



Introduction

- Success in metal cutting depends on selection of the proper cutting tool (material and geometry) for a given work material.
- A wide range of cutting tool materials is available with a variety of properties, performance capabilities, and cost.
- These include:
 - High carbon Steels and low/medium alloy steels,
 - High-speed steels,
 - Cast cobalt alloys,

Contd...

- Cemented carbides,
- Cast carbides,
- Coated carbides,
- Coated high speed steels,
- Ceramics,
- Cermets,
- Whisker reinforced ceramics,
- Sialons,
- Sintered polycrystalline cubic boron nitride (CBN),
- Sintered polycrystalline diamond, and single-crystal natural diamond.

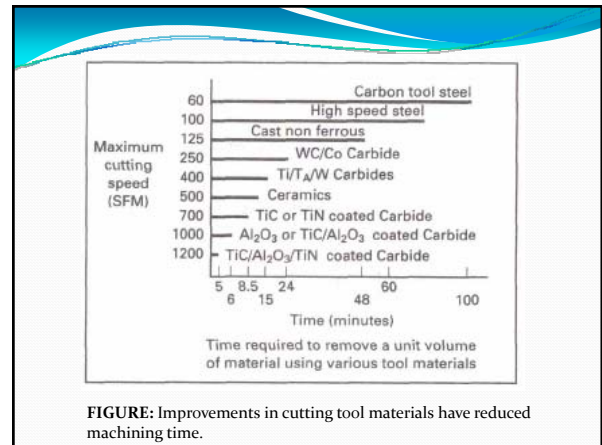


FIGURE: Improvements in cutting tool materials have reduced machining time.

Carbon Steels

- Limited tool life. Therefore, not suited to mass production
- Can be formed into complex shapes for small production runs
- Low cost
- Suited to hand tools, and wood working
- Carbon content about 0.9 to 1.35% with a hardness ABOUT 62 C Rockwell
- Maximum cutting speeds about 26 ft/min. dry
- The hot hardness value is low. This is the major factor in tool life.

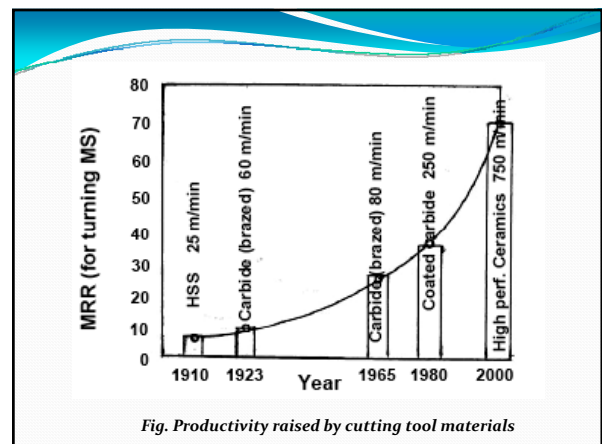


Fig. Productivity raised by cutting tool materials

IAS – 1997

Assertion (A): Cutting tools made of high carbon steel have shorter tool life.

Reason(R): During machining, the tip of the cutting tool is heated to 600/700°C which cause the teal tip to lose its hardness.

- (a) Both A and R are individually true and R is the correct explanation of A
 (b) Both A and R are individually true but R is **not** the correct explanation of A
 (c) A is true but R is false
 (d) A is false but R is true **Ans. (a)**

High Speed Steel

High speed steel

- These steels are used for cutting metals at a much higher cutting speed than ordinary carbon tool steels.
- The high speed steels have the valuable property of retaining their hardness even when heated to red heat.
- Most of the high speed steels contain tungsten as the chief alloying element, but other elements like cobalt, chromium, vanadium, etc. may be present in some proportion.

Contd...

- With time the effectiveness and efficiency of HSS (tools) and their application range were gradually enhanced by improving its properties and surface condition through -
 - Refinement of microstructure
 - Addition of large amount of cobalt and Vanadium to increase hot hardness and wear resistance respectively
 - Manufacture by powder metallurgical process
 - Surface coating with heat and wear resistive materials like TiC , TiN , etc by Chemical Vapour Deposition (CVD) or Physical Vapour Deposition (PVD)

IAS-1997

Which of the following processes can be used for production thin, hard, heat resistant coating at TiN, on HSS?

1. Physical vapour deposition.
2. Sintering under reducing atmosphere.
3. Chemical vapour deposition with post treatment
4. Plasma spraying.

