INVESTIGATION OF CRYOGENIC TREATED DRILL BIT

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ABSTRACT

We look into brief introduction of cryogenic treatment. Our focus throughout the report is more on cryogenic treatment of tool steel and high speed steel. In metal forming industry tools are exposed to very complex and rough surface conditions, which are the result of different effects (mechanical, thermal and chemical) and thus require well defined mechanical properties. Different approaches are followed to increase the surface properties of tool steels. The surface hardening treatments of steel has shown significant improvement of various properties including wear and fatigue resistance. Cryogenic treatment is yet another approach acknowledged by some to extend the tool life of many cutting tools. We will describe the complete procedure and investigate the effects on the metallurgical changes in the tool steel. However real mechanisms behind the better performance of tools are still in doubt. Studies in the given references on cryogenically treated tool steel shows micro structural changes in material that can influence the tool life. However little is gained from the experimental results showing involvement of carbide precipitations. Cryogenic treatments of carbides has yet to be extensively studied. In this paper drill bits are treated with cryogenic method and to predict the hardness, wear strength and other results are analysing.

Chapter-1

INTRODUCTION

Metal cutting process form the basis of engineering industry and is involved either directly or indirectly in the manufacture of nearly every product we use in our daily life. Over the years of demand and economic competition a lot of research is done leading to the increased performance of tools and increase in overall productivity. As manufacturers always need new materials that are lighter, stronger and more fuel efficient, it is clear that such materials must be so developed to give highest productivity. The most important part of designing of such cutting tools is material construction by careful selection.

. The properties that a drill bit material must process are as follows

- Capacity to retain form stability at elevated temperatures during high cutting speeds.
- Cost and ease of fabrication
- High resistance to brittle fracture
- Resistance to diffusion
- Resistance to thermal and mechanical shock

Developmental activities in the area of tool materials are guided by the knowledge of the extreme conditions of stress and temperature produced at the tool-work piece interface. Tool wear occurs by one or more complex mechanisms which includes abrasive wear, chipping at the cutting edge, thermal cracking etc. Since most of these processes are greatly accelerated by increased temperatures, the more obvious requirements for tool materials are improvements in physical, mechanical and chemical properties at elevated temperature.

Drilling is a process to make a well bore in ground to reach a typical targeted depth where we can extract crude oil , natural gas and petroleum. A Drill bit is set at end of drill string that breaks apart, cuts or crushes, rock structure when drilling a well bore. The drill bits are hollow and allow expulsion of drilling fluid at high velocity and high pressure helps to clean the bit and take apart the drilled cuttings.

HISTORY

- The first successful rolling cutter rock bit was introduced into the oil field by Howard Hughes Sr. in 1909.
- This was a two-cone bit with cones that did not mesh, The bit was redesigned with meshing teeth (self-cleaning) in the 1920s and in the early 1930's, the Tri-cone bit.
- The tri-cone bits was working on Intrusion, where teeth are forced into the rock by the weight-on-bit, and pulled through the rock by the rotary action.
- In starting era it was made from hardened steel then Tungsten Carbide used instead.
- In 1976,PDC bits came in oil and gas exploration.

DRILL BITS - THE DIFFERENT TYPES

- ❖ To drill a satisfactory hole in any material, the correct type of drill bit must be used; it must be used correctly and be sharpened as appropriate.
- ❖ Many jobs around the house require a hole of some kind to be drilled - whether it is putting up a shelf, building a cabinet or hanging a light fitting.
- ❖ For basic requirements, a set of high-speed steel twist drills and some masonry bits will probably be sufficient for the average handyman. But for more sophisticated jobs/material, others bits will be required - perhaps larger, or designed for a specific material/purpose.
- ❖ Good quality drill bits can be expensive, so take care of them, keep them in a case or box if possible, rather than allowing them to roll around loose in a toolbox where the cutting edges may be damaged.
- ❖ Learning how to sharpen drill bits is cost effective, it better to keep a bit sharp by occasional sharpening rather than waiting until it becomes really blunt. A sharp bit cuts better with less effort whether used in a power or hand drill. A sharp bit will also give a cleaner hole.

TWIST BITS

- ❖ Usually referred to as twist drills, twist bits are probably the most common drilling tools used by the handyman with either a hand or electric drill. The front edges cut the material and the spirals along the length remove the debris from the hole and tend to keep the bit straight.

- ❖ They can be used on timber, metal, plastics and similar materials. Most twist bits are made from either:
- 'high speed steel' (HSS), these are suitable for drilling most types of material, when drilling metal the HSS stands up to the high temperatures.
- 'carbon steel', these bits are specially ground for drilling wood and should not be used for drilling metals, they tend to be more brittle, less flexible than HSS bits.
- ❖ Twist bits are also available coated with Titanium nitride (TiN), these are easily identified by the gold like colour. This coating increases the hardness of the bit and adds a self-lubricating property. The coating is only really effective when metal is being drilled, it has little effect when working with other materials.

- ❖ Twist drills are usually available in sizes 0.8-12 mm plus. They are designed for drilling relatively small holes, they sometimes tend to clog quickly especially when the wood is 'green' so when drilling deep holes (especially in hardwood) the bits should be withdrawn regularly to remove the waste.

- ❖ Special care is required when using the smallest sizes since these bits are thin and brittle. Always hold the drill square to the work and apply only light pressure when drilling.

- ❖ Sharpening - use a drill sharpener, a grindstone jig or an oilstone.

- ❖ Titanium nitride bits cannot be sharpened without destroying the coating (although if the drill needs sharpening, the coating will probably have already been destroyed). Forming the correct angle at the tip is important for efficient cutting.

SCREWDRIVER BIT DRILLS

- ❖ Designed to fit in rechargeable screwdriver these bits have a hexagonal shank. They are ideal for drilling pilot holes but are limited by the low power of these type of screwdrivers and the limited size of small bits available.

- ❖ Sharpening - as for twist drills.

MASONRY BIT

- As the name suggests, these are designed for drilling into brick, block, stone, quarry tiles or concrete. The cutting tip is often made from tungsten carbide bonded to a spiralled steel shaft. Some masonry drills are described as 'durium tipped', this term refers to a highly durable silicon bronze alloy used instead of tungsten as the cutting point.

