Selecting the Right Tool In Turning Applications

The world of Metal cutting is quite complex and Turning is relatively a simpler process to understand compared with Milling and Drilling as its just a single cutting edge in action. Even so many parameters influence the success of the Turning process. Selection of the right tool plays an important part of this process.
This selection is influenced by the following parameters:
1. Workpiece material- its condition- whether forged, bar stock, the hardness, with or without interruptions, symmetric or asymmetric etc.

2. The type of machine, Tool holder shank size, Coolant flow and pressure, type of workpiece clamping – Hydraulic or mechanical etc.

Considering a normal Turning Center and a symmetrical component with interruptions which would constitute more than 65% of normal turning applications, for the purpose of this article, we can now go ahead with the process of understanding the approach to the selection of the right tool.

Generally with index able Tool holders, it's the machine that determines the shank size and the type of insert and insert geometry depends on the turning application and workpiece condition, the insert grade is decided as per the workpiece material.

Let us now look at this process in detail....

1.According to ISO nomenclature the six main groups of materials have different letters.

- **P for Steel**: This is the largest material group for machining, ranging from unalloyed to high-alloyed material including steel castings. They are all called long chipping type of materials.
- **M for Stainless steel:** These are materials alloyed with min. 12% Chromium, other alloys are Nickel and Molybdenum. Different conditions of stainless materials such as ferritic, martensitic, austenitic and austenitic-ferritic (duplex), makes the area large and common for all these typeas are that they generate a great deal of heat, notch wear and built up edges.
- **K-cast iron:** These are, contrary to steel, a short chipping type of material. GCI and Malleable irons are quite easy to machine while NCI and CGI/ADI are more difficult. All cast irons contain SiC which is very abrasive to the cutting edge

- **N-Non ferrous metals:** Thes are softer type of metals such as aluminium, copper, brass etc. Al with a Si-content of 13% Si is very abrasive. Generally high cutting speeds and long tool-life can be expected. Aluminium is dominant in this CMC group.
- **S- Heat Resistant Super Alloys (HRSA):** hese include a great number of high-alloyed iron, nickel, cobalt or titanium based materials. They are sticky workhardens and generate heat i.e. very similar to the M-area but much more difficult.
- **H-Hardened steel:** These contain hardened and tempered and extra hard steels with 45-65 HRC hardness and also Chilled cast iron around 400 HB which makes them all extremely difficult to machine. The materials generate heat during cutting and they are very abrasive.

To cope with all the different machinability characteristics for each material group, there are specific geometries and grades developed and adapted for each one of the material groups.

2. It is the combination of the tool material and the cutting geometry that make up the index able insert.

The main ranges of cutting tool materials are:

- Uncoated cemented carbide (HW)
- Coated cemented carbide (HC)
- Cermet (HT, HC)
- Ceramic (CA, CN, CC)
- Cubic boron nitride (BN)
- Polycrystalline diamond (DP, HC)

2.1.Uncoated cemented carbide (HW)

- Used in moderate to difficult applications related to steel, HRSA, titanium, cast iron and aluminium in turning, milling and drilling
- Good combination of abrasive wear resistance and toughness
- Gives sharp cutting edges
- Good edge security but limited wear resistance at higher speeds

These represents a very small percentage of the insert grades today considering the focus on Produciviy and hence the emphasis on high cutting speeds and feeds.