Select the correct answer using the codes given below:

Codes:

- (a) 1 and 3 (b) 2 and 3
 (c) 2 and 4 (d) 1 and 4 **Ans. (a)**

18-4-1 High speed steel

- This steel contains 18 per cent tungsten, 4 per cent chromium and 1 per cent vanadium.
- It is considered to be one of the best of all purpose tool steels.
- It is widely used for drills, lathe, planer and shaper tools, milling cutters, reamers, broaches, threading dies, punches, etc.

IES-2003

The correct sequence of elements of 18-4-1 HSS tool is

- (a) W, Cr, V
- (b) Mo, Cr, V
- (c) Cr, Ni, C
- (d) Cu, Zn, Sn

Ans. (a)

IES 2007

Cutting tool material 18-4-1 HSS has which one of the following compositions?

- (a) 18% W, 4% Cr, 1% V
- (b) 18% Cr, 4% W, 1% V
- (c) 18% W, 4% Ni, 1% V
- (d) 18% Cr, 4% Ni, 1% V

Ans. (a)

IES-1993

The blade of a power saw is made of

- (a) Boron steel
- (b) High speed steel
- (c) Stainless steel
- (d) Malleable cast iron

Ans. (b)

Molybdenum high speed steel

- This steel contains 6 per cent tungsten, 6 per cent molybdenum, 4 per cent chromium and 2 per cent vanadium.
- It has excellent toughness and cutting ability.
- The molybdenum high speed steels are better and cheaper than other types of steels.
- It is particularly used for drilling and tapping operations.

Super high speed steel

- This steel is also called *cobalt high speed steel* because cobalt is added from 2 to 15 per cent, in order to increase the cutting efficiency especially at high temperatures.
- This steel contains 20 per cent tungsten, 4 per cent chromium, 2 per cent vanadium and 12 per cent cobalt.

IES-1995

The compositions of some of the alloy steels are as under:

1. 18 W 4 Cr 1 V
2. 12 Mo 1 W 4 Cr 1 V
3. 6 Mo 6 W 4 Cr 1 V
4. 18 W 8 Cr 1 V

The compositions of commonly used high speed steels would include

- (a) 1 and 2
- (b) 2 and 3
- (c) 1 and 4
- (d) 1 and 3

Ans. (d)

IES-2000

Percentage of various alloying elements present in different steel materials are given below:

1. 18% W; 4% Cr; 1% V; 5% Co; 0.7% C
2. 8% Mo; 4% Cr; 2% V; 6% W; 0.7% C
3. 27% Cr; 3% Ni; 5% Mo; 0.25% C
4. 18% Cr; 8% Ni; 0.15% C

Which of these relate to that of high speed steel?

- (a) 1 and 3 (b) 1 and 2
(c) 2 and 3 (d) 2 and 4 **Ans. (b)**

IES-1992

The main alloying elements in high speed Steel in order of increasing proportion are

- (a) Vanadium, chromium, tungsten
- (b) Tungsten, titanium, vanadium
- (c) Chromium, titanium, vanadium
- (d) Tungsten, chromium, titanium

Ans. (a)

IAS-2001

Assertion (A): For high-speed turning of magnesium alloys, the coolant or cutting fluid preferred is water-miscible mineral fatty oil.

Reason (R): As a rule, water-based oils are recommended for high-speed operations in which high temperatures are generated due to high frictional heat. Water being a good coolant, the heat dissipation is efficient.

- (a) Both A and R are individually true and R is the correct explanation of A
- (b) Both A and R are individually true but R is **not** the correct explanation of A
- (c) A is true but R is false
- (d) A is false but R is true **Ans. (a)**

IAS 1994

Assertion (A): The characteristic feature of High speed Steel is its red hardness.

Reason (R): Chromium and cobalt in High Speed promote martensite formation when the tool is cold worked.

- (a) Both A and R are individually true and R is the correct explanation of A
- (b) Both A and R are individually true but R is **not** the correct explanation of A
- (c) A is true but R is false
- (d) A is false but R is true **Ans. (b)**

Cast cobalt alloys/Stellite

- Cast cobalt alloys are cobalt-rich, chromium-tungsten- carbon cast alloys having properties and applications in the intermediate range between high-speed steel and cemented carbides.
- Although comparable in room-temperature hardness to high-speed steel tools, cast cobalt alloy tools retain their hardness to a much higher temperature. Consequently, they can be used at higher cutting speeds (25% higher) than HSS tools.
- Cutting speed of up to 80-100 fpm can be used on mild steels.
- Cast cobalt alloys are hard as cast and cannot be softened or heat treated.
- Cast cobalt alloys contain a primary phase of Co-rich solid solution strengthened by Cr and W and dispersion hardened by complex hard, refractory carbides of W and Cr.

Contd...

