of time "dt" a small temperature rise "d" takes place.

Then,

Heat developed = p.dt

Heat developed = Gh.d*q*

Heat dissipated = *Sql*. dt

Therefore, total heat developed=heat stored + heat dissipated

HEATING AND COOLING CURVES

$$Ghd\theta + S\theta\lambda.dt = p.dt$$

$$\frac{d\theta}{dt} + \theta.\frac{s\lambda}{Gh} = \frac{p}{Gh}$$

This is a differential equation and solution of this equation is,

$$\theta = \frac{p}{s\lambda} + ke^{-(s\lambda/Gh)t}$$

Where k is a constant of integration determined by initial conditions. Let the initial temperature rise to be zero at t=0.

$$\text{Then, } 0 = \frac{p}{s\lambda} + k$$

$$k = \frac{-p}{s\lambda}$$

HEATING AND COOLING CURVES

Hence, $\theta = \frac{p}{s\lambda}(1 - e^{-(\frac{s\lambda}{Gh}t)})$ -------------- (1)

When t= ∞ , $\theta = \frac{p}{s\lambda} = \theta_m$, the final steady temperature rise.

Represent $\frac{p}{s\lambda} = \theta_m$ and $\frac{Gh}{s\lambda} = \tau$ --------------(2)

Equation 1 can be written as

$$\theta = \theta_m(1 - e^{-1})$$ -------------(3)

Where is called as heating time constant and it has the dimensions of time.

HEATING AND COOLING CURVES

Heating time constant

Heating time constant is defined as the time taken by the machine to attain 0.623 of its final steady temperature rise.

When t= τ ,

$$\theta = \theta_m (1 - e^{-1})$$
$$\theta = 0.632 \theta_m$$

The heating time constant of the machine is the index of time taken by the machine to attain its final steady temperature rise.

We know that $\tau = \frac{Gh}{s\lambda}$, therefore, the time constant is inversely proportional to has a larger value for ventilated machines and thus the value of their heating time constant is small.

The value of heating time constant is larger for poorly ventilated machines with large or totally enclosed machines, the heating time constant may reach several hours or even days.

HEATING AND COOLING CURVES

When a hot body is cooling due to reduction of the losses developed in it, the temperature time curve is again an exponential function

$$\theta = \theta f + (\theta_i - \theta f)e^{-\frac{t}{\tau}} \quad \text{- - - - - - - - - - - - - - (4)}$$

Where,

θf =final temperature drop (the temperature at which whatever heat is generated is dissipated)

$\frac{p}{s\lambda'}$ = where, λ is rate of heat dissipation while cooling

θ_i = the temperature rise above ambient in the body at time t=0

τ' = cooling time constant= $\frac{Gh}{s\lambda'}$

If motor where disconnected from supply during cooling, there would be no losses taking place and hence, final temperature reached will be the ambient temperature.

There fore, θf =0 and hence equation (4) becomes

$$\theta = \theta_i e^{\frac{1}{\tau'}}$$

HEATING AND COOLING CURVES

Cooling time constant

At $t = \tau' , \theta = 0.368\theta_i$

Cooling time constant is, therefore, defined as the time required cooling the machine down to 0.368 times the initial temperature rise above ambient temperature.

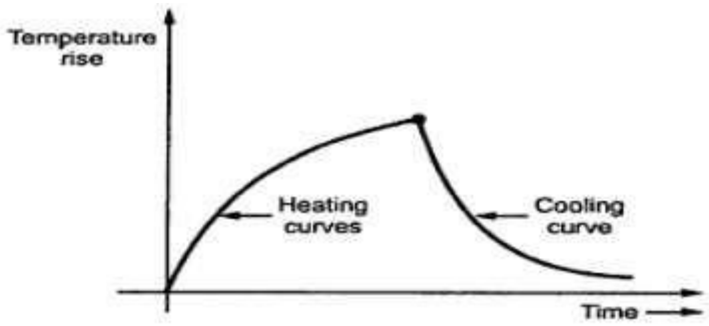

Fig.1.2 Heating and cooling time curves

KEEP
LEARNING.

Thank u

SEE YOU IN NEXT CLASS