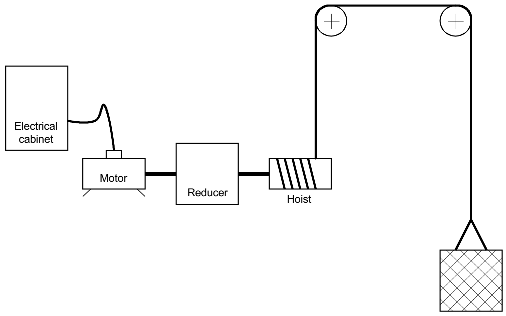
T4 – THE DC MOTOR

A lift moves a 2-tonne load vertically at a linear speed of 0.2 m/s.

The drum of the hoist has a diameter of 217 mm. The reducer that links the hoist to the electrical motor has a reduction ratio **r** of 1/78.6 (r = 1/78.6). The assembly reducer - hoist - pulley has an efficiency of 85%. For motor selection, a safety coefficient of 2 is applied (s = 2).



Study for motor selection

1) **Calculate** P_{LEV}, the lifting power required to lift the maximum load to the required speed.
2) **Calculate** P_{UM}, the mechanical power of the motor required for nominal operation of the lift by applying the safety coefficient and taking into account the overall efficiency of the drive chain.
3) **Calculate** n_T, the rotation speed of the hoist for the maximum linear speed of the load, then n_{MOT}, the rotation speed of the motor.
4) **Calculate** C_T, the torque at the reducer ouput, required to lift the maximum load, then C_{MOT}, the torque developed by the motor.

The selected motor is a NIDEC Independent Excitation DC Machine with reference LSK 1124 M04. The manufacturer's data are as follows:

- Armature supply voltage: U = 440 V;
- Amature current intensity: I_A = 28.5 A;
- Inductor (or excitation) current intensity: I_E = 1.8 A at 360 V;
- Armature resistance, measured hot: R_A = 2.54 Ω.

Two tests were performed on the motor:

- No-load generator test: E_V = 487 V for I_E = 1.8 A and for n_V = 2000 rpm;
- No-load motor test: U = 369 V and P_0 = 473 W (power absorbed by the armature).

In what follows, the excitation remains the same: I_E = 1.8 A. The armature magnetic reaction is neglected.

No-load motor study

5) **Calculate** I_0, the armature current intensity and n_0, the rotation speed of the motor during the test at no load.
6) **Check** that the Joule effect losses, P_{J0}, can be neglected compared to other losses.
7) **Deduce** C_P, the loss torque.

Subsequently, it will be assumed that C_P, the loss torque, is independent of the rotation frequency.

Study of the motor at its nominal operating point

8) **Show** that the electromagnetic torque is proportional to the current intensity in the armature if the excitation of the motor remains constant.

9) Under **motor** nominal operating conditions, **calcultate:**
   - E_N, the electromotive force,
   - n_N , the rotation speed,
   - C_{EMN}, the electromagnetic torque,
   - C_{UN}, the useful torque,
   - P_{AN}, the absorbed power,
   - P_{UN}, the useful power,
   - η_N, the motor armature efficiency.

Study of the motor at the lift operating point during the ascent

The lift operates with its maximum load at nominal speed. The motor develops the torque and rotates at the speed calculated in the first part.

10) Under the **lift** nominal operating conditions, **calculate:**
    - C_{EMM}, the electromagnetic torque,
    - I_{AM}, the motor armature current,
    - n_M, the rotation speed,
    - E_M, the electromotive force,
    - P_{UM}, the useful power,
    - P_{AM}, the absorbed power,
    - η_M, the motor armature efficiency.

Study of the motor at the lift operating point during the descent

The load now moves down with the same speed as the ascent.

11) If, during the ascent, the speed sign and the motor torque sign are positive, **indicate:**
    - The speed sign during the descent,
    - The motor torque sign during the descent,
    - The sign of the power developed by the motor during the descent.

12) Deduce **from this**
    - the sign of the voltage to be applied to the motor,
    - the sign of the current flowing through the motor,
    - Is the machine motor or generator?

13) Under the lift nominal descent operating conditions**, calculate:**
    - C_{MOTD}, the torque applied to the motor by the reducer,
    - C_{EMD}, the electromagnetic torque of the motor,
    - I_{AD},the current flowing in the armature,
    - n_D, the rotation speed,
    - E_D, the electromotive force,
    - U, the supply voltage to be applied to the armature,
    - P_{MD},the mechanical power transmitted to the motor by the reducer
    - P_{ED}, the electrical power returned by the motor to its power supply
    - η_D, the motor efficiency.