- Other elements added include V, B, Ni, and Ta.
- Tools of cast cobalt alloys are generally cast to shape and finished to size by grinding.
- They are available only in simple shapes, such as single-point tools and saw blades, because of limitations in the casting process and expense involved in the final shaping (grinding). The high cost of fabrication is due primarily to the high hardness of the material in the as-cast condition.
- Materials machinable with this tool material include plain-carbon steels, alloy steels, nonferrous alloys, and cast iron.
- Cast cobalt alloys are currently being phased out for cutting-tool applications because of increasing costs, shortages of strategic raw materials (Co, W, and Cr), and the development of other, superior tool materials at lower cost.

IES 2011

Stellite is a non-ferrous cast alloy composed of:

- (a) Cobalt, chromium and tungsten
- (b) Tungsten, vanadium and chromium
- (c) Molybdenum, tungsten and chromium
- (d) Tungsten, molybdenum, chromium and vanadium

Ans. (a)

Cemented Carbide

- Carbides, which are nonferrous alloys, are also called, sintered (or cemented) carbides because they are manufactured by powder metallurgy techniques.
- Most carbide tools in use today are either straight **tungsten carbide (WC)** or multicarbides of W-Ti or W-Ti-Ta, depending on the work material to be machined.
- Cobalt is the binder.
- These tool materials are much harder, are chemically more stable, have better hot hardness, high stiffness, and lower friction, and operate at higher cutting speeds than do HSS.
- They are more brittle and more expensive and use strategic metals (W, Ta, Co) more extensively.

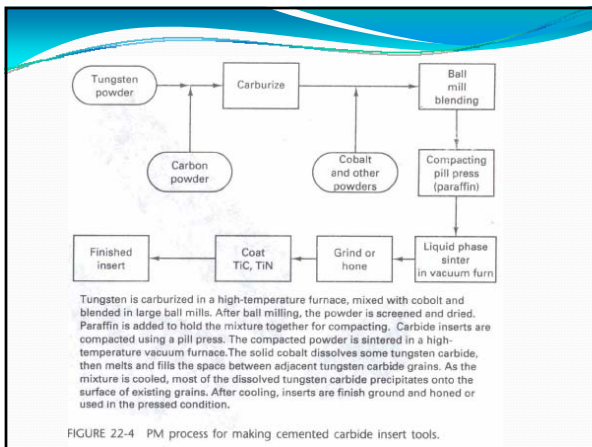
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- Cemented carbide tool materials based on TiC have been developed, primarily for auto industry applications using predominantly Ni and Mo as a binder. These are used for higher-speed (> 1000 ft/min) finish machining of steels and some malleable cast irons.
- Cemented carbide tools are available in insert form in many different shapes; squares, triangles, diamonds, and rounds.
- Compressive strength is high compared to tensile strength, therefore the bits are often brazed to steel shanks, or used as inserts in holders.
- These inserts may often have negative rake angles.

Contd...

- Speeds up to 300 fpm are common on mild steels
- Hot hardness properties are very good
- Coolants and lubricants can be used to increase tool life, but are not required.
- Special alloys are needed to cut steel

Contd...



IES-1995

The straight grades of cemented carbide cutting tool materials contain

- (a) Tungsten carbide only
- (b) Tungsten carbide and titanium carbide
- (c) Tungsten carbide and cobalt
- (d) Tungsten carbide and cobalt carbide

Ans. (c)

IAS – 1994

Assertion (A): Cemented carbide tool tips are produced by powder metallurgy.
Reason (R): Carbides cannot be melted and cast.

(a) Both A and R are individually true and R is the correct explanation of A
 (b) Both A and R are individually true but R is **not** the correct explanation of A
 (c) A is true but R is false
 (d) A is false but R is true

Ans. (a)

The standards developed by ISO for grouping of carbide tools and their application ranges are given in Table below.

ISO Code	Colour Code	Application
P		For machining long chip forming common materials like plain carbon and low alloy steels
M		For machining long or short chip forming ferrous materials like Stainless steel
K		For machining short chipping, ferrous and non-ferrous material and non – metals like Cast Iron, Brass etc.

