ravinaikconsultingspecialist

Power & Torque Optimization on Machining Centres with Direct Spindle Drives

The machine requirement for spindle speed, power and torque will vary depending upon:-

- component geometrical features
- material type
- tolerance requirement
- production quantity

Today it is becoming more and more important to complete the component in one set up, due to accuracy considerations, reducing number of setups, etc.

This means that it is necessary to do Roughing,Semi Finishing and Finishing operations in the same machine. Selecting such a machine can be difficult unless one accepts the need to change Machining strategies as well as have a different approach to Tooling selection.

This is because if you mainly use your machine for roughing operations – mainly then you need a high torque spindle. Such machines invariably have lower spindle RPMs and hence it can be difficult to do Semi Finish Operations at lower RPMs and possibly hardly any Finishing operations, which need smaller diameters of Tools both Indexable and Solid Carbidel;

Therefore if you have a lot of semi-finishing and finishing operations in the same machine, then it can be more preferable to go for a spindle with higher rpm and less torque and hence it becomes necessary for us to understand the interplay of Power and Torque with Spindle RPM.

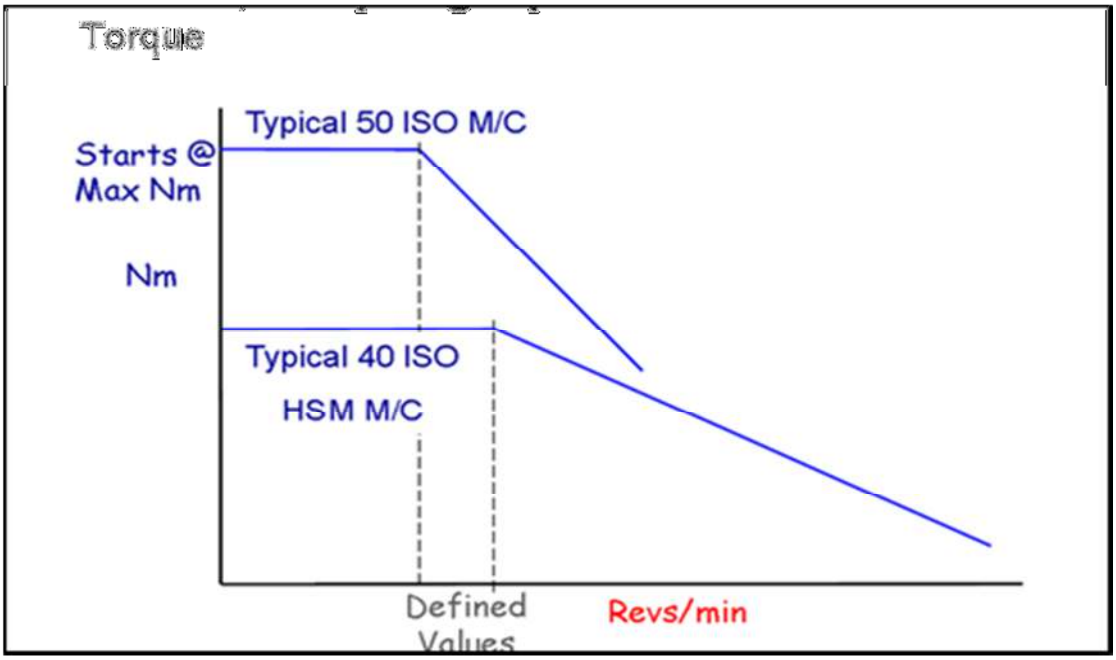
The majority of modern machining centers have direct drive spindles.
With ever increasing spindle speed capabilities the result is:

-

- Lower torque at higher rpms
- Lower power at lower rpms.

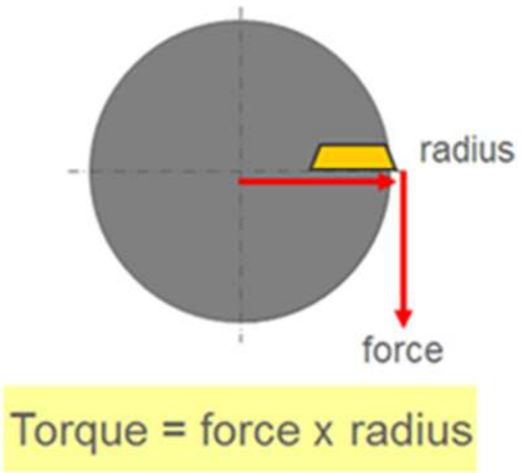
So let us see the impact of spindle RPM on Torque –Fig 1.

