The procedure for sizing a brake in an application subjected to overhauling loads has four steps:

I. Determine rotational moment of inertia acting at motor brake.
II. Determine minimum torque required to stop and hold system.
III. Calculate system performance using selected brake.
IV. Evaluate system performance.

Before starting this process, the following application information is needed to conduct the sizing calculations:

- A detailed sketch of the brake-motor application.
- Motor data, including horsepower rating, speed (rpm), rotational inertia (lb-ft²) and NEMA frame size.
- Rotational inertia (lb-ft²) of all system components acting at the brake.
- Rotational speed (rpm) of all system components acting at the brake.
- Weight (lbs) and velocity (ft/min) of loads subjected to linear motion.
- Angle of inclination if overhauling load is not acting vertically.
- Cycle rate of system (stops/minute).

Example: Application Information for Bucket Conveyor

**Motor Data:**
- Horsepower Rating: 5 HP
- Speed: 1,760 RPM
- Rotational Inertia: 0.30 lb-ft²
- NEMA Frame Size: 184 TC

**Rotational Inertia of All Active System Components:**

**Motor Brake Data:**
- Rotational Inertia: 0.11 lb-ft²

**Gear Reducer Data:**
- Gear Reduction Ratio: 50:1
- Gear Reducer Inertia: 0.14 lb-ft²

**Drive Roll Data:**
- Roll Diameter: 0.955 ft
- Roll Length: 2.5 ft
- Rotational Inertia: 99.338 lb-ft²
- Tension Roll Data: Same as Drive Roll

**Rotational Speed of All Components Acting at Brake:**
- Motor: 1,760 RPM
- Brake: 1,760 RPM
- Gear Reducer: 1,760 RPM (in)
  - 35.2 RPM (out)
- Drive Roll: 35.2 RPM
- Tension Roll: 35.2 RPM

**Weight and Velocity of Loads Subjected to Linear Motion:**

For this example, we will use the following conveyor data:
- Empty weight of conveyor belt (per foot basis): 15 lbs
- Total length of conveyor belt: 53 ft
- Empty weight of conveyor bucket: 20 lbs
- Spacing of buckets on conveyor: 1 ft
- Total number of buckets on conveyor: 52
- Load capacity of each bucket: 75 lbs

\[ W_c = (53 \text{ ft})(15 \text{ lb/ft}) + (52)(20 \text{ lbs}) = 1,835 \text{ lbs} \]

\[ W_l = (0.5)(52)(75 \text{ lbs}) = 1,950 \text{ lbs} \]

*The \( W_l \) calculation assumes that only half of the buckets will carry a load at any given instant.

\[ W = W_c + W_l = 3,785 \text{ lbs} \]

(For velocity calculations)

\[ V_l = (35.2 \text{ rev/min})(0.955 \text{ ft}) \pi = 105.6 \text{ ft/min} \]

**Angle of Inclination:**

\[ \theta = \sin^{-1} \left( \frac{H}{L} \right) = \sin^{-1} \left( \frac{15}{25} \right) = 36.87^\circ \]

\[ \sin \theta = 0.600 \]

Then: (For weight calculations)

**Cyclic Rate of System:**
- Maximum of 2 stops/minute.

Using the application information, select a brake for this system.

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I. DETERMINE ROTATIONAL MOMENT OF INERTIA ACTING AT MOTOR BRAKE

Known Quantities:

- Motor: 0.3000 lb-ft²
- Brake: 0.1100 lb-ft²
- Gear Reducer: 0.1400 lb-ft²

(A) Contribution from rotary load at different speed than brake shaft:

For Drive Roller

\[
WK_{DR}^2 = \frac{N_L}{N_B} \left( \frac{352}{1760} \right)^2 = 0.0397 \text{ lb-ft}^2
\]

For Tension Roller

\[
WK_{TR}^2 = \frac{N_L}{N_B} \left( \frac{352}{1760} \right)^2 = 0.0397 \text{ lb-ft}^2
\]

*This assumes that there is no slippage between conveyor belt and rollers.