Table below shows detail grouping of cemented carbide tools

ISO Application group	Material	Process
P01	Steel, Steel castings	Precision and finish machining, high speed
P10	Steel, Steel castings	Turning, threading, and milling high speed, small chips
P20	Steel, steel castings, malleable cast iron	Turning, milling, medium speed with small chip section
P30	Steel, steel castings, malleable cast iron	Turning, milling, medium speed with small chip section
P40	Steel and steel casting with sand inclusions	Turning, planning, low cutting speed, large chip section
P50	Steel and steel castings of medium or low tensile strength	Operations requiring high toughness turning, planning, shaping at low cutting speeds

K01	Hard grey C.I., chilled casting, Al. alloys with high silicon	Turning, precision turning and boring, milling, scraping
K10	Grey C.I. hardness > 220 HB. Malleable C.I., Al. alloys containing Si	Turning, milling, boring, reaming, broaching, scraping
K20	Grey C.I. hardness up to 220 HB	Turning, milling, broaching, requiring high toughness
K30	Soft grey C.I. Low tensile strength steel	Turning, reaming under favourable conditions
K40	Soft non-ferrous metals	Turning milling etc.
M10	Steel, steel castings, manganese steel, grey C.I.	Turning, milling, medium cutting speed and medium chip section
M20	Steel casting, austenitic steel, manganese steel, spheroidized C.I., Malleable C.I.	Turning, milling, medium cutting speed and medium chip section
M30	Steel, austenitic steel, spheroidized C.I. heat resisting alloys	Turning, milling, planning, medium cutting speed, medium or large chip section
M40	Free cutting steel, low tensile strength steel, brass and light alloy	Turning, profile turning, specially in automatic machines.

IES-1999

Match List-I (ISO classification of carbide tools) with List-II (Applications) and select the correct answer using the codes given below the Lists:

List-I		List-II			
A. P-10		1. Non-ferrous, roughing cut			
B. P-50		2. Non-ferrous, finishing cut			
C. K-10		3. Ferrous material, roughing cut			
D. K-50		4. Ferrous material, finishing cut			

Code: A B C D

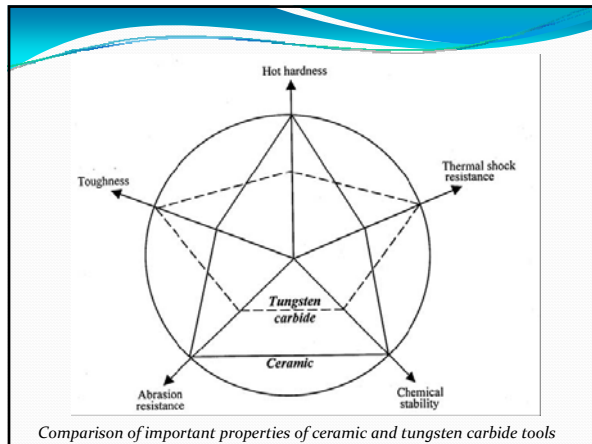
(a) 4	3	1	2	(b) 3	4	2	1
(c) 4	3	2	1	(d) 3	4	1	2

Ans. (c)

Ceramics

- Ceramics are essentially alumina (Al_2O_3) based high refractory materials introduced specifically for high speed machining of difficult to machine materials and cast iron.
- These can withstand very high temperatures, are chemically more stable, and have higher wear resistance than the other cutting tool materials.
- In view of their ability to withstand high temperatures, they can be used for machining at very high speeds of the order of 10 m/s.
- They can be operated at from two to three times the cutting speeds of tungsten carbide.

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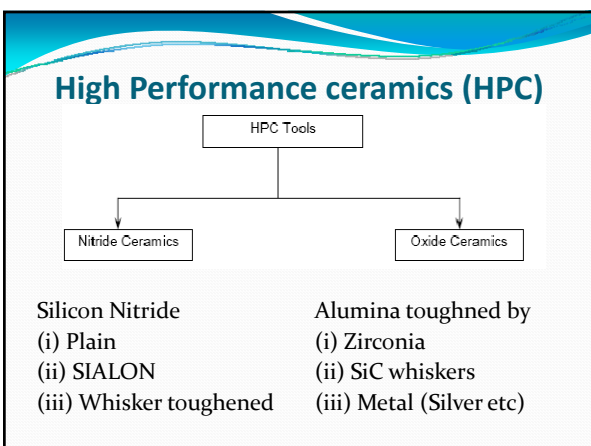


- It is possible to get mirror finish on cast iron using ceramic turning.
 - The main problems of ceramic tools are their low strength, poor thermal characteristics, and the tendency to chipping.
 - They are not suitable for intermittent cutting or for low cutting speeds.
 - Very high hot hardness properties
 - Often used as inserts in special holders.
- Contd...

- Through last few years remarkable improvements in strength and toughness and hence overall performance of ceramic tools could have been possible by several means which include;
 - Sinterability, microstructure, strength and toughness of Al_2O_3 ceramics were improved to some extent by adding TiO_2 and MgO ,
 - Transformation toughening by adding appropriate amount of partially or fully stabilised zirconia in Al_2O_3 powder,
 - Isostatic and hot isostatic pressing (HIP) – these are very effective but expensive route.
- Contd...