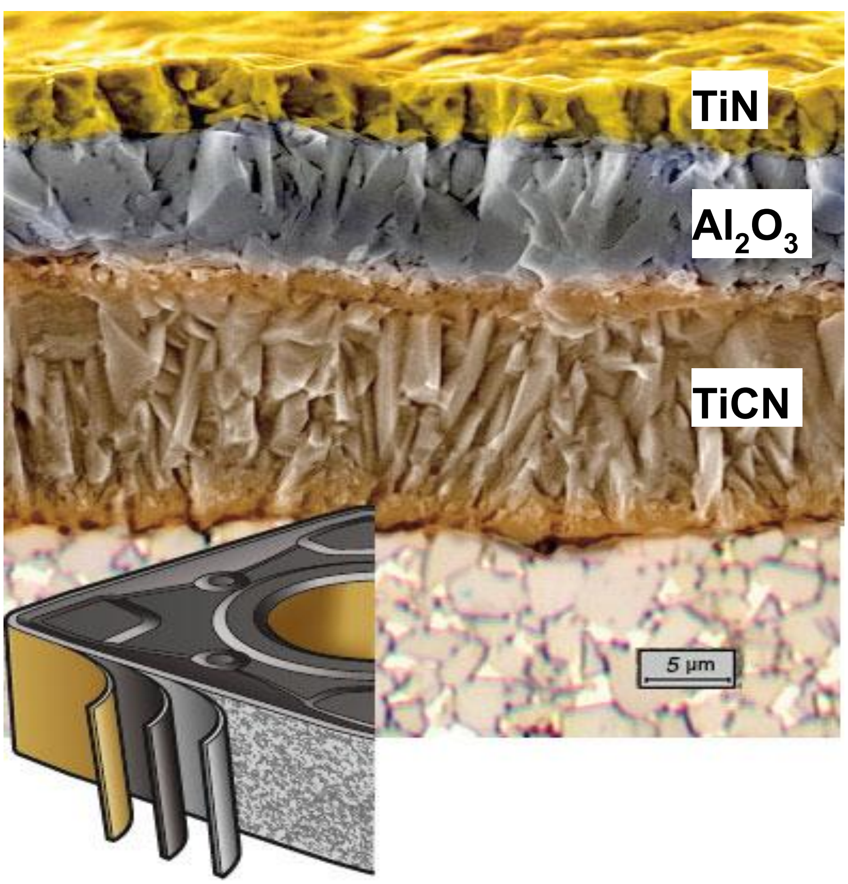
2.2 Coated Cemented Carbides

- General use in all kinds of components and material for turning applications
- Extremely good combination of wear resistance and toughness in a variety of jobs
- Consists of a large variety of grades with hard to tough substrates, usually with gradient sintering, and various coatings of CVD and PVD-type
- Shows very good wear characteristics with long tool-life

Coated carbides dominate the Insert programs of all Tool Manufacturers and all of them have very detailed recommendations for their insert Programs – grades, geometries etc backed up by strong technical support from their sales teams.

There are mainly two types of coating processes..... CVD i.e. Chemical Vapour Deposition & PVD ie Physical Vapour Deposition.

Example of a typical CVD Coating:



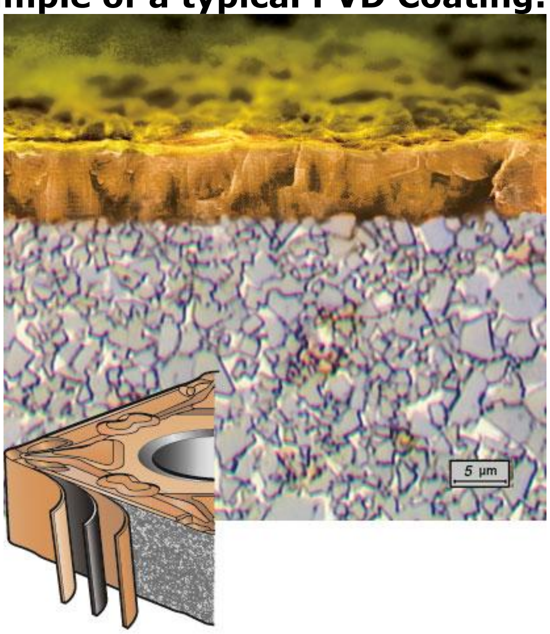
CVD – The function of the different layers

The most commonly used coating types with the CVD technique are TiCN (Titanium Carbon Nitride), Al2O3 (aluminum oxide) and TiN (Titanium Nitride).