- Masonry drills are usually used in a power drill; although they can be used with a lot of effort in a hand brace. Most masonry bits can be used with a hammer action power drill, but always check as the action is quite punishing on the bit and cheaper bits have been known to shatter when subjected to the pounding. Always use a slow rotational speed for drilling into harder materials to avoid overheating the tip, and frequently withdraw the bit to remove dust.
- Long Masonry bits (300 to 400mm) are available for drilling through masonry walls.
- Bit sizes range from 4 to 16mm.
- Sharpening - use a drill sharpener or grindstone to sharpen the tungsten carbide tip.

SPUR POINT BIT

- Also known as a wood or dowel bit, they have a central point and two raised spurs that help keep the bit drilling straight. The bit cuts timber very fast when used in a power drill and leaves a clean sided hole. They are ideal for drilling holes for dowels as the sides of the holes are clean and parallel. Sizes range from 3 to 10mm. Spur point bits should only be used for drilling wood or some plastics.
- Sharpening - a bit fiddly as it has to be done by hand. Sharpen the point and spurs with a fine file or edge of a fine grindstone; the angle between the point and spurs should be 90°.

BULLET PILOT POINT

- With their central point and two spurs, Bullet drills resemble spur point bits, but can be used in metal, wood and plastics. Unlike normal twist drills, the twisted flutes are ground away; making a truer, more accurate bit than normal twist bits. They cut a clean hole and cause little damage when they break through the back of the workpiece.
- Bit sizes range from 1.5 to 13 mm.
- Sharpening - cannot be carried out satisfactorily.

COUNTERSINK

- Although not a true 'drill', it is used in a power or hand drill to form the conical recess for the heads of countersunk screws. These bits tend to be designed for use on soft materials such as timber and plastics, not metals. When used with a power drill to counter sink an existing hole, the bit tends to 'chatter', leaving a rough surface. Better results be will obtained if the countersink bit is used before the hole is drilled, then take care to ensure that the hole is in the centre of the countersunk depression.

- Countersinks are available with fitted handles so that they can be used by hand twisting, often easier than changing the bit in the drill when only a relatively few holes need countersinking.
- Sharpening: difficult, but can be done with a fine triangular file.

COUNTERSINK WITH CLEARANCE DRILL

- These combination bits are quite clever, they drill the clearance hole and countersinks it all in one stroke. Can be used in a power drill or some routers. Different bits are required for different size of clearance holes and they are probably not cost effective unless a large number of a given hole size need to be drilled and countersunk.
- Sharpening - difficult, due to shape of spur points.

TILE BIT

- A bit for drilling ceramic tiles and glass, it has a ground tungsten carbide tip. They can be used with a hand drill, but are best used in a variable speed power drill on a slow speed. When drilling glass, some form of lubricant (i.e. turpentine or white spirit) should be used to keep the tip cool.
- Ceramic tiles can also be drilled using a masonry bit if it is used at slow speed and without hammer action.
- Sharpening - difficult because of the hard tungsten carbide and curved cutting edge. With care and patience, a blunt edge can be made good using an oilstone.

FLAT WOOD BIT

- Intended for power drill use only, the centre point locates the bit and the flat steel on either side cuts away the timber. These bits are used to drill fairly large holes and they give a flat bottomed hole (with a central point) so are ideal where the head of a screw/bolt needs to be recessed into the timber - always use this bit before drilling the clearance hole for the bolt.
- The larger bits require a fairly powerful drill to bore deep holes. The bits cause a lot of splintering as they break out the back of the workpiece - using a sacrificial backing board will reduce this. Flat wood bits are not really suitable for enlarging an existing hole.
- Sizes range between 8 and 32mm.
- Sharpening - use a fine file, oilstone or grindstone.

TECHNOLOGICAL DEVELOPMENT

Tool materials have improved rapidly during the last sixty years and in many instances, the development of new tool materials has necessitated a change in the design trend of machine tools to make full use of the potentialities of tool materials for high productivity. Progress from carbon tool steels, high speed steels and cast alloys to carbides and ceramics has facilitated the application of higher speeds at each stage of development. With the advent of carbides and ceramics radical changes have taken place in the design of tool holders and cutters and the concept of the throw away tipped tool where the insert is held mechanically and is discarded after use represents a major advance in the metal removing technology of modern times. Till 1900 machining was performed by plain carbon tool steel, shortly after 1900 high speed steel was introduced which has undergone many modifications giving rise to several types of HSS. The next notable improvement came with the introduction of cobalt bonded sintered tungsten carbide. However shortage of tungsten has led to the development of many non-tungsten cutting tool materials. Ceramic tools exhibit very high hardness and wear resistance facilitating the use of higher cutting speeds. UCON a new tool material consisting of columbium, tungsten, titanium permits 60% increase in the cutting speed when compared with tungsten carbide. Cubic Boron Nitride with hardness next to diamond which is claimed to give speed 5 to 8 times that of carbide can be used to cut hardened materials.

Traditional tool materials such as HSS continue to undergo substantial improvement in there properties through suitable modifications in their composition by optimizing the processing technique as well as incorporating various surface treatments. As a result of these technological advances HSS are still in use having surviving competition from carbides and ceramics. Carbide because of the ability to retain its strength and hardness at very high temperatures, to withstand cutting speeds 6 or more than 6 times higher than tools of HSS and the economical price has become a logical choice of many cutting industries. However with the incorporation of suitable surface treatments, its service life as well as its properties can be enhanced even more.

SURFACE TREATMENTS

Advances in manufacturing technologies (increased cutting speeds, dry machining, etc.) triggered the fast commercial growth of various surface treatments for cutting tools; on the other hand these surface coating technologies enabled these advances in manufacturing technologies. No single treatment will solve every problem and their use should be restricted to those operations where extra expense of the treatment can be justified by a substantial performance gain. The processes of surface treatments more formally surface engineering tailor the surfaces of engineering materials to:

- Control friction and wear
- Improve corrosion resistance
- Change physical property
- Vary appearance
- Reduce cost

Special treatments such as cryogenic, magnetic and sonic treatment Cryogenic treatment is an inexpensive one time permanent treatment affecting the entire section or bulk of the component unlike coatings. The treatment is an add on process over conventional heat treatment in which the samples are cooled down to prescribed cryogenic temperature for a long time and then heated back to room temperature. It is believed that life of cutting tool get substantially extended due to cryogenic treatment. However, researchers have been skeptical about the process because it imparts no apparent visible change. Moreover mechanism is also unpredictable and research articles are also not sufficient to support the treatment. So in general cryogenic treatment is still in the dormant level.

