**DC Motors:**

What effect does increasing the current at constant voltage have on DC motor performance?

Increases Torque

A DC motor is found to produce a maximum of 0.01 Nm of torque when using a battery capable of delivering 2 Amps at 12V. This is well below the manufacturers rated maximum torque at 12V. How would you get more torque from this motor?

Put two batteries in parallel to deliver more current, or choose a battery capable of delivery more current.

What effect does increasing the voltage at constant current have on DC motor performance?

Increases the speed

A motor datasheet gives the no load speed as 12,000 rpm at a nominal voltage of 10.8V. What will the motor’s maximum speed be at 5 V?

12000\*5/10.8 = 5600 rpm

What effect does increasing the number of winding while reducing the wire diameter have on a DC motor?

Motor will now operate as before but at a higher voltage.

What effect does increasing the wire diameter and decreasing the number of windings have on the terminal resistance?

Reduces terminal resistance, reduces nominal voltage

Two motors of identical size are intended for very different voltgaes, one for 7.2V and one for 48V. What is likely to be the difference in the construction of the motors?

The 48V motor is constructed using many turns of smaller wire while the 7.2V motor is constructed using fewer turns of larger diameter wire.

At what speed does a brushed DC motor deliver peak efficiency?

Around two thirds to three quarters of peak speed.

At what torque does a brushed DC motor deliver peak efficiency?

Around 1/3 to ¼ of maximum torque.

What is the power delivered by a motor which spins at 1000 rpm against a load torque of 1 Nm?

1000rpm = 1000\*1/60\*2\*pi = 104.7 rad/sec

Power = torque \* rotational speed = 104.7\*1 = 105 W

A motor has a motor or torque constant of 0.015 Nm/A. How many amps are required to achieve a torque of 0.1 Nm?

i\*kt = 0.1, i=0.1/0.015 = 6.7 A

A motor has an electrical constant of 1.8 mV s/rad and a winding resistance of 2 . How much current would you expect to flow at 2000 rad/s using a 5V source.

At 2000 rpm the back emf is 2000\*0.0018 =3.6 V

The remaining 1.4 V must be dropped over the winding resistance. I=1.4/2 = 0.7A

A motor has an electrical constant of 0.4 V s/rad and a winding resistance of 6 . How much current would you expect to flow to the motor at 400 rad/s using a 150 V source.

At 3000 rpm the back emf is 400\*0.4 =160 V

The exceeds the supply voltage so current flows back to the source, with 10V dropped over the winding resistance. I=10/6 = -1.67 A

What power is generated and what power is lost to resistive heating?

Generated: 1.67 A x 150V = 250 W

Lost: 1.672\*6 = 16.7 W

A motor is found to have an output power of 500W and an input power of 800W. What is the electrical power loss?

300W

For a power supply that operates at low voltage but high current, what winding type is most appropriate?

A winding with fewer turns of larger wire giving low resistance

A brushed DC motor has a no load speed of 16200 rpm. At what speed does the motor deliver peak output power?

16200/2 = 8100 rpm

Under what condition does a DC motor draw maximum current?

Stall

What happens when a motor is spun faster than it’s no-load speed?

The back EMF becomes greater than the applied voltage and current flows from the motor to the power supply.

The motor is generating energy.

What happens when a DC motor is operated below its rated speed for extended times?

It gets too hot, possibly causing a breakdown of winding insulation, causing a short, following by a rapid loss of torque, speed and back emf. This causes more current and further thermal damage ie smoke.

How does internal friction affect the no-load speed?

It reduces it slightly from the linear intersection of the torque-speed curve with the axis.

What happens to the stall torque when a motor heats up?

It is reduced slightly because the winding resistance increases and current is reduced.

A motor is observed to consume 150W of electrical power and deliver 100W of mechanical power. What is the efficiency of this drive?

 = 100/150= =66%

A 30x reducing gearbox is rated as 80% efficient. The motor can deliver 80W by itself. When connected through the gearbox, the system must deliver of torque of 25 Ncm (eg. constant lift). What speed will the motor operate at?

What effect does the winding type have on the motor power?

Minimal

Why is it important to be able to choose the winding type?

It allows a good match between motor and power supply

**Drive Selection**

Linear motion versus rotational motion.

What power is delivery by a torque of 13 Nm at a speed of 100 rpm?

P=13\*100/60\*2\*3.14 = 136 W

What power is delivery by a force of 4.5 kgf at a speed of 0.8 m/s?

P=4.5 \*9.81 \*0.8 = 35.3 W

What torque is required to hold a 10 kg mass using a 5cm radius drum?

T= 10\*9.81\*0.05 = 4.9 Nm

What torque is required to lift a 10 kg mass at 0.5 m/s from a 2cm radius drum?

No acceleration means steady state. T=10\*9.81\*0.02 = 1.96 = 2.0 Nm

Approximately what power is required to lift a 1.5 kg mass to a height of 1.2 m in 0.5 seconds?

Energy = 1.5kg\*9.81N/kg\*1.2m = 17.66 J

Power = 17.66J/0.5s = 35.3 = 35 W

A motor has a no load speed of 12,000 rpm and a stall torque of 15 mN m. What is the operating speed with a load of 4 mN m?

=(15-4)/15\*12000=8800 rpm

What is the linear velocity of a load driven by a lead screw where the lead is 6mm and the rotational speed is 100 Hz?

100 \* 6 = 600mm/s = 0.6 m/s

What loss-inducing steps are involved in transferring power from the power supply to the load?

Power supply to controller (losses) to motor (losses) to gearhead or drive (losses) to load.

Rank the following components in terms of typical power transfer efficiency

Electrical transformer, DC motor, Gearhead, ball screw, trapezoidal lead screw

Name two environmental emissions of a electrical motor drive system.

Electromagnetic radiation, heat and noise

A motor is connected to horizontal lead screw. With no loads applied to the nut block, it is found that a current of 8.5 Amps is need to initiate motion. The motor has a torque constant of 0.019 Nm/A. What is the friction torque?

T = kT I = 0.019\*8.5 = 0.162 Nm

RMS Load: A motion profile requires the motor to produce torques of:

100 gcm for 0.2 s

15 gcm for 0.2 s

85 gcm for 0.2 s

0.0 gcm for 0.4 s

This profile is repeated continuously. What is the RMS torque value that is required of the drive?

(RMS torque)2 = (sum of Ti^2\*ti)/(sum of ti)

(RMS torque)2 = (1002\*0.2 + 152\*0.2 + 852\*0.2 + 02\*0.2)/(1) = 3490

RMS Torque = 59 gcm

A motor drives a conveyor belt by means of a 2cm radius pulley. The belt must move at 0.4 m/s. What is the rotational speed of the pulley?

=0.4 / (2pi 0.02) \*2pi = 20 rad/sec

n= 20 rad/sec \* 1 rev/2pi rad \*60sec/1min = 191 rpm

For a drive which requires a speed of 200 rpm would a gear head be recommended and why?

Yes, as most DC motors are not able to continuously operate at such low speeds.

What piece of equipment is needed for position control with a DC motor?

Encoder

Is it possible to approximate speed without the use of a tachometer?

Yes, using measured current and known winding resistance to calculate back emf, which is proportional to speed.