Fig 1. Torque vs Spindle RPM



Torque is the measure of how much immediate rotational force a spindle drive motor can generate. Many times when methods engineers look at cutting tool speeds and feeds, they are often misled into believing that they should be concerned with horsepower (HP). The real driving force is not horsepower; it's TORQUE (T-Nm). In order to maximize your speeds and feeds you should have a good understanding of how your CNC machine develops and holds torque.

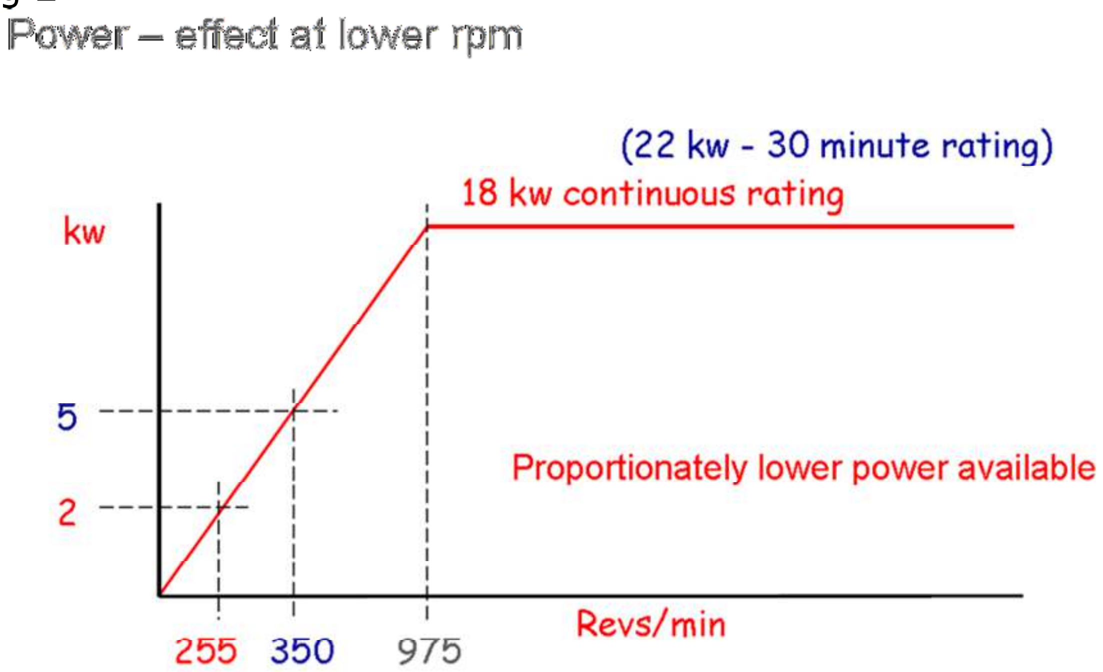
The Torque needed to drive a Milling cutter is graphically shown below:



The Chip area – A_p x A_e x f_z influences the force

Similarly see the effect of RPM on Power in these modern machines with direct spindle drives; You have lower Power available at lower RPMs upto a point. See fig 2.