- Introducing nitride ceramic (Si_3N_4) with proper sintering technique – this material is very tough but prone to built-up-edge formation in machining steels
 - Developing SIALON – deriving beneficial effects of Al_2O_3 and Si_3N_4
 - Adding carbide like TiC (5 ~ 15%) in Al_2O_3 powder – to impart toughness and thermal conductivity
 - Reinforcing oxide or nitride ceramics by SiC whiskers, which enhanced strength, toughness and life of the tool and thus productivity spectacularly.
 - Toughening Al_2O_3 ceramic by adding suitable metal like silver which also impart thermal conductivity and self lubricating property; this novel and inexpensive tool is still in experimental stage.
- Contd...

- Cutting fluid, if applied should in flooding with copious quantity of fluid, to thoroughly wet the entire machining zone, since ceramics have very poor thermal shock resistance. Else, it can be machined with no coolant.
- Ceramic tools are used for machining work pieces, which have high hardness, such as hard castings, case hardened and hardened steel.
- Typical products can be machined are brake discs, brake drums, cylinder liners and flywheels.



IES 2010

Constituents of ceramics are oxides of different materials, which are

- (a) Cold mixed to make ceramic pallets
- (b) Ground, sintered and palleted to make ready ceramics
- (c) Ground, washed with acid, heated and cooled
- (d) Ground, sintered, palleted and after calcining cooled in oxygen

Ans. (b)

IAS-1996

Match List I with List II and select the correct answer using the codes given below the lists:

List I (Cutting tools)

- A. Stellite
- B. H.S.S.
- C. Ceramic
- D. DCON

List II (Major constituent)

- 1. Tungsten
- 2. Cobalt
- 3. Alumina
- 4. Columbium
- 5. Titanium

Codes:	A	B	C	D	A	B	C	D
(a)	5	1	3	4	(b)	2	1	4
(c)	2	1	3	4	(d)	2	5	3

Ans. (c)

IES-1997

Assertion (A): Ceramic tools are used only for light, smooth and continuous cuts at high speeds.

Reason (R): Ceramics have a high wear resistance and high temperature resistance.

- (a) Both A and R are individually true and R is the correct explanation of A
- (b) Both A and R are individually true but R is not the correct explanation of A
- (c) A is true but R is false
- (d) A is false but R is true

Ans. (b)

IES-1996

A machinist desires to turn a round steel stock of outside diameter 100 mm at 1000 rpm. The material has tensile strength of 75 kg/mm². The depth of cut chosen is 3 mm at a feed rate of 0.3 mm/rev. Which one of the following tool materials will be suitable for machining the component under the specified cutting conditions?

- (a) Sintered carbides
- (b) Ceramic
- (c) HSS
- (d) Diamond

Ans. (b)

IES 2007

Which one of the following is not a ceramic?

- (a) Alumina
- (b) Porcelain
- (c) Whisker
- (d) Pyrosil

Ans. (d)

IAS-2000

Consider the following cutting tool materials used for metal-cutting operation at high speed:

- 1. Tungsten carbide
- 2. Cemented titanium carbide
- 3. High-speed steel
- 4. Ceramic

The correct sequence in increasing order of the range of cutting speeds for optimum use of these materials is

- (a) 3,1,4,2
- (b) 1,3,2,4
- (c) 3,1,2,4
- (d) 1,3,4,2

Ans. (c)

IAS-2003

At room temperature, which one of the following is the correct sequence of increasing hardness of the tool materials?

- (a) Cast alloy-HSS-Ceramic-Carbide
- (b) HH-Cast alloy-Ceramic-Carbide
- (c) HSS-Cast alloy-Carbide-Ceramic
- (d) Cast alloy-HSS-Carbide-Ceramic

Ans. (d)

Coated Carbide Tools

- Coated tools are becoming the norm in the metalworking industry because coating, can consistently improve, tool life 200 or 300% or more.
- In cutting tools, material requirements at the surface of the tool need to be abrasion resistant, hard, and chemically inert to prevent the tool and the work material from interacting chemically with each other during cutting.
- A thin, chemically stable, hard refractory coating of TiC, TiN, or Al_2O_3 accomplishes this objective.
- The bulk of the tool is a tough, shock-resistant carbide that can withstand high-temperature plastic deformation and resist breakage.

Contd...

- The coatings must be fine grained, & free of binders and porosity.
- Naturally, the coatings must be metallurgically bonded to the substrate.
- Interface coatings are graded to match the properties of the coating and the substrate.
- The coatings must be thick enough to prolong tool life but thin enough to prevent brittleness.
- Coatings should have a low coefficient of friction so that the chips do not adhere to the rake face.
- Multiple coatings are used, with each layer imparting its own characteristic to the tool.

