Diamond Sintering etc

Information

Diamond

Bill Short

SHORT CUTS

IN DIAMOND DRILLING TECHNOLOGY

DIAMOND IMPREGNATION OF TUNGSTEN CARBIDE MATRIX MATERIALS WITH INCREASED COMPACTION "HOT PRESSING"

Two common uses of diamond impregnation are currently in use for petroleum application diamond drill bits . the most common application is meant to be used in extremely hard , broken and abrasive formations where conventional diamond size and exposure cannot be reduced enough to prevent abrasive wear heat build-up and/or impact loading diamond breakage . The method used to impregnate the extremely small mesh diamonds in this case is very simply to premix with WC powder and tamp the desired blade thickness into the bit mold and infiltrate normally . The resulting impregnated blade usually does not exceed 20% diamond content (by volume) and is intended for very small diamond penetration that approaches grinding . The surrounding matrix material is of normal compaction and hardness and never acts as a cutting element itself .

The other current diamond impregnation method is intended for a very different application , extremely soft , fast drilling formations that are low in abrasion. Although usually called a blade bit , each cutting element is intended to penetrate the formation as much as 1/4" so matrix as well as diamonds act as a single cutting unit . The harder , more dense matrix that surrounds the diamonds must be formed by infiltrating under increased compaction , or by Hot Pressing . Diamond concentration can be , but not always is , about 40 to 50% by volume .

9714 LANWARD
DALLAS, TEXAS 75238
214 - 348-5300

Most fabricators limit diamond concentration to the leading edge of the cutter , mainly for cost efficiency , where it is needed most . The majority of the cutters made by this method are relatively large , 1"x1" x 1/2" thick , and are made at the same temperature as the bit body matrix in which it is to be used . The specific manufacturing method used by two bit fabricators in particular is said to be proprietary information and cannot be discussed in this report . The generally accepted method for Hot Pressing industry wide is to use a piston/cylinder high grade Graphite mold assembly with sufficient piston travel to account for the usual volume reduction that occurs during infiltration . This will vary according to the total binder contained in the matrix powder mix . If a large percentage by weight of binder is used (40% or more) , volume reduction and piston travel will be great and the resulting matrix will be relatively soft . The maximum pressure seen in practical production using ATJ Graphite has not exceeded about 2000 $lbs./in^2$ when a single ram (vertical) press has been used . Graphite distortion usually occurs above this tonnage and can be prevented partially by the use of a side ram that simply aids the mold assembly in resisting distortion . The maximum pressure achieved in this manner as directly witnessed by the author is about 10,000 psi . The resulting matrix had a hardness of about 60 Rockwell "C" , about twice that of the same materials infiltrated normally . Binder content was about 15% by weight (about 30% by volume) and a product volume reduction of about 50% was seen upon infiltration .

9714 LANWARD
DALLAS, TEXAS 75238
214-348-5300

SHORT CUTS
IN DIAMOND DRILLING TECHNOLOGY

A ONE HOUR INTRODUCTION TO OIL AND GAS DRILLING

Generally , the term petroleum is used to designate a large number of gaseous and liquid hydrocarbons found throughout the earth . The two more common forms that are commercially drilled for are crude oil and natural gas . The vast majority of oil and gas deposits are found in sedimentary rocks , or rocks that have been formed by the settling of mineral or organic particles that through many millions of years have been cemented together to form a compacted , hard sedimentary rock formation . The more popular theories of petroleum deposit formation state that plant and animal remains of long ago are transformed into petroleum by bacterial action , heat , pressure , catalytic reactions and perhaps radioactive bombardment . Oil and gas deposits are rarely found in commercial quantity in the rock in which they were formed , but in porous formations to which they have migrated and been trapped by non-porous sealing or capping formations . These subsurface geological structures are formed by naturally occuring earth movements and can be identified by modern seismic exploration . The three most common rock types associated with oil and gas resrvoirs are andstone, limestone, and shale . Typically, oil reservoirs are either sandstone or limestone while caprocks are most usually shale and act as the confining formation that traps the petroleum and allows it to accumulate . Petroleum geology is much too complex to even capsulize in one hour , but it is hoped that the above brief discussion will suffice .

9714 LANWARD
DALLAS, TEXAS 75238
21[illegible] - 348-5300

The modern rotary drilling rig system in use today evolved from the first such rig that was used in 1901 . The main functions of the rig are to hoist, rotate, pump and move .

HOIST- To lift the pipe and bit in and out of the hole and all other pulling , torquing and pushing requires thousands of horsepower and is transferred to the work to be done by the use of gearing , braking , block and tackle and sometimes air and electric motors known as the "DRAW WORKS" .