Over the past few years there has been an increase in interest in the application of cryogenic temperature to different materials. Some literature says that the cryogenic treatment can improve the life span would depend a lot on the cutting conditions. Hence various research works are being carried out to study the effects of this treatment on the performance of various cutting tools so that it could be added to the regular heat treatment cycle for the components the production sector manufacture. However for evaluating the performance of the cutting tools it is very necessary to study the effect of cutting parameters (cutting speed, depth of cut and feed) on the tool wear. This necessitates planning experiments in advance so that maximum benefit can be derived from data obtained from organized sets of experiment. Designs of experiment (DOE) are one such approach that has proved to be a powerful technique in getting a quantitative relationship among the variables (in the form equations). One important benefit of DOE is that this not only evaluates the significant effect of each of the individual factors (parameters) but also determines the interaction effects among all the factors. When an interaction is large the corresponding main effect cease to have much meaning. Hence, it is very important to determine the interaction effects of various process variables to fully evaluate the performance of the tools.

OBJECTIVE

- To make a comparative study on the hardness and wear toughness of cryogenically treated HSS-CO drill bit with untreated drill bit.
- To study the effect of different drilling parameters on the tool life of cryogenically treated tool (HSS-CO).

Chapter-2
LITERATURE SURVEY

Methods to enhance the life of the component are based on application 12 of wear resistant materials or formation of hard, wear-resistant surface material. The wear rate of steels depends on their chemical constituents and conventional heat treatment as outlined by Suchanek and Kuklik (2009).

Susheel Kaila (2010) pointed out that cryogenics is an exciting, important and inexpensive method to increase the life of the steel component. It improves abrasive wear resistance, erosion and corrosion resistance and stabilizes the strength characteristics of the steels. Hasim et al (2002) pointed out that the cryogenic treatment of materials are gaining importance in recent days because of their potential to produce steel components that find enormous application in industries, nuclear power plants, fertilizer plants, medical, aerospace and avionics.

Due to the fact that materials treated under cryogenic environments attain superior properties that call for operation under severe environments as indicated by Charles and Arunachalam (2006)

In recent decades, there has been an increase in interest in the application of cryogenic treatment to different materials. Research has shown that cryogenic treatment increases product life, and in most cases, provides additional qualities to the product, such as stress relieving. In the area of cutting tools, extensive study has been done on tool steels, which include high-speed steel (HSS) and medium carbon steels. It has been reported that cryogenic treatment can double the service life of HSS tools, and also increase hardness and toughness simultaneously. In recent decades, there has been an increase in interest in the application of cryogenic treatment to different materials. Research has shown that cryogenic treatment increases product life, and in most cases, provides additional qualities to the product, such as stress relieving.

In the area of cutting tools, extensive study has been done on tool steels, which include high-speed steel (HSS) and medium carbon steels. It has been reported that cryogenic treatment can double the service life of HSS tools, and also increase hardness and toughness simultaneously. Cryogenic treatment of cutting tool materials such as tungsten carbide, have yet to be extensively studied. Tungsten carbide has been proven to be much more efficient than HSS when machining hard materials such as steel itself. If cryogenic treatments can double the service life of HSS, it could probably do the same for tungsten carbide tools. Unlike coatings that are only a superficial treatment, the cryogenic treatment is applied to the whole volume of the material, reaching the core of the tools. This guarantees maintenance of their properties even after regrinding or resharpening. One of the most prevalent claims in low-temperature treatment is an increase in wear resistance of certain steels. However, most researchers believe that cryogenic treatment promotes the complete transformation of retained austenite into martensite at cryogenic temperatures, which is attributed to improved wear resistance. Others claim that cryogenic treatment facilitates the formation of fine carbides in the martensite, thus improving the wear resistance. However, the lack of common sense in the literature regarding to the metallurgical aspects that cryogenic treatment confers better wear resistance and consequently higher tool lives as well as contradictory results that are also encountered lead to many doubts and questions involving the practical application of this sort of treatment.

Several different cryogenic processes have been tested by researchers. These involve a combination of deep freezing and tempering cycles. Generally, they can be described as a controlled lowering of temperature from room temperature to the boiling point of liquid nitrogen (−196 °C), maintenance of the temperature for about twenty four hours, followed by a controlled raising of the temperature back to room temperature. Subsequent tempering processes may follow. There are different levels of treatment temperatures. In order to avoid confusion, cryogenic treatment has been classified into shallow cryogenic treatment (SCT) and deep cryogenic treatment (DCT) depending upon the temperatures in which the material is treated. The common practice for shallow cryogenic treatment is to keep the specimens in a mechanical freezer at 193 K for 5 h and then exposed to room temperature. But in deep cryogenic treatment the materials are slowly brought down from room temperature to 77 K at 1.26 K/min, held at the same temperature for 24 h and subsequently brought back to room at 0.63 K/min. In order to achieve deep cold temperatures, materials cannot be directly kept in freezer at 77 K similar to that of shallow cryogenic treatment because the temperature difference is very high and fast cooling will lead to quench cracks. The conventional heat treatment normally uses cooling conditions only until room temperature, which may leave some retained austenite on the microstructure. This fact must be considered during heat treatment of tool steels. This retained austenite is soft and unstable at lower temperatures that it is likely to transform into martensite under certain conducive conditions.