Contd...

- The most successful combinations are TiN/TiC/TiCN/TiN and TiN/TiC/ Al_2O_3 .
- Chemical vapour deposition (CVD) is the technique used to coat carbides.

Contd...

Titanium carbide remains as the basic material covering the substrate for strength and wear resistance. The second layer is aluminum oxide which has proven chemical stability at high temperatures and resists abrasive wear. The third layer is a thin coating of titanium nitride to give the insert a lower coefficient of friction and to reduce edge build-up.

WC, Titanium carbide (TiC) as first layer—strength and wear resistance, Titanium nitride coating—low coefficient of friction, Aluminum oxide 2nd layer, Titanium carbide (TiC) as first layer—strength and wear resistance, Al_2O_3 Aluminum oxide 2nd layer—chemical stability at high temperature—resists abrasive wear.

Relative thickness of coatings: Titanium nitride coating, Aluminum oxide-2nd layer, Titanium carbide-1st layer, Carbide substrate.

FIGURE 22-6 Triple-coated carbide tools provide resistance to wear and plastic deformation in machining of steel, abrasive wear in cast iron, and built-up edge formation.

IAS-1999

The coating materials for coated carbide tools, includes

- (a) TiC, TiN and NaCN
- (b) TiC and TiN
- (c) TiN and NaCN
- (d) TiC and NaCN

Ans. (b)

TiN-Coated High-Speed Steel

- Coated high-speed steel (HSS) does not routinely provide as dramatic improvements in cutting speeds as do coated carbides, with increases of 10 to 20% being typical.
- In addition to hobs, gear-shaper cutters, and drills, HSS tooling coated by TiN now includes reamers, taps, chasers, spade-drill blades, broaches, bandsaw and circular saw blades, insert tooling, form tools, end mills, and an assortment of other milling cutters.

Contd...

- Physical vapour deposition (PVD) has proved to be the best process for coating HSS, primarily because it is a relatively low temperature process that does not exceed the tempering point of HSS.
- Therefore, no subsequent heat treatment of the cutting tool is required.
- The advantage of TiN-coated HSS tooling is reduced tool wear.
- Less tool wear results in less stock removal during tool regrinding, thus allowing individual tools to be reground more times.

Cermets

- These sintered hard inserts are made by combining 'cer' from ceramics like TiC, TiN or TiCN and 'met' from metal (binder) like Ni, Ni-Co, Fe etc.
- Harder, more chemically stable and hence more wear resistant
- More brittle and less thermal shock resistant
- Wt% of binder metal varies from 10 to 20%.
- Cutting edge sharpness is retained unlike in coated carbide inserts
- Can machine steels at higher cutting velocity than that used for tungsten carbide, even coated carbides in case of light cuts.
- Modern cermets with rounded cutting edges are suitable for finishing and semi-finishing of steels at higher speeds, stainless steels but are not suitable for jerky interrupted machining and machining of aluminium and similar materials.

IES 2010

The cutting tool material required to sustain high temperature is

- High carbon steel alloys
- Composite of lead and steel
- Cermet
- Alloy of steel, zinc and tungsten

Ans. (c)

IES-2000

Cermets are

- Metals for high temperature use with ceramic like properties
- Ceramics with metallic strength and luster
- Coated tool materials
- Metal-ceramic composites

Ans. (d)

IES – 2003

The correct sequence of cutting tools in the ascending order of their wear resistance is

- HSS-Cast non-ferrous alloy (Stellite)-Carbide-Nitride
- Cast non-ferrous alloy (Stellite)-HSS-Carbide-Nitride
- HSS-Cast non-ferrous alloy (Stellite)-Nitride-Carbide
- Cast non-ferrous alloy (Stellite)-Carbide-Nitride-HSS

Ans. (a)

Diamonds

- Diamond is the hardest of all the cutting tool materials.
- Diamond has the following properties:
 - extreme hardness,
 - low thermal expansion,
 - high heat conductivity, and
 - a very low co-efficient of friction.
- This is used when good surface finish and dimensional accuracy are desired.
- The work-materials on which diamonds are successfully employed are the non-ferrous one, such as copper, brass, zinc, aluminium and magnesium alloys.
- On ferrous materials, diamonds are not suitable because of the diffusion of carbon atoms from diamond to the work-piece material.

Contd..