ROTATE- In order to disrupt the formation , the bit must be rotated at the end of the "DRILL STRING" made up of the "DRILL PIPE" that comes in "JOINTS" of about 30 ft. each and usually put into "STANDS" of three joints each to allow faster "TRIPPING" of the string in and out of the hole . The "DRILL COLLARS" are much thicker, heavier pipe that are placed nearest the bit to add weight to the string and sometimes to help stabilize the string . The entire string must be rotated by the "ROTARY TABLE" and still allowed downward movement at the same time . This is done by use of the "KELLY BUSHING" and the four or six sided pipe called the "KELLY" . The kelly is attatched to the "SWIVEL" that allows fluid to be circulated through it as it rotates . The swivel is latched into the "HOOK" which is part of the "TRAVELING BLOCK" to which lines are strung in block and tackle manner .

PUMP- "MUD PUMPS" are used to list drilling fluid from the "MUD PITS" and force it up the "STAND PIPE" and the "KELLY HOSE" which is attatched to the swivel . The fluid is forced down through the kelly and the entire drill string and out through restrictions in the bit sometimes called "JETS" , thus assisting in the disruption and removal of the "CUTTINGS" formed by the bit . The mud continues up the "ANNULUS" between the drill string snd well bore , carrying with it the cuttings and other debris all the way up to the surface and out into the FLOW LINE" that empties across the vibrating screens called a "SHALE SHAKER" that filters the rock cuttings out of the mud . The cuttings are dumped into earthen "RESERVE PITS" . The mud is sometimes additionally filtered of fine-grained solids by use of "DESANDERS" and "DESILTERS" . The mud is then pumped back into the mud pits where it is recirculated back through the pump and down the hole . One "FULL CIRCULATION" is the time it takes at a given circulation rate for the fluid to travel from the pump through the drill string and annulus to the flow line . "BOOTOMS UP" refers to the time or amount of pump strokes to lift cuttings from the bit to the shale shaker .

The typical well is started by a proceedure called "STAKING" in which a survey party precisely determines the exact surface location as dictated by the geologists and places a stake in the ground where drilling is to start . The rig location is then prepared by leveling the ground and digging whatever earthen pits may be required . In some cases a concrete "CELLAR" is dug to provide easier confinement of spilled fluids and better conservation of the earthen foundation . Water wells must be drilled and/or water supply lines laid and facilities established for crew and support members . In most cases living quarters are created at least for the round the clock personel such as the rig "TOOLPUSHER" and the operator's representative or"COMPANY MAN" . The rig site completed , the rig is then moved onto the location and "RIGGING UP" then takes place , where the seperate pieces of the rig are assembled and placed in their correct position about the stake . This procedure takes from a few hours to possibly weeks , depending on the depth well to be drilled and the complexity of the equipment . Once the rig is in place then the well can be "SPUDDED" , referring to the procedure of beginning the hole . A relatively large hole (from 10 to 30") is initially drilled through the surface formations including any water sands to be protected and "SURFACE PIPE" is set and cemented into place . "BLOWOUT PREVENTERS" are secured at the top , creating a sealing mechanism in case of a high prssure accident . A slightly smaller diameter bit is used then to drill out of the surface pipe to either the final desired depth or to such a depth that the pressure is abnormally high and must be shielded from other formations . In this case one or more progressively smaller strings of "IMTERMEDIATE CASING" must be set and cemented into place and still smaller bits used to drill ahead . Often the final bit size used to reach "TD" is as small as 6" even when the initial bit size was 26" . Upon reaching the desired depth the well is evaluated to determine whether or not it has reached an oil or gas formation . The hole is analized with electric logs and other geological evaluation techniques and, if the well is found to be a potential producer , the final string of pipe or the "PRODUCTION CASING" will be set and cemented . At this point a smaller , less expensive "WORKOVER or COMPLETION RIG" is moved in to complete the well which usually involves the perforation of the production casing and/or the stimulation of the formation to increase yield .

Of all the tools and associated technologies developed for rotary drilling , perhaps modern drilling mud is the most important and certainly the most complex . Since even an introduction to all the functions of modern drilling mud would take hours in itself , and since the author is certainly not an expert on the subject , we will discuss only the most basic functions of the most common drilling fluids . The fluid usually consists of water, various chemicals and a weighting material called barite . The basic functions of drilling mud are:

1. To carry rock and debris to the surface, allowing free movement of the drill string .
2. By means of hydrostatic pressure of the mud column create a counterbalance to pressures contained in the formations.
3. Physically and chemically inhibit certain formation characteristics that sometimes create hole swelling or caving.
4. Cool and clean the bit by bottom hole jetting .
5. In some cases increase the rate of penetration through certain formations by altering their physical reaction characteristics .
6. Increase production in certain reservoir rock by use of oil based drilling fluids .