Fig 2



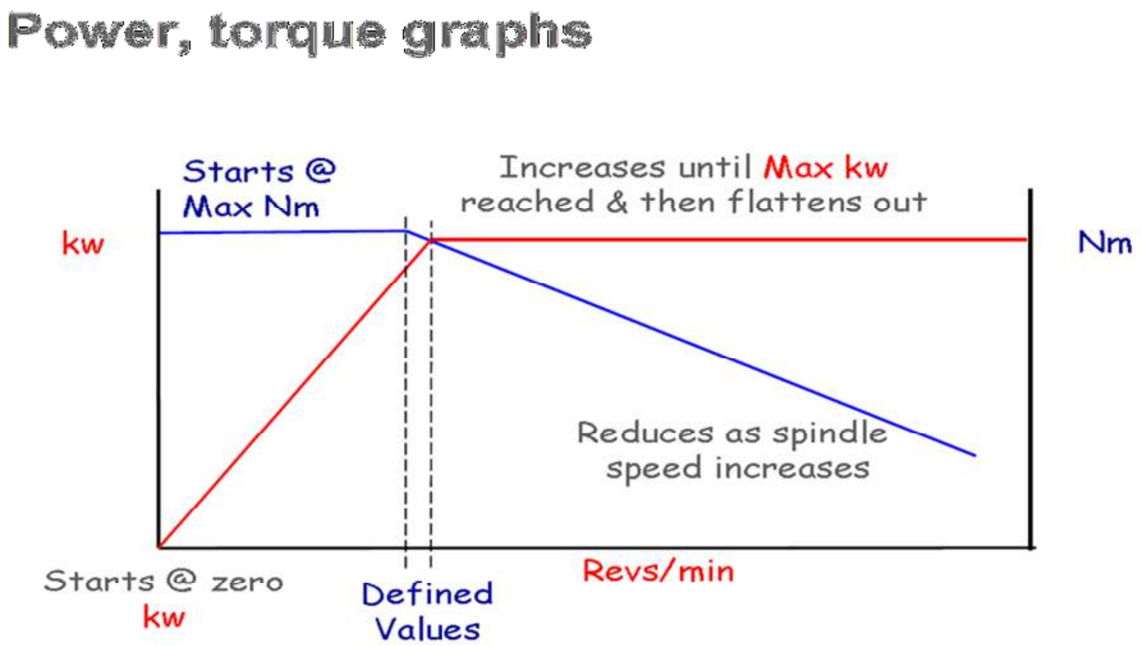
–

From these observations on the behaviour of modern machining centres with direct drives it is clear that the approach to the selection of Tooling would be significantly different from that which is taken on conventional machining centres with geared drives.

The main Driver towards such machines being the need of most Industry Segments to process relatively small batches, which are not necessarily just Prototypes, but are full Production runs of different components or models.

From the above it is clear that we need to look more closely at the Power Torque Diagrams wrt to Spindle RPM while selecting Machining Centres with direct drives. (see fig 3)

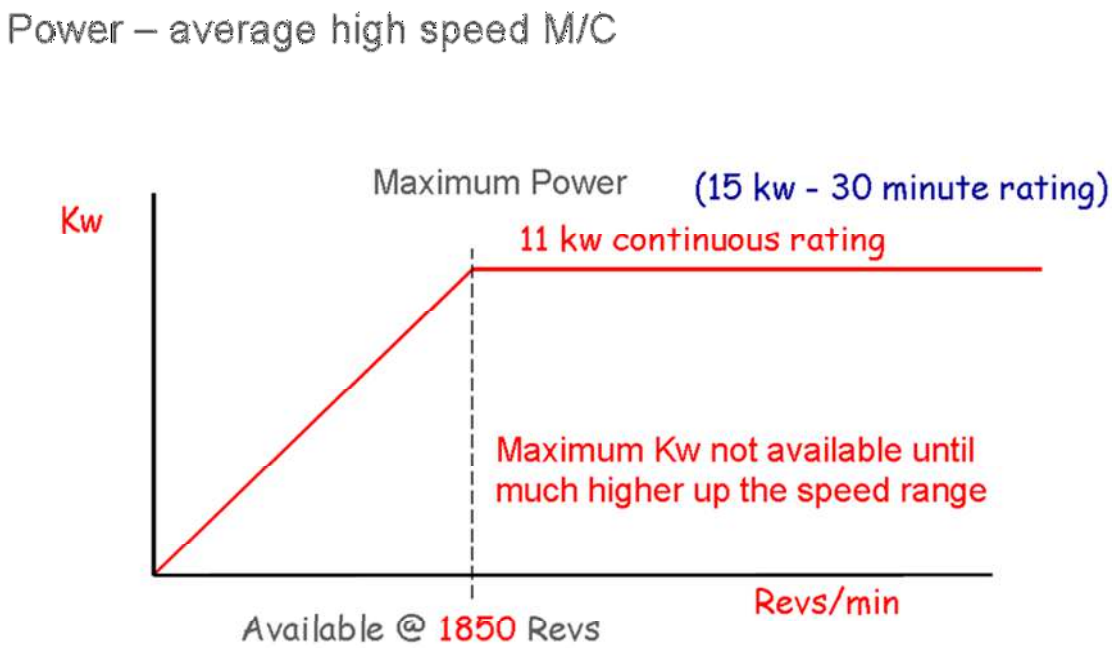
Fig 3: Power Torque Graphs wrt to Spindle RPM



It can be seen that at Max Power the Torque available is @75-90% of the rated torque of a direct drive machine- based on its specifications.

-

Let us now assume that we have selected a Vertical Machining Centre of Taper 40 with direct spindle drive, having Max Power of 15KW and Torque of @700Nm.
It can be seen from the Machine's Power graph shown below that the rated power of the machine is available only @ 1850rpm; While at the max Power of 11KW , max Torque available is 85% of 700 Nm ie @ 600 Nm.
Fig 4. Power to RPM of average Maching Centre with Direct Drive.