- Diamond tools have the applications in single point turning and boring tools, milling cutters, reamers, grinding wheels, honing tools, lapping powder and for grinding wheel dressing.
- Due to their brittle nature, the diamond tools have poor resistance to shock and so, should be loaded lightly.
- Polycrystalline diamond (PCD) tools consist of a thin layer (0.5 to 1.5 mm) of fine grain- size diamond particles sintered together and metallurgically bonded to a cemented carbide substrate.
- The main advantages of sintered polycrystalline tools over natural single-crystal tools are better quality, greater toughness, and improved wear resistance, resulting from the random orientation of the diamond grains and the lack of large cleavage planes.

Contd..

- Diamond tools offer dramatic performance improvements over carbides. Tool life is often greatly improved, as is control over part size, finish, and surface integrity.
- Positive rake tooling is recommended for the vast majority of diamond tooling applications.
- If BUE is a problem, increasing cutting speed and the use of more positive rake angles may eliminate it.
- Oxidation of diamond starts at about 450°C and thereafter it can even crack. For this reason the diamond tool is kept flooded by the coolant during cutting, and light feeds are used.

IES-1995

Assertion (A): Non-ferrous materials are best machined with diamond tools.

Reason (R): Diamond tools are suitable for high speed machining.

- Both A and R are individually true and R is the correct explanation of A
- Both A and R are individually true but R is **not** the correct explanation of A
- A is true but R is false
- A is false but R is true

Ans. (b)

IES-2001

Assertion (A): Diamond tools can be used at high speeds.

Reason (R): Diamond tools have very low coefficient of friction.

- Both A and R are individually true and R is the correct explanation of A
- Both A and R are individually true but R is **not** the correct explanation of A
- A is true but R is false
- A is false but R is true

Ans. (c)

IES – 1999

Consider the following statements:

For precision machining of non-ferrous alloys, diamond is preferred because it has

- Low coefficient of thermal expansion
- High wear resistance
- High compression strength
- Low fracture toughness

Which of these statements are correct?

- 1 and 2
- 1 and 4
- 2 and 3
- 3 and 4

Ans. (a)

IES-1992

Which of the following given the correct order of increasing hot hardness of cutting tool material?

- (a) Diamond, Carbide, HSS
- (b) Carbide, Diamond, HSS
- (c) HSS, carbide, Diamond
- (d) HSS, Diamond, Carbide

Ans. (d)

IAS – 1999

Assertion (A): During cutting, the diamond tool is kept flooded with coolant.

Reason (R): The oxidation of diamond starts at about 450°C

- (a) Both A and R are individually true and R is the correct explanation of A
- (b) Both A and R are individually true but R is not the correct explanation of A
- (c) A is true but R is false
- (d) A is false but R is true

Ans. (a)

Cubic boron nitride/Borazon

- Next to diamond, cubic boron nitride is the hardest material presently available.
- It is made by bonding a 0.5 – 1 mm layer of polycrystalline cubic boron nitride to cobalt based carbide substrate at very high temperature and pressure.
- It remains inert and retains high hardness and fracture toughness at elevated machining speeds.
- It shows excellent performance in grinding any material of high hardness and strength.

Contd...

- The operative speed range for cBN when machining grey cast iron is 300 – 400 m/min
- Speed ranges for other materials are as follows:
 - Hard cast iron (> 400 BHN) : 80 – 300 m/min
 - Superalloys (> 35 R_C) : 80 – 140 m/min
 - Hardened steels (> 45 R_C) : 100 – 300 m/min
- It is best to use cBN tools with a honed or chamfered edge preparation, especially for interrupted cuts. Like ceramics, cBN tools are also available only in the form of indexable inserts.
- The only limitation of it is its high cost.

Contd...

- CBN is less reactive with such materials as hardened steels, hard-chill cast iron, and nickel- and cobalt-based superalloys.
- CBN can be used efficiently and economically to machine these difficult-to-machine materials at higher speeds (fivefold) and with a higher removal rate (fivefold) than cemented carbide, and with superior accuracy, finish, and surface integrity.

IES-1994

Consider the following tool materials:

- | | |
|------------|-------------|
| 1. Carbide | 2. Cermet |
| 3. Ceramic | 4. Borazon. |

Correct sequence of these tool materials in increasing order of their ability to retain their hot hardness is

- (a) 1,2,3,4
- (b) 1,2,4,3
- (c) 2, 1, 3, 4
- (d) 2, 1, 4, 3

Ans. (a)

IES-2002

Which one of the following is the hardest cutting tool material next only to diamond?

- (a) Cemented carbides
- (b) Ceramics
- (c) Silicon
- (d) Cubic boron nitride

Ans. (d)

IES-1996

Cubic boron nitride

- (a) Has a very high hardness which is comparable to that of diamond.
- (b) Has a hardness which is slightly more than that of HSS
- (c) Is used for making cylinder blocks of aircraft engines
- (d) Is used for making optical glasses.