- The first layer on top of the substrate is often a TiCN coating for protection against abrasive wear (flank wear).
- The next layer of Al2O3 to protect against thermal- and chemical wear (plastic deformation and crater wear protection). The hotter it gets in the application, the thicker the Al2O3 coating you will need. Coatings are very hard so in applications with high mechanical interruptions, the coatings are thinner otherwise the coatings can be so brittle that you get edge damages.. Some coatings are then post treated by a blasting method, with a special grinding media that enhances the toughness of the insert even more and gives a smoother surface of the insert.
- TiN provides easy wear detection and a smooth finish on the insert.

CVD inserts in different substrates ranging from soft, medium, hard with the above coating combinations cover a wide range of Steel and Cast Iron machining applications in Cutting speeds ranging from 150m/min to 350m/min in turning.

Example of a typical PVD Coating:



PVD means Physical Vapour Deposition

It is made at a temperature of about 500 degrees Celsius. In PVD we use a solid precursor(electrode), it means that coating particles comes from a metal (the metal evaporation source).

Right pressure and temperature in the PVD chamber will make the particles from the solid precursor to move and stick to the surface of the insert substrate. The coating particles can only stick to the surface that is free, and hence the hole of PVD coated inserts is black or left uncoated.

With PVD it is possible to have a sharp cutting edge due to the possibility of producing thin multilayer nano coatings which enhance crack resistance properties of the insert, which make the grade favourable in tough applications.

PVD inserts are mainly used in finishing and semifinishing applications as well as in HRSA materials that require a sharp cutting edge.

2.3 Cermet Inserts

- Used in finishing and semi-finishing applications where close tolerance and good surface finish is required
- Chemically stable with a hard and wear resistant substrate
- Consists of Titanium based (Tic, TiCN) cemented carbide with cobalt as a binder
- PVD-coating adds wear resistant and tool-life. “Self-sharpening” properties. Limited toughness behaviour

Cermet inserts have a low share of the total insert range and are mainly used in finishing application on steel – where tight tolerances are demanded.

2.4 Ceramic Inserts

- Depending on type of ceramic the grades are mainly used in cast iron and steel, hardened materials and HRSA
- Ceramic grades are in general wear resistant and with good hot-hardness. Wide application area in different type of material and components
- Ceramics are considered brittle and need stable conditions. With additions in the mix and whisker reinforced ceramic, toughness is improved

Ceramic inserts constitute @ 20 % of an insert program but their usage is dominant in the aerospace application area(mainly Engine components) and hardened steel-cast iron area- like Roll turning, Cast Iron Boring at high speeds etc.

2.5 Cubic Boron Nitride.

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- For finish turning of hardened steel.
- Roughing of grey cast iron at high cutting speeds.
- Rough turning of rolls in white/chilled cast iron
- Applications that require extreme wear-resistance and toughness.
- CBN consists of Boron nitride with Ceramic or Titanium nitride binder
- Resists high cutting temperatures at high cutting speeds

CBN have a Special application area and need very rigid Turning centrers and secure balanced clamping to get the right level of economics and maintain tolerances and finish at the level of grinding.
CBN perform better than Ceramics in most cases above 55HRc ......
The trend today is more towards Hard Part Turning(HPT) instead of Grinding.. especially on hardened gear blanks, drive shafts etc – wherever the User is prepared to invest in dedicated Hard Part CNC Machines like Hardinge etc.

2.6 Polycrystalline Diamond (PCD)

- Turning of normal aluminum at low temperature and very abrasive hypereutectic aluminum (> 10% Silicon). Used in non-metal and non-ferrous materials
- Extremely wear resistant grades. Sensitive to chipping
- Brazed in corners of polycrystalline diamond (PCD tip) to an insert or thin diamond coated film on a substrate
- Long tool-life and extremely good wear resistance. Decompose at high temperatures. Dissolves easily in iron

Wide spread usage in aluminium boring of two wheeler and 4 wheeler components due to the ability to hold tight tolerances and maintain good surface finish for prolonged period of time (multiple times) compared with carbide.