It should be noted that freshly formed martensite is also brittle and only tempered martensite is acceptable. To further aggravate this problem the transformation of austenite to martensite yields a 4% volume expansion causing distortion which cannot be ignored. Thus retained austenite should be alleviated to the maximum possible before any component or tool is put into service. The degree of under cooling decides the potential to transform retained austenite to martensite completely. In this context cryogenic treatment is handy. It also causes the precipitation of finely dispersed carbides in the martensite. It would be the interest of researchers to quantify the benefits and also know the conditions at which the treatment derives maximum benefits. For instance in case of the eutectoid steel the M_f temperature is of approximately of −50 °C, therefore after quenching some percentage of retained austenite will be present. Lately this structure can be transformed into martensite if the material is submitted to reheating or to a stress field, causing distortion on its body. This non-tempered martensite may cause cracks, particularly in complex shape tools made of highly alloyed steels. The subzero treatment will transform a great deal of this retained austenite by reaching the M_f line, giving more dimensional stability in the tool microstructure. The main variables during heat treatment have a great deal of influence on the results. A research done in steels equivalent to M2, varying the cryogenic cycles has quantified the precipitated particles and verified their influence onto the material properties. Their research involved seven steel samples, each of them submitted to different heating and cooling (up to −70 °C) cycles. The microstructure was analyzed and the carbide particles quantified using SEM, X-ray difractometer, quantitative metallography and differential dilatometer. The results confirmed an increase in carbide precipitation (from 6.9% to 17.4%), a reduction of the retained austenite (from 42.6% to 0.9%) and an increase in the martensite content (from 66% to 81.7%).

The machining tests carried out with bits in turning AISI 1050 steels showed a significant increase in tool lives of cryogenically treated tools. These results can be attributed to minimum quantity of retained austenite, higher amount of martensite content, higher density of fine carbides (smaller than 1 μm) and a more favourable distribution of the alloying elements among the carbide of the matrix. When temperature was applied in the range of −80 to −100 °C for periods of about 30 min–1 h, and the improvement on tool life was credited to the transformation of retained austenite (softer) into martensite (harder) and the production of a more stable structure. In general the addition of alloying elements lowers the M_s (temperature of the beginning of martensite transformation) and M_f (final transformation temperature) lines in a way that the latter dwells at subzero temperatures. Barron after cryogenically treating several materials including the M2 high speed steel at −84 °C (maintaining it at this temperature for 24 h) observed a significant improvement on the wear resistance in sliding abrasion tests when compared to conventionally heat treated steel (quenched and tempered). When the temperature of the cryogenic treatment was reduced further to −196 °C, the wear resistance was increased even more. He has attributed the improvement of the wear resistance of these tools to another mechanism besides the transformation of the retained austenite into martensite. He verified that the tool steels submitted to conventional heat treatment presented only a small amount of retained austenite, but those submitted to cryogenic treatment showed better performance during machining. This new mechanism would be time and temperature dependent due to the long period (8 h or more) during which the tools would have to stay at cryogenic temperatures. Before the cryogenic treatment the microstructure showed relatively large carbides (20 μm) dispersed in the matrix. After the cryogenic treatment, carbide particles as small as 5 μm were found. The carbide refinement could in such a way contribute to the improvement of the wear resistance of the tool. Barron thus attributed this achievement both to austenite transformation and to the presence of hard and small carbide particles well distributed among the larger carbide particles within the martensite matrix.

Dong et al. did a detailed study on the effects of varying the deep freezing and tempering cycles on high speed steel and confirmed that in tool steels, this treatment affects the material in two ways. Firstly, it eliminates retained austenite, and hence increases the hardness of the material. Secondly, this treatment initiates nucleation sites for precipitation of large numbers of very fine carbide particles, resulting in an increase in wear resistance. Popandopulo and Zhukova carried out dilatometry studies and microstructure analysis during cryogenic treatment. They observed volume reduction of the specimen at the temperature range of −90 to +20 °C. This behaviour was attributed to partial decomposition of the martensite and precipitation of carbon atoms at dislocation lines and formation of ultramicroscopic carbides.

Paulin also verified the presence of fine precipitated carbide particles and their importance to the material properties. The precipitated carbides reduce internal tension of the martensite and minimize micro cracks susceptibility, while the uniform distribution of fine carbides of high hardness enhances the wear resistance. Huang et al. confirmed that cryogenic treatment not only facilitate the carbide formation but can also make the carbide distribution more homogeneous.

Yun et al. verified changes in the microstructure of M2 high speed steel when this material was submitted to different cycles of cryogenic treatment at −196 °C. Comparing the conventional quenching cycle with other cryogenic cycles it was observed increases of 11.5% in the bending strength, 43% in the toughness and changes in the room temperature and hot hardness. The results were again attributed to transformation of the retained austenite into martensite and precipitation of ultra-fine carbides, with this latter being considered the key point for the changes in the properties.

Molinari found out that the deep cryogenic treatment (−196°C) of quenched and tempered high speed steel tools improves their properties; in particular, it increases the hardness and improves the hardness homogeneity, reduces the tool consumption and the down time for the equipments set up, thus leading to about 50% cost reduction. The greatest improvement in properties is obtained by carrying out the deep cryogenic treatment between quenching and tempering. However, a significant improvement can be obtained even by treating the tools at the end of the usual heat treatment cycle, i.e. the finished tools. This last solution is more flexible than the other one and can extend the use of the treatment to many practical applications. Mohan Lal et al., made a comparative study on wear resistance improvement of cryogenically treated samples with standard heat-treated samples through flank wear test and sliding wear test. Un tempered samples when cryogenically treated yield 3%, 10% and 10.6% extra life over tempered and cryogenically treated T1, M2 and D3 samples, respectively. Hence it is suggested to cryogenically treat without tempering. Tempered samples when cryogenically treated at 133 K for 24 h yielded negative results, but when cryogenically treated at 93 K for 24 h the results were favourable. Hence tempered samples if treated at still lower temperatures may yield still better results on par with un tempered cryo treated samples. This also suggested concluding that the stabilization of phases that would take place during tempering requires sufficient degree of under cooling and time to get transformed to stable harder/tougher phases that offer better wear resistance. Cryogenic treatment done at 93 K as per the prescribed cycle yields 20% extra life as compared to the maximum life achieved through cold treatment. Cryogenic treatment at 93K for 24 hours is superior to TiN coatings also. The effect of cryo treatment on TiN coating is not favourable which may be because of uneven contraction of the coating material and the substrate leading to incipient cracks at the interface. Hence cryotreatment should not follow TiN coating.

