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Talk About Torque

By Craig Dunne
Development Engineer

NHP Electrical Engineering Products Pty Ltd

Most "driven" machines apply an opposing torque against the rotation of the motor, with the exception of lifting machines during the lowering motion.

Knowing the torque of your motor is an advantage. But how does one manage to physically measure it?

NHP has built a mobile motor starting demonstration unit which incorporates a torque measuring device.

Using the twisting action of the motor, a servo-potentiometer has been fitted to give an electrical signal proportionate to the angle of rotation of the motor. This signal is then fed into an oscilloscope giving a relatively accurate depiction of the torque delivered by the motor. This same signal is also applied to a conventional analogue meter to give the observer a percentage reading of the torque seen by the motor **(see figure 2)**.

So how were the mechanics of this achieved?

Knowing the rated power of the motor and the operating speed, electromagnetic torque can be deduced.

The motor, which is supported by bearings on the main shaft is able to freely rotate. Springs are attached to the motor, (50mm from centre), to limit the rotation of the motor to a 15mm arc **(see figure 1)**. Knowing the maximum torque produced and the distance to the springs fixing point on the motor, a maximum

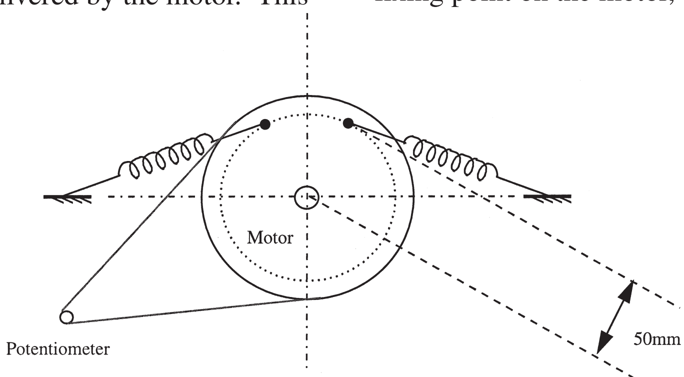

Figure 1

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force can be calculated. Knowing this force and the stretch required by the spring means that the corresponding spring constant can be calculated. The results of our calculations gave us all we needed to choose which springs would be best suited to the job.

To link the rotation of the motor to the potentiometer string was wrapped around the motor and tensioned using a small spring.

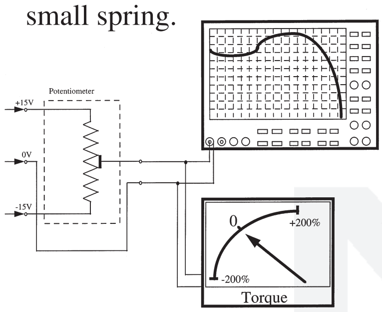

Figure 2

A servo potentiometer was used so as to give precise changes in resistance with very little electrical noise. Both drive and breaking torque can be measured.

Motor starters

Motor torque characteristics can be altered to suit the particular application by choosing the appropriate motor starter.

Primary factors to consider when determining which motor starting method is the best choice:

1. price
2. starting current restrictions and
3. torque requirements.

As torque is the topic of discussion we will focus on the third factor a little more closely.

Starting torques

Starting a typical induction motor using a Direct-On-Line (DOL) starter generally causes a very large starting torque **(see figure 4)**. In many cases this high torque may be unacceptable. Large starting torque may cause severe mechanical shock that can be detrimental to both the motor and its load.

An example of this can be seen by the starting of a motor running a conveyor. It would be absolutely necessary to start the conveyor in the smoothest possible way so as not to cause fragile goods to topple move or break.

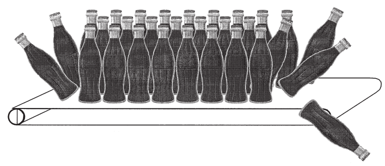

Figure 3

Ideally one would choose something like a liquid resistance starter, a variable speed drive or perhaps a soft starter, so as to control the torque **(see figure 5)**. Let's not forget that there are many factors to consider before making such a decision. If smooth starting is required, often some degree of smooth stopping is also necessary, eg. to prevent fluid hammer in the case of pumping.