The Cutting Speed that gets calculated for different Diameter of Cutting Tools without going into specifics is given below;

Cutter Dia	M/min @1850 revs
12	70
16	93
20	116

-

25	145
50	291
80	465
125	727

As we now the normal limitations of Cutting Speed for different types of Steel, Stainless Steel, Cast Iron, Aluminium, Titanium etc it will be clear to us what would be the most suitable Diameter of the Tool that is to be selected to get the optimum efficiency of Metal removal on the VMC selected above.

It can be seen from the above that for optimum Metal removal rate for the selected machine the best suited Tool Diameters would be:

1. Dia 12mm to 50 mm for all Steels, Cast Iron, SG Iron.
2. Dia 12mm to Dia 25mm for most Stainless Steels-Duplex etc.
3. Dia 12 & Dia 16mm for HRSA materials.

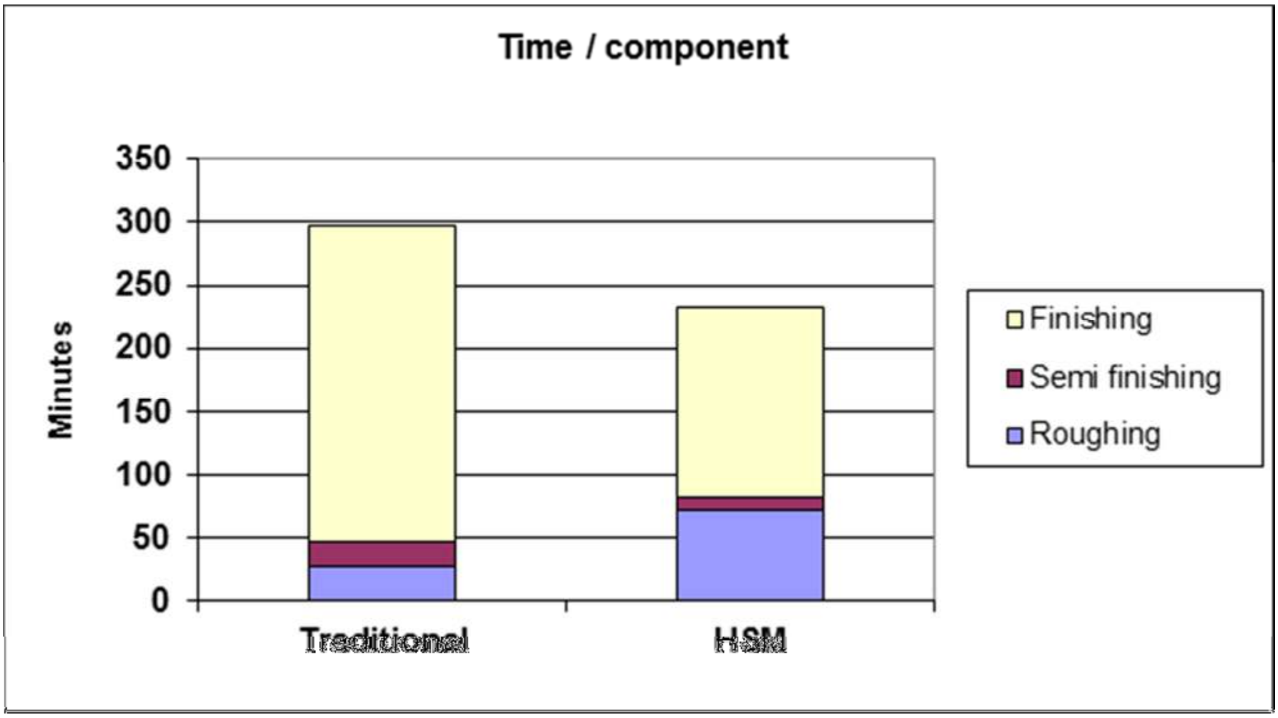
The above will mean that Machining strategies need to be adopted that will support – smaller cutter diameter, lower depth of cut (Ap),lower engagements(Ae) and higher feed per tooth (*fz*) to get higher metal removal rates**.**

(For Milling strategies one can refer to article on Milling Optimisation in Dhatukam magazines of October & November 2017)

In such cases it is quite likely that the Rough machining time would more than double……… but from the illustration below it can be seen that the Finishing time in the conventional set up that is almost 8-10 time the Rough machine time will reduce drastically to Half with the new machining strategies that support High Speed Machining(HSM)

-

Fig 5: Time per component Conventional(Traditional) vs Direct Drive(HSM):



-