Ans. (a)

IES-1994

Cubic boron nitride is used

- (a) As lining material in induction furnace
- (b) For making optical quality glass.
- (c) For heat treatment
- (d) For none of the above.

Ans. (d)

IAS-1998

Which of the following tool materials have cobalt as a constituent element?

- 1. Cemented carbide
- 2. CBN
- 3. Stellite
- 4. UCON

Select the correct answer using the codes given below:

Codes:

- (a) 1 and 2
- (b) 1 and 3
- (c) 1 and 4
- (d) 2 and 3

Ans. (b)

Coronite

- Coronite is made basically by combining HSS for strength and toughness and tungsten carbides for heat and wear resistance.
- Microfine TiCN particles are uniformly dispersed into the matrix.
- Unlike a solid carbide, the coronite based tool is made of three layers;
 - the central HSS or spring steel core
 - a layer of coronite of thickness around 15% of the tool diameter
 - a thin (2 to 5 μm) PVD coating of TiCN
- The coronite tools made by hot extrusion followed by PVD-coating of TiN or TiCN outperformed HSS tools in respect of cutting forces, tool life and surface finish.

IES-1993

Match List I with List II and select the correct answer using the codes given below the lists:

<p>List - I (Cutting tool Material)</p> <ul style="list-style-type: none"> A. High speed steel B. Stellite C. Diamond D. Coated carbide tool 	<p>List - II (Major characteristic constituent)</p> <ul style="list-style-type: none"> 1. Carbon 2. Molybdenum 3. Nitride 4. Columbium 5. Cobalt
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Codes:

A	B	C	D
(a) 2	1	3	5
(c) 5	2	4	3

Ans. (b)

IES-2003

Which one of the following is not a synthetic abrasive material?

(a) Silicon Carbide (b) Aluminium Oxide
 (c) Titanium Nitride (d) Cubic Boron Nitride

Ans. (b)

IES-2000

Consider the following tool materials:

1. HSS 2. Cemented carbide
 3. Ceramics 4. Diamond

The correct sequence of these materials in decreasing order of their cutting speed is

(a) 4, 3, 1, 2 (b) 4, 3, 2, 1
 (c) 3, 4, 2, 1 (d) 3, 4, 1, 2

Ans. (b)

IES-1999

Match List-I with List-II and select the correct answer using the codes given below the Lists:

<p>List I (Materials)</p> <p>A. Tungsten carbide B. Silicon nitride C. Aluminium oxide D. Silicon carbide</p>	<p>List II (Applications)</p> <p>1. Abrasive wheels 2. Heating elements 3. Pipes for conveying liquid metals 4. Drawing dies</p>
---	--

Code: A	B	C	D
(a) 3	4	1	2
(c) 3	4	2	1

A	B	C	D
(b) 4	3	2	1
(d) 4	3	1	2

Ans. (d)

IAS-2001

Match. List I (Cutting tool materials) with List II (Manufacturing methods) and select the correct answer using the codes given below the Lists:

<p>List I</p> <p>A. HSS B. Stellite C. Cemented carbide D. UCON</p>	<p>List II</p> <p>1. Casting 2. Forging 3. Rolling 4. Extrusion 5. Powder metallurgy</p>
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Codes:A	B	C	D
(a) 3	1	5	2
(c) 3	5	4	2

A	B	C	D
(b) 2	5	4	3
(d) 2	1	5	3

Ans. (d)

Attrition wear

- The strong bonding between the chip and tool material at high temperature is conducive for adhesive wear.
- The adhesive wear in the rough region is called attrition wear .
- In the rough region, some parts of the worn surface are still covered by molten chip and the irregular attrition wear occurs in this region .
- The irregular attrition wear is due to the intermittent adhesion during interrupted cutting which makes a periodic attachment and detachment of the work material on the tool surface.
- Therefore, when the seizure between workpiece to tool is broken, the small fragments of tool material are plucked and brought away by the chip.

IES-1996

The limit to the maximum hardness of a work material which can be machined with HSS tools even at low speeds is set by which one of the following tool failure mechanisms?

(a) Attrition
 (b) Abrasion
 (c) Diffusion
 (d) Plastic deformation under compression.

Ans. (a)

IES-2005

Consider the following statements: An increase in the cobalt content in the straight carbide grades of carbide tools

1. Increases the hardness.
2. Decreases the hardness.
3. Increases the transverse rupture strength
4. Lowers the transverse rupture strength.

Which of the statements given above are correct?

- (a) 1 and 3 (b) 2 and 4
(c) 1 and 4 (d) 2 and 3 **Ans. (d)**

The End