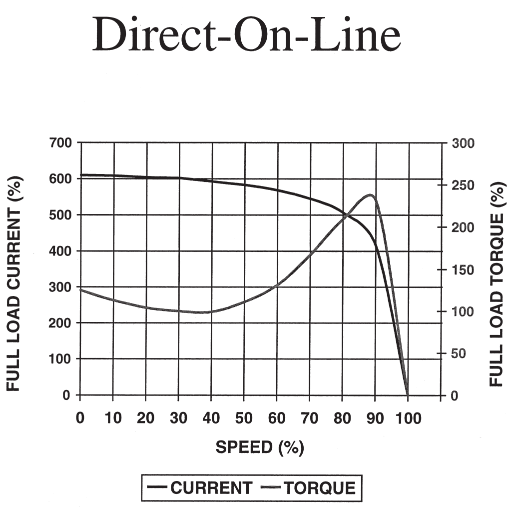

Figure 4

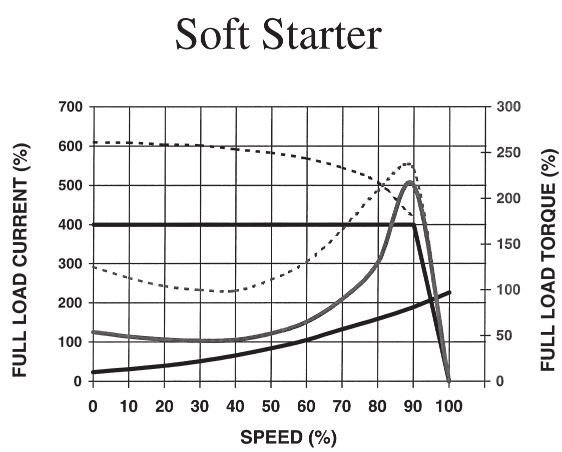

Figure 5

Typical torque curves and definitions

(Refer to figure 6)

Motor Torque: also known as acceleration torque.

Locked Rotor torque: sometimes called breakaway torque, is the torque generated by the motor at standstill.

Pull-Up Torque: also called pull-through torque is the smallest torque during acceleration. In any case, it must be greater than the load torque, otherwise the motor will not accelerate.

Breakdown Torque: this is the maximum torque which the motor can deliver. If the power is increased above the rated load, slip continues to increase, speed decreases and the motor delivers a higher torque. This can be increased to a maximum value known as breakdown torque. At this point the motor becomes unstable and if the motor is loaded any further, the developed torque reduces and the rotor falls out of step. The machine will finally come to a stop and must, before that, be disconnected from the supply as a precautionary measure.

Working Point: at the intersection of the two torque lines the motor operates with constant speed.

Load Torque: the counter-torque which represents the load during acceleration. Certain loads can also be represented by a constant torque line.

So what are the advantages of measuring torque?

Well in the case of the motor demonstration unit, it comes in very handy in displaying how different motor starters produce varying levels of torque in starting and in the case of variable speed drives, braking.

Reduced voltage starters

It should be noted that torque is reduced by the square of the voltage reduction. It would be reasonable to expect that a reduction in starting voltage will also result in a proportioned reduction in starting current.

Take for example, the auto transformer with a 60% tapping **(see figure 8)**. Let's see what starting current is reduced to:

⇛ 60% of 600% (let's say)
= 0.6 x 600 = 360%
(of rated FLC)

Starting torque is reduced to $(0.6)^2$ or 36%, the torque corresponding to a full voltage start.

In a star delta starter, **(see figure 9)** starting torque is reduced to one third of the torque produced by a full voltage start, however, switching from star to delta causes severe mechanical and current transients if the motor has not reached at least 80% of full speed, before change over.

