PSE2

1205, Labelle Street,
Montreal, Quebec H2L 4C1
CANADA
Tel. : 514-664-2048
Fax : 438-320-0496
www.pse2.ca

Induction motor : Cooling time

Cooling status is referred to the condition defined by a motor temperature reduction caused by a decreasing current from running condition to a less than the Full Load Amps (FLA) condition known as minimum running condition. The cooling status is also initiated by a stopped motor following a running condition.

Motor thermal status, also referred as motor thermal capacity is a parameter used to evaluate the thermal condition of the motor.

Thermal status is measured in percentage of the motor thermal limit. When a motor is stopped for a long time, the thermal status is 0% which means that zero percent of its capacity is used. At motor starting, the thermal capacity used can reach let's said 40%. If the motor has two cold starts, then the thermal capacity after these actions would be 80%. Exceeding the thermal capacity of the motor produces a loss of insulation life due to deterioration by overheating the windings.

During the cooling time, the thermal status decreases from a higher running thermal status to a lower one.

The equation of the cooling motor is given by:

$$\theta_{actual} = \theta_{final} + \left(\theta_{initial} - \theta_{final}\right)e^{-t/\tau}$$

where :

$\theta_{initial}$: Thermal status at the start of the cooling period (t= *0*) in percent

θ_{final} : Thermal status at the end of the cooling period ($t \rightarrow \infty$) in percent

θ_{actual}: Thermal status after time t in percent

t : Time in seconds

τ : Cooling time constant in seconds

1205, Labelle Street,
Montreal, Quebec H2L 4C1
CANADA
Tel. : 514-664-2048
Fax : 438-320-0496
www.pse2.ca

Thermal status is proportional to I squared and the equation can be expressed in the following form:

$$I^2_{(t)} = I^2_f + \left(I^2_0 - I^2_f\right)e^{-t/\tau}$$

where :

I^2_0: Motor current squared at the start of the cooling period (*t= 0*) in per unit (pu)

I^2_f : Motor current squared at the end of the cooling period ($t \rightarrow \infty$) in pu

$I^2_{(t)}$: Motor current squared after time *t* in pu

t : Time in seconds

τ : Cooling time constant in seconds

Example :

A motor with a cooling time constant of 3.5 hours is stopped with a thermal status of 90%. Calculate the time required to reach 40% motor status.

Replacing the data in the first equation gives:

$$40 = 0 + (90 - 0)e^{-t/12600}$$

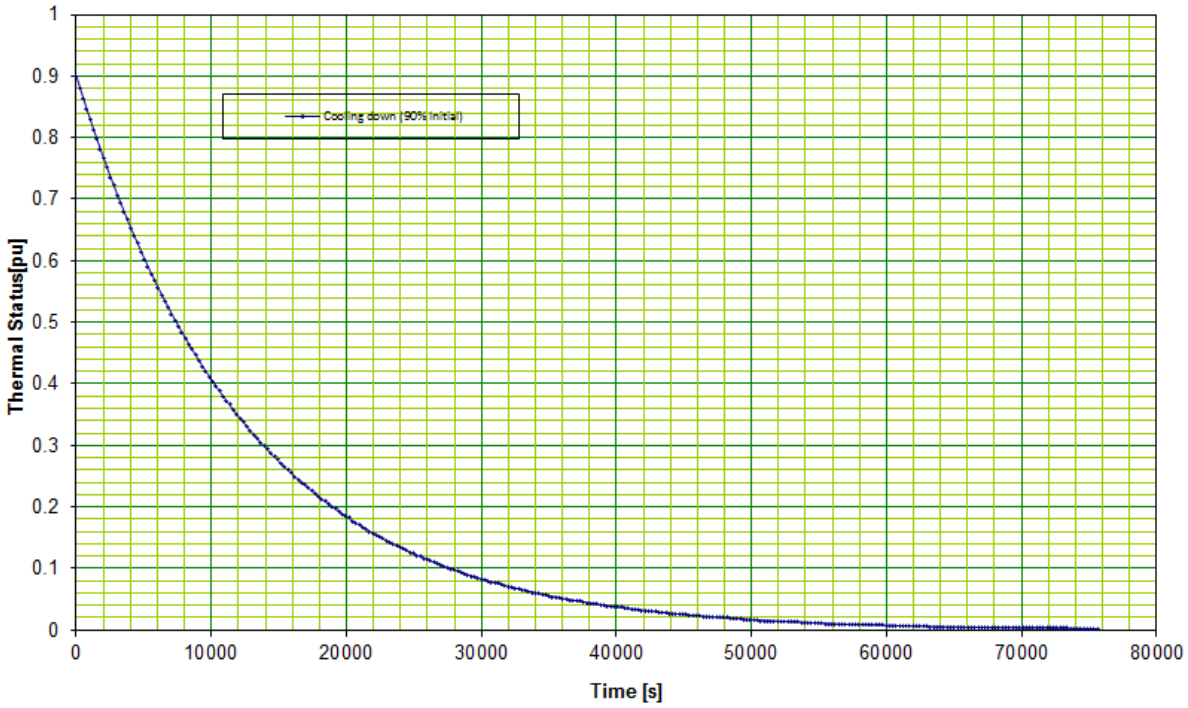
$$t = -12600 \ \ln\frac{40}{90} = 10217\ s$$

The required time is 2 hours 50 minutes.

The curve below shows the motor thermal status variation with time for this example.

1205, Labelle Street,
Montreal, Quebec H2L 4C1
CANADA
Tel. : 514-664-2048
Fax : 438-320-0496
www.pse2.ca

Motor Stopped Cooling Curve



Ernesto Hidalgo-Tupia, Eng., M. A. Sc.
Electrical Engineer