Chapter-3
MATERIALS AND METHODS

HSS DRILL BIT

High speed steel (HSS) is a form of tool steel. HSS bits are much more resistant to heat. They can be used to drill metal, hardwood, and most other materials at greater cutting speeds than carbon steel bits.HSS tools are so named because they were developed to cut at higher speeds. Developed around 1900 H S S is the most highly alloyed tool steels. The tungsten (T series) was developed first and typically contains 12 - 18% tungsten, plus about 4% chromium and 1 - 5% vanadium. Most grades contain about 0.5% molybdenum and most grades contain 4- 12% cobalt. Cryogenic treatment on HSS will result in the conversion of retained austenite into martensite. This results in increase in hardness of HSS drill bit due to increase in density of dislocation and gaps.

FIG. DRILL BIT(HSS)

SELECTION OF MATERIAL
HIGH SPEED COBALT (HSS-CO)

Cobalt drill bits are made from cobalt steel blended with a fairly large percentage of cobalt. The cobalt actually makes the drill bit incredibly hard, with an abrasion quality. Cobalt bits are also superior for their resistance to heat. Cobalt drill bits are particularly successful in cutting through hard metals such as stainless steel and cast iron, although they can be used for softer materials, too.The main effect of cobalt in high speed tool steel is to increase the hot hardness and thus to increase the cutting efficiency when high tool temperatures are attained during the cutting operation. Cobalt raises the heat-treating temperatures because it elevates the melting point. Hardening temperatures for cobalt high-speed tool steels can be 14 to 28 °C (25 to 50 °F) higher than would be normal for similar grades without cobalt. Cobalt additions slightly increase the brittleness of highspeed tool steels.

Different types of drill bits are used to cut holes in different types of materials. Diamond drill bits are used for materials such as glass and tile; black oxide bits are common for plastics and carbon. Cobalt drill bits are particularly successful in cutting through hard metals such as stainless steel and cast iron, although they can be used for softer materials, too. Cobalt drill bits are not made of pure cobalt, but rather a steel alloy with 5 to 8 percent cobalt. The 5-percent alloy is known as M35 grade, and the 8-percent alloy is M42. The cobalt increases the strength of the steel and makes it more heat-resistant; this is an important factor in drilling hard materials because the friction of metal against metal can produce high temperatures that damage the material or the drill bit. Bosch, for instance, makes a cobalt drill bit that can withstand temperatures of up to 1,100 degrees Fahrenheit (593 degrees Celsius).

New cobalt drill bits are a dull gold color, making them distinctive on the shelf (or in your toolbox). The color occurs when the drill bits are baked in the process of production; it's not a paint or plating -- cobalt drill bits are cobalt alloy through and through. For this reason, they can be sharpened relatively easily with cutting fluid while retaining their strength and durability (although the gold color may wear off)

FIG. DRILL BIT(HSS-CO)

HISTORY

Although development of modern high speed steel began in the second half of the 19th century, there is documented evidence of steels produced earlier with similar content. These include hardened steels in China in 13th century BC, wootz steel manufactured in India around 350 BC and production of Damascus and Japanese layered steel blades in years 540 AD and 900 AD. High speed properties of those steels would be mostly coincidental (as no machining technology that involved quantification of speeds and feeds existed at the time) and would be the result of local iron ores containing natural traces of tungsten or other favorable alloying components. In 1868 the English metallurgist Robert Forester Mushet developed Mushet steel, considered to be the forerunner of modern high speed steels. It consisted of 2% carbon (C), 2.5% manganese (Mn), and 7% tungsten (W).

The major advantage of this steel was that it hardened when air cooled from a temperature at which most steels had to be quenched for hardening. Over the next 30 years the most significant change was the replacement of manganese (Mn) with chromium (Cr). In 1899 and 1900, Frederick Winslow Taylor and Maunsel White, working with a team of assistants at the Bethlehem Steel Company at Bethlehem, Pennsylvania, US, performed a series of experiments with the heat treating of existing high-quality tool steels, such as Mushet steel, heating them to much higher temperatures than were typically considered desirable in the industry. Their experiments were characterised by a scientific empiricism in that many different combinations were made and tested, with no regard for conventional wisdom or al chemic recipes, and with detailed records kept of each batch. The end result was a heat treatment process that transformed existing alloys into a new kind of steel that could retain its hardness at higher temperatures, allowing much higher speeds and rate of cutting when machining.

The Taylor-White process was patented and created a revolution in the machining industries. Heavier machine tools with higher rigidity were needed to use the new steel to its full advantage, prompting redesigns and replacement of installed plant. The patent was hotly contested and eventually nullified. The first alloy that was formally classified as high-speed steel is known by the AISI designation T1, which was introduced in 1910. It was patented by Crucible Steel Co. at the beginning of the 20th century. Although molybdenum-rich high-speed steels such as AISI M1 have been used since the 1930s, material shortages and high costs caused by World War II spurred development of less expensive alloys substituting molybdenum for tungsten. The advances in molybdenum-based high speed steel during this period put them on par with and in certain cases better than tungsten-based high speed steels. This started with the use of M2 steel instead of T1 steel

TYPES

High speed steels are alloys that gain their properties from either tungsten or molybdenum, often with a combination of the two. They belong to the Fe–C–X multi component alloy system where X represents chromium, tungsten, molybdenum, vanadium, or cobalt. Generally, the X component is present in excess of 7%, along with more than 0.60% carbon. The alloying element percentages do not alone bestow the hardness-retaining properties; they also require appropriate high-temperature heat treatment to become true HSS; see History above. In the unified numbering system (UNS), tungsten-type grades (e.g. T1, T15) are assigned numbers in the T120xx series, while molybdenum (e.g. M2, M48) and intermediate types are T113xx. ASTM standards recognize 7 tungsten types and 17 molybdenum types. The addition of about 10% of tungsten and molybdenum in total maximises efficiently the hardness and toughness of high speed steels and maintains those properties at the high temperatures generated when cutting metals.