Torque Curves

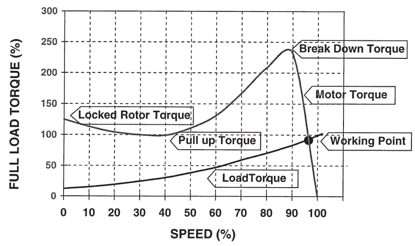

Figure 6

Primary Resistance Starting

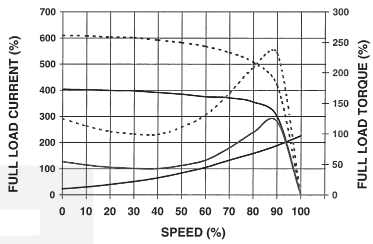

Figure 7

Auto Transformer Starting

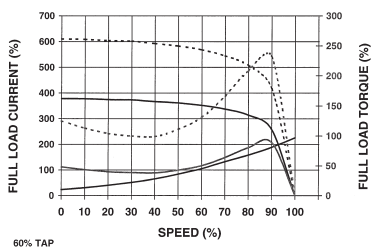

Figure 8

Star Delta Starter

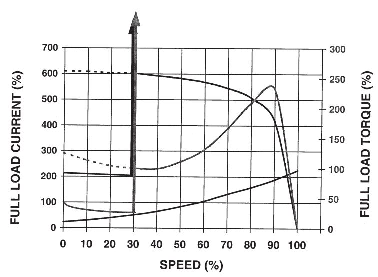

Figure 9

NHP makes motor starting simple

With the help of NHP's mobile motor starting demonstration unit starters can be compared on oscilloscope making your choice easier.

Starters include:

- D.O.L.
- STAR-DELTA
- AUTO TRANSFORMER
- LIQUID RESISTANCE
- ADJUSTABLE FREQUENCY
- SOFT START

Motor protection and control:

- CEF electronic overloads
- CET4 motor protection
- CEP7 overloads
- CT4 overloads

Contact NHP for all your switchgear requirements from the one source

Editorial content: - Please address all enquiries to 'The Editor - 'NHP Technical News' PO Box 199, Richmond Victoria 3121.

NHP Electrical Engineering Products Pty Ltd A.C.N. 004 304 812

Melbourne
43 - 67 River Street,
Richmond VIC. 3121
Phone: (03) 9429 2999
Fax: (03) 9429 1075

Sydney
30 - 34 Day Street North,
Silverwater N.S.W. 2128
Phone: (02) 9748 3444
Fax: (02) 9648 4353

Brisbane
25 Turbo Drive,
Coorparoo QLD. 4151
Phone: (07) 3891 6008
Fax: (07) 3891 6139

Adelaide
50 Croydon Road,
Keswick S.A. 5035
Phone: (08) 8297 9055
Fax: (08) 8371 0962

Perth
38 - 42 Railway Parade,
Bayswater W.A. 6053
Phone: (09) 271 8666
Fax: (09) 272 3906

Newcastle
575 Maitland Road,
Mayfield West N.S.W. 2304
Phone: (02) 4960 2220
Fax: (02) 4960 2203

Townsville
62 Leyland Street,
Garbutt QLD. 4814
Phone: (07) 4779 0700
Fax: (07) 4775 1457

Rockhampton
208 Denison Street,
Rockhampton QLD. 4700
Phone: (07) 4927 2277
Fax: (07) 4922 2947

Toowoomba
Cnr Carroll Street &
Struan Court,
Toowoomba QLD. 4350
Phone: (07) 4634 4799
Fax: (07) 4633 1796

Cairns
14/128 Lyons Street,
Bungalow QLD. 4870
Phone: (07) 4035 6888
Fax: (07) 4035 6999

Darwin
3 Steele Street,
Winnellie N.T. 0820
Phone: (08) 8947 2666
Fax: (08) 8947 2049

Agents

Hobart
H. M. Bamford (Hobart)
199 Harrington Street,
Hobart TAS. 7000
Phone: (03) 6234 9299
Fax: (03) 6231 1693

Launceston
H. M. Bamford (Launceston)
59 Garfield Street,
Launceston TAS. 7250
Phone: (03) 6344 8811
Fax: (03) 6344 4069

Burnie
H. M. Bamford (Burnie)
8 Wellington Street,
Burnie TAS. 7320
Phone: (03) 6432 2588
Fax: (03) 6432 2580

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