National University of Singapore

Department of Electrical & Computer Engineering

EE-4502:Electric Drives and Control

Tutorial - 2: Sizing of Adjustable Speed Drives

Year 2022-2023

1. An electric motor has a heating time-constant of 1.5 hours and cooling time constant of 2.0 hours. The motor has an intermittent periodic load of full-load for 30 mins. followed by a standstill period of 30 min. The minimum temperature-rise at steady-state is 30^0C.

   Determine the maximum steady-state temperature-rise if the machine is operated under the periodic intermittent load as mentioned above.

   Determine the steady-state temperature-rise if the machine is operated continuously at rated load.

   (Ans. 38.5^0C and 60.8^0C)

2. An electric motor has a heating time constant of 80 minutes. The steady-state temperature-rise of the motor is 100^0C when it is continuously loaded at rated load.

   (a) The motor is started with an initial temperature-rise of 0^0C. Determine the temperature rise of the motor just after 2.2 hours when it is loaded with rated load.

   (b) Assume that the motor is started with an initial temperature-rise of 0^0C and is now overloaded. The temperature-rise after 2.2 hours of continuous operation is found to reach the maximum permissible temperature-rise of 100^0C. Determine the corresponding steady-state temperature-rise if the machine is run continuously at this overload condition.

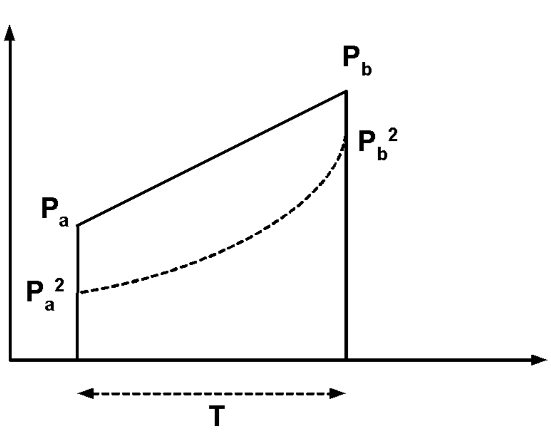
   Determine the corresponding overloading factor. You may assume that constant loss is half of the full-load copper losses.

   (Ans. (a) 80.8^0C and (b) 123.8^0C, 1.165)

3. The 10 min. rating of a motor used in a domestic mixer is 200 W. The heating time constant is 40 min. and the maximum efficiency occurs at full-load. Determine the corresponding continuous rating of the motor.

   (Ans. 70.5 W)

4. Consider the power/time curve as shown in Fig. 1 which in general has a trapezoidal shape. It can be shown that the r.m.s power is given by



$$P_{rms} = \sqrt{\frac{1}{3}\left[{P_a}^2 + P_a P_b + {P_b}^2\right]}$$

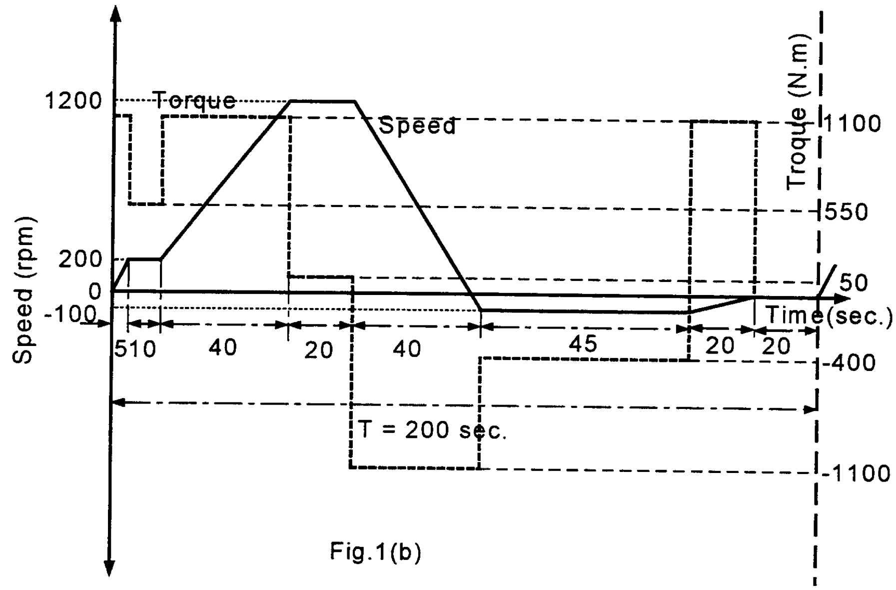


Figure 2:

The speed and torque profiles of a sugar centrifuge drive over one cycle are shown in Fig. 2. Sketch the corresponding power profile of the motor drive system and hence determine a suitable power rating for the electric motor using the information provided. You may make use of the formula provided for determining the rms value of power.

(Ans. $\sim$ 53 kW)

5. An electric motor has a heating time-constant of 2.2 hours and cooling time constant of 3.5 hours. The motor has a final steady-state temperature rise of 65^0 and losses are proportional to $(load)^2$. The motor is started from no-load and runs on a duty cycle of rated load for 2 hours, followed by the motor being completely switched off for 1 hour and then followed by a loading of rated load for 1.5 hours. Determine the corresponding temperature rise at the end of the cycle.

   (Ans. 29.16^0 C, 38.81^0 C and 46.9^0C)

6. The temperature rise of a motor when operating for 25 minutes on full-load is 25^0C and becomes 40^0C when the motor operates for another 25 minutes on the same load. Determine the heating time constant and the steady-state temperature rise.

   (Ans. 48.94 min, 62.5^0C)

7. An electric motor has a continuous rating of 100 kW. The heating and cooling time constants are 50 and 70 min respectively. The motor has a maximum efficiency at 80% of full-load. The motor is employed in an intermittent periodic load cycle consisting of a load period of 10 min. followed by a no-load period of 10 min. Determine the maximum permissible value of the load in kW during the load period.

   (Ans. 140.93 kW)

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