PROPERTIES OF HIGH. SPEED TOOL

Steels High-speed tool steels, regardless of whether they are an AISI M-type or T-type, have a rather striking similarity in their physical makeup:

- They all possess a high-alloy content
- They usually contain sufficient carbon to permit hardening to 64 HRC
- They harden so deeply that almost any section encountered commercially will have a uniform hardness from center to surface
- They are all hardened at high temperatures, and their rate of transformation is such that small sections can be cooled in still air and be near maximum hardness hardened high-speed tool steel.

By partially dissolving during heat treatment, these carbides provide the matrix of the steel with the necessary alloy and carbon content for hardenability, hot hardness, and resistance to tempering. While all high-speed tool steels have many similar mechanical and physical characteristics, the properties may vary widely due to changes in chemical composition. Basically, the most important property of a high-speed tool steel is its cutting ability. Cutting ability depends on a combination of properties, the four most important of these being:

HARDNESS

Resistance to penetration by diamond-hard indenter, measured at room temperature hot hardness the ability to retain high hardness at elevated temperatures

WEAR RESISTANCE

Resistance to abrasion, often measured by grind ability, metal-to metal, or various other types of tests to indicate a relative rating

TOUGHNESS

Ability to absorb (impact) energy the relative importance of these properties varies with every application. High machining speeds require a composition with a high initial hardness and a maximum resistance to softening at high temperatures. Certain materials may abrade the cutting edge of the tool excessively; hence, the wear resistance of the tool material may well be more important than its resistance to high cutting temperatures. Hardness is necessary for cutting harder materials and generally gives increased tool life, but it must be balanced against the toughness required for the application.

SELECTION OF METHODS

CRYOGENIC TREATMENT

Introduction

Cryogenics is defined as the branches of physics and engineering that study very low temperatures, how to produce them, and how materials behave at those temperatures. Rather than the familiar temperature scales of Fahrenheit and Celsius, cryogenicists use the Kelvin and Rankine scales. The word cryogenics literally means "the production of icy cold"; however the term is used today as a synonym for the low-temperature state. It is not well-defined at what point on the temperature scale refrigeration ends and cryogenics begins. The workers at the National Institute of Standards and Technology at Boulder, Colorado have chosen to consider the field of cryogenics as that involving temperatures below –180 °C (93.15 K). This is a logical dividing line, since the normal boiling points of the so-called permanent gases (such as helium, hydrogen, neon, nitrogen, oxygen, and normal air) lie below -180 °C while the Freon refrigerants, hydrogen sulfide, and other common refrigerants have boiling points above -180 °C.

Cryogenic temperatures are achieved either by the rapid evaporation of volatile liquids or by the expansion of gases confined initially at pressures of 150 to 200 atmospheres. The expansion may be simple, that is, through a valve to a region of lower pressure, or it may occur in the cylinder of a reciprocating engine, with the gas driving the piston of the engine. The second method is more efficient but is also more difficult to apply. Cryogenic treatment is a one-time permanent treatment process and it affects the entire cross-section of the material usually done at the end of conventional heat treatment process but before tempering. Also it is not a substitute process but rather a supplement to conventional heat treatment process. It is believed to improve wear resistance as well the surface hardness and thermal stability of various materials.

This treatment is done to make sure there is no retained austenite during quenching. When steel is at the hardening temperature, there is a solid solution of Carbon and Iron, known as Austenite. The amount of martensite formed at quenching is a function of the lowest temperature encountered. At any given temperature of quenching there is a certain amount of martensite and the balance is untransformed austenite. This untransformed austenite is very brittle and can cause loss of strength or hardness, dimensional instability, or cracking. The structure of austenite and martensite. Quenches are usually done to room temperature. Most medium carbon steels and low alloy steels undergo transformation to 100 % martensite at room temperature. However, high carbon and high alloy steels have retained Austenite at room temperature. To eliminate retained Austenite, the temperature has to be lowered.

Liquefied gases, such as liquid nitrogen and liquid helium, are used in many cryogenic applications. Liquid nitrogen is the most commonly used element in cryogenics and is legally purchasable around the world. Liquid helium is also commonly used and allows for the lowest attainable temperatures to be reached. These gases are held in either special containers known as Dewar flasks, which are generally about six feet tall (1.8 m) and three feet (91.5 cm) in diameter, or giant tanks in larger commercial operations. Cryogenic transfer pumps are the pumps used on LNG piers to transfer Liquefied Natural Gas from LNG Carriers to LNG storage tanks.