(B) Contribution from loads subjected to linear motion:

\[
WK_L^2 = W \left( \frac{V_L}{2 \pi N_B} \right)^2 = 3.785 \text{ lbs} \left( \frac{105.6}{2 \pi 1760} \right)^2 = 0.3452 \text{ lb-ft}^2
\]

Then:

\[
WK_T^2 = WK_M^2 + WK_R^2 + WK_{GR}^2 + WK_{DR}^2 + WK_{TR}^2
\]

\[
WK_T^2 = 0.9746 \text{ lb-ft}^2
\]

II. DETERMINE MINIMUM TORQUE REQUIRED TO STOP AND HOLD SYSTEM

(A) Calculate overhauling torque of fully loaded conveyor belt:

\[
T_O = \frac{0.158(SN(O))(W_L)(V_L)}{N_B} \text{ lb-ft}
\]

\[
T_O = \frac{(0.158)(0.600)(1950 \text{ lb})(105.6 \text{ ft/min})}{1760 \text{ RPM}} = 11.092 \text{ lb-ft}
\]

(B) Calculate minimum brake torque:

\[
T_{BM} = \frac{WK_T^2(N_B)}{308} + T_O
\]

\[
T_{BM} = \frac{(0.9746 \text{ lb-ft})^2(1760)}{(308)(1)} + 11.092 \text{ lb-ft}
\]

\[
T_{BM} = 5.569 \text{ lb-ft} + 11.092 \text{ lb-ft} = 16.661 \text{ lb-ft}
\]

Please note that the maximum stopping time should not exceed one second.

Therefore, we must select a brake with a torque rating of at least 16.661 lb-ft which fits on a NEMA 184 TC frame size.

Selected Brake Data:

- Dings Model Number: 4-72025-46
- Enclosure Type: NEMA 4
- Brake Style: Double “C” Face
- Rated Thermal Capacity: 12
- Rotational Inertia: 0.1097 lb-ft²

III. CALCULATE SYSTEM PERFORMANCE USING SELECTED BRAKE

(A) Stopping time calculation:

\[
t_{SHM} = \frac{WK_T^2}{(308)(T_{SHM} + T_O)} = \frac{(0.9746 \text{ lb-ft})^2(1760)}{(308)(25+11.092)} = 0.154 \text{ sec}
\]

\[
t_{SHB} = \frac{WK_T^2}{(308)(T_{SHB} + T_O)} = \frac{(0.9746 \text{ lb-ft})^2(1760)}{(308)(25+11.092)} = 0.400 \text{ sec}
\]

(B) Travel distance during stop calculations:

\[
TDS_1 = \frac{0.5 V_L t_{SHM}}{60} = \frac{(0.5)(105.6 \text{ ft/min})(0.154)}{60} = 0.136 \text{ ft}
\]

\[
TDS_2 = \frac{0.5 V_L t_{SHB}}{60} = \frac{(0.5)(105.6 \text{ ft/min})(0.400)}{60} = 0.352 \text{ ft}
\]

(C) Thermal requirement calculations:

(without overhauling load)

\[
\text{H.P. Sec/Stop} = \frac{WK_T^2(N_B)}{1800} = \frac{(0.9746 \text{ lb-ft})^2(1760)}{1800} = 0.932 \text{ HPS/Stop}
\]

(with ascending overhauling load)

\[
\text{H.P. Sec/Stop}_A = \frac{T_{SHM}}{T_{SHM} + T_O} = \frac{25}{25+11.092} = 0.646 \text{ HPS/Stop}_A
\]

(with descending overhauling load)

\[
\text{H.P. Sec/Stop}_D = \frac{T_{SHB}}{T_{SHB} + T_O} = \frac{25}{25+11.092} = 1.675 \text{ HPS/Stop}_D
\]

Since the worst case scenario is a descending overhauling load, it will be used to determine allowable stops:

(D) Allowable stops calculation:

\[
\text{ASM} = \frac{RTC}{(HPS \text{ MIN})} = \frac{12}{1.675} = 7.16 \text{ STOPS MIN}
\]

IV. EVALUATE SYSTEM PERFORMANCE

(1) Stopping time of system is less than one second so brake torque is adequate.

(2) Allowable stops per minute is more than three times the specified number of two, so rated thermal capacity is adequate.

Therefore, we can conclude that the brake will function as intended.

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