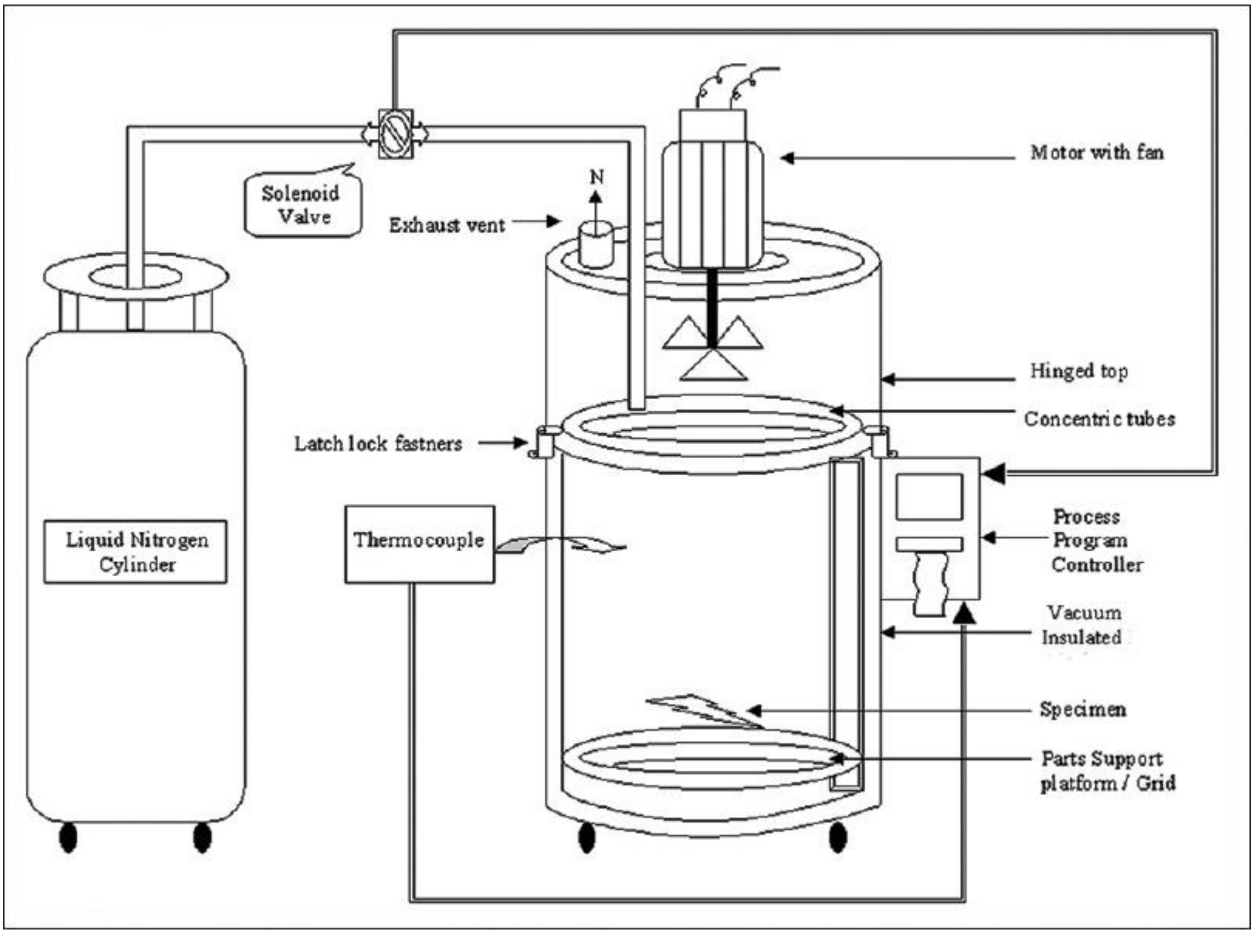
THE MAKING OF LIQUID NITROGEN

A common method for production of liquid nitrogen is the liquefaction of air. Liquefaction is the phase change of a substance from the gaseous phase to the liquid phase. In the liquid nitrogen compressors or generators, air is compressed, expanded and cooled via the Joule-Thompson's effect as depicted and **the set up for making nitrogen.** Since nitrogen boils at a different temperature than oxygen, the nitrogen can be distilled out of the liquid air, recompressed and re-liquefied. Once liquid nitrogen is removed from the distillation chamber it is stored in a pressurized tank or a well insulated deewar flask. Liquid nitrogen is converted to a gas before it enters the chamber so that at no time does liquid nitrogen come in to contact with the parts assuring that the dangers of cracking from too rapid cooling are eliminated.

Fig. Set up for nitrogen making

CRYOGENIC TREATMENT PROCEDURE

The liquid nitrogen as generated from the nitogen plant is stored in storage vessels. With help of transfer lines, it is directed to a closed vacuum evacuated chamber called cryogenic freezer through a nozzle. The supply of liquid nitrogen into the cryo freezer is operated with the help of soleniod valves. Inside the chamber gradual cooling occurs at a rate of 2º C /min from the room temperature to a temperature of -80º C. Once the sub zero temperature is reached, specimens are transferred to the nitrogen chamber or soaking chamber where in they are stored for 24 hours with continiuos supply of liquid nitrogen. **Fig** illustrates the **entire set up for cryogenic treatment**. The entire process is schematically.

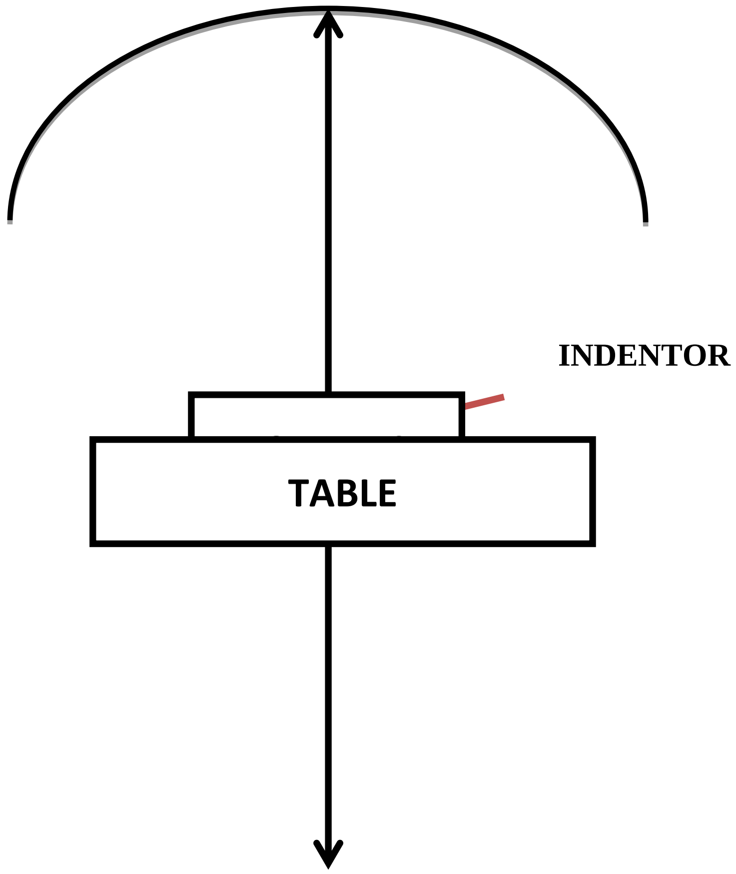


Cryogenic treatment

Chapter-4
EXPERIMENTAL TESTING

HARDNESS TEST

This gives the metals ability to show resistance to indentation which show it's resistance to wear and abrasion. Hardness testing of welds and their Heat Affected Zones (HAZs) usually requires testing on a microscopic scale using a diamond indenter.



SELECTION OF TEST
ROCKWELL HARDNESS TEST

Stanley P. Rockwell invented the Rockwell hardness test. He was a metallurgist for a large ball bearing company and he wanted a fast non-destructive way to determine if the heat treatment process they were doing on the bearing races was successful. The only hardness tests he had available at time were Vickers, Brinell and Scleroscope. The Vickers test was too time consuming, Brinell indents were too big for his parts and the Scleroscope was difficult to use, especially on his small parts

To satisfy his needs he invented the Rockwell test method. This simple sequence of test force application proved to be a major advance in the world of hardness testing. It enabled the user to perform an accurate hardness test on a variety of sized parts in just a few seconds.

TYPES OF THE ROCKWELL TEST

There are two types of Rockwell tests: 1. Rockwell: the minor load is 10 kgf, the major load is 60, 100, or 150 kgf. 2. Superficial Rockwell: the minor load is 3 kgf and major loads are 15, 30, or 45 kgf. In both tests, the indenter may be either a diamond cone or steel ball, depending upon the characteristics of the material being tested. If no specification exists or there is doubt about the suitability of the specified scale, an analysis should be made of the following factors that control scale selection:

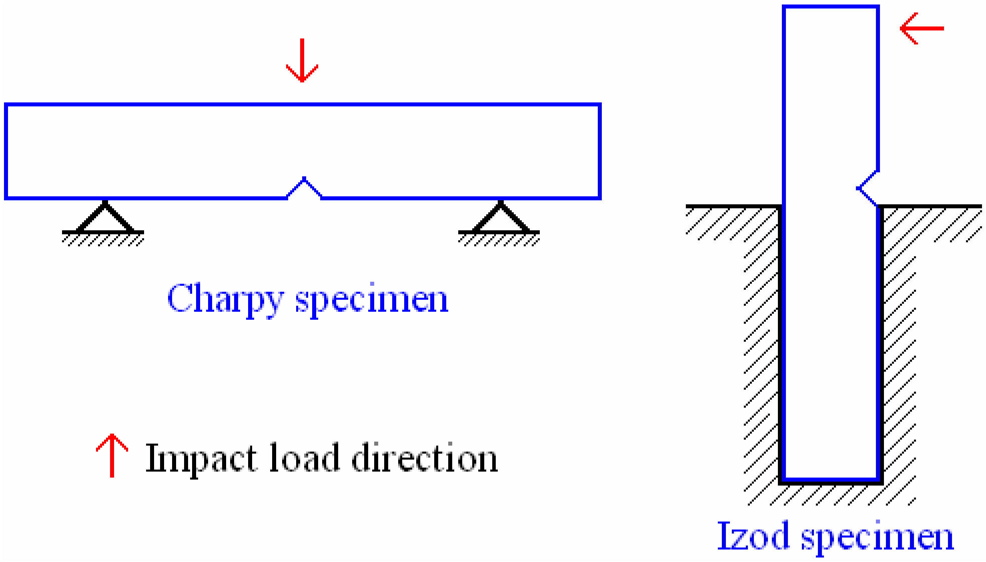
- Type of material
- Specimen thickness
- Test location
- Scale limitations

PRINCIPE OF THE ROCKWELL TESTS

- The indenter moves down into position on the part surface
- A minor load is applied and a zero reference position is established
- The major load is applied for a specified time period (dwell time) beyond zero
- The major load is released leaving the minor load applied The resulting Rockwell number represents the difference in depth from the zero reference position as a result of the application of the major load.

TOUGHNESS TEST

The principal measurement from the impact test is the energy absorbed in fracturing the specimen. Energy expended during fracture is sometimes known as notch toughness. The energy expended will be high for complete ductile fracture, while it is less for brittle fracture. However, it is important to note that measurement of energy expended is only a relative energy, and cannot be used directly as design consideration. Another common result from the Charpy test is by examining the fracture surface. It is useful in determining whether the fracture is fibrous (shear fracture), granular (cleavage fracture), or a mixture of both.



Fracture toughness test

The fracture toughness of the composite specimens was measured using Fracture Tester (MTS 810 material test system) as shown in Figure 7. The specimens were cut according to dimensions as specified by the ASTM E1820; this test method is for the opening mode (Mode I) of loading. The objective of this test method is to load a fatigue pre cracked test specimen as shown in Figure 8 to induce either or both of the following responses:

- Unstable crack extension, including significant pop-in, referred to as “fracture instability” in this test method;
- Stable crack extension, referred to as “stable tearing” in this test method.

Toughness determined at the point of instability. Stable tearing results in continuous fracture toughness versus crack extension relationship (R-curve) from which significant point-values may be determined. Stable tearing interrupted by fracture instability results in an R-curve up to the point of instability. This investigation split into two major computation scopes to estimate the fracture toughness and energy release rate: it include the experiment data for fiber reinforcement epoxy composites specimens. Meanwhile, the compact tension (CT) specimen was instructed according to the ASTM E 1820 standard for the fracture toughness measurement. The thickness was 10mm for all the specimens, while the initial notch length to specimen was between 10mm and the notch tip was sharpened with a razor blade to simulate a sharp crack.

Chapter-5
ADVANTAGES
CRYOGENIC TREATMENT ADVANDAGES

- Transforms almost all soft retained austenite to hard marten site,.
- Increases abrasive wear resistance,
- Increases tensile strength, toughness and stability,
- Decreases residual stresses,
- Effective Micro Structural changes.
- Decreases brittleness,
- The result is a larger contact surface area that reduces friction, heat and wear
- Increases durability or wear life,
- Reduction of ideal time of machine parts for replacement.

Chapter-6
APPLICATION

- ❖ USING INDUSTRIAL COMPONENTS

Chapter-7
CONCLUSION

Comparative study on the hardness and toughness of cryogenically treated HSS drill bit with that of untreated drill bit. In the sliding wear test, the weight loss of cryogenically treated drill bits is more as compared to that of untreated drill bits.
By this technique specially hardness, wear resistance, corrosion resistance, toughness increases. Cryogenics materials will be part of the dynamic future. We must not only continue to make incremental improvements in present materials but develop whole new technologies of manufacturing and processing for to achieve the highest performance in cryogenics materials field. Cryogenics-based technologies have applications in wide variety of areas as metallurgy, chemistry, power industry, medicine, rocket propulsion and space simulation, food processing.

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