The enormous economic burden placed on the operator to initiate and maintain the use of a fully operational rotary drilling rig creates new meaning for the term , "time is money" , because in the drilling industry it quite literally is . Rig cost per hour is usually the term used to account for the total expenditure not only for the rig , but for all associated tools and services required to operate the drilling program , and in some

9714 LANWARD
DALLAS, TEXAS 75238
214 - 348-5300

cases include the salaries of engineering support personel in offices hundreds of miles from the rig site . A low extreme for this hourly cost in the domestic U.S. for a small land rig drilling to no deeper than say 10,000 ft. would be about $250 to $300 per hour . The average figure for most U.S. land rigs is , however , well over $500/hr. with some operations in remote, hazardous areas reaching well over$10,000 per hour . This extremely high constant cost creates an underlying sense of urgency in all drilling , support and service personel . Advance planning and preparedness are the by-words of most people associated with the drilling industry .

9714 LANWARD
DALLAS, TEXAS 75238
214 - 348-5300

SHORT CUTS
IN DIAMOND DRILLING TECHNOLOGY

INFILTRATED DIAMOND BIT MATRIX MATERIALS AND THEIR GENERAL METHODS OF FABRICATION

Modern diamond bit matrices are formed , with one exception , with a relatively large mass of Tungsten Carbide (WC) powder infiltrated about a mild steel blank by a Copper/Nickel binder alloy . The one exception is the commonly known "strip" matrix bit , in which only small strips or blades of matrix is infiltrated onto a steel body that makes up the majority of the bit body. These "strip" bits are intended for use only in very low hydraulic applications as they are made from low erosion resistance materials . The vast majority of modern diamond drill bits are made to withstand high erosion and abrasion . The evolved matrix materials is intended to hold natural or polycrystalline diamonds mechanically in place while resisting wear from formation abrasion and drilling fluid erosion for hundreds of hours of continual use . All diamond bits are simply tools that transfer energy in order to disrupt and remove formation at the fastest possible rate for as long as possible . The more energy is transferred , without destructing the bit body materials , the faster the rate of drilling . With the enormous cost of drilling equipment being what it is , in the drilling industry time is literally money . The savings of that time is usually the sole justification for an operator to buy a relatively high priced diamond bit . The need for the bit body to have a long life while transferring this energy has

9714 LANWARD
DALLAS, TEXAS 75238
21[illegible] - 348-5300

SHORT CUTS

IN DIAMOND DRILLING TECHNOLOGY

water - bentonite - fireclay - water - graphite powdr. 75%
paste ↑15% ↑ for making molds
Press-Pattern Concept ~ 20% U.S. ~ 10% world

flush to 30% of diameter of diamond exposed

stuck to Carbon mold to make water channels etc.

special clay and dist resin (2%) coated moulding sand.

dictated the development of today's state of the art matrices . The wear resistance emphasized most during the past ten years has been that of erosion , with abrasive wear not being a major problem and confined mainly to the gauge portion of the bit.

Although specific preference for various methods differ with each manufacturer , all are made by the following seven basic steps :

1. Mold Fabrication — ATJ & HLM Union Carbide — $250/ft 10" diam.
2. Diamond Setting — latex glue or Elmer's glue
3. Powder and Blank Loading
4. Powder Compaction (Vibration) ← can be too loose or too tight — 5 ea 2 sec bursts of 2.8 g's
5. Infiltration Furnacing — 1150 - 1175°C
6. Cooling
7. Machining

binder (matrix) Cu-Ni-Zn + Mn sometimes — tends to oxidize

As each step is discussed in this report the range of extremes , if any , will be mentioned as they apply for the general step . No information will be disclosed that may be proprietary to any of the bit fabricators .

sand casting for fluid matrix to run down

mild steel

side mix powder usually reclaim

powder stored at 120°C to keep moisture out

face mix powder virgin

~6 licks with a hammer on the bottom until powder sinks to a certain level

7-8 stones/ct. available west african

Congo

Cominskin (soft) conditioned off to get "hardcore".

9714 LANWARD
DALLAS, TEXAS 75238
214 - 348-5300

MOLD FABRICATION

Molds for infiltrated diamond bits are made exclusively from Graphite , although some research has been made into the use of other refractoy materials such as Silicon without full production success . Two methods are in use ; "Hard Carbon" , in which the mold detail in made in mirror image to the bit ("Female" Mold) each time the specific bit is to be made, and; "Pressed Pattern" technique where a "male" die or pattern is made with all details of the bit on its surface . The pattern is then pressed into a graphite shell or bowl that contains a paste of Graphite powder , Bentonite , Fire Clay and water . The paste is extruded under pressure so as to form a mirror image mold which is then convection dried to harden the paste . Pressed Pattern technique is normally used when a repeatable,highly detailed product is desired in quantity without major change , as pattern cost can be a major expense . "Hard Carbon" molds are usually detailed by hand and require a certain amount of skill to accurately reproduce . Some limited production of NC machine made molds is under way at this time .

Some mold details can be added in the form of a special clay mixture that is extruded in mass and then fashioned by hand or in the form of molded or cast resin coated sand . Both materials will withstand infiltration temperatures and will maintain tolerances sufficient for the forming of most details in the bit .

It should be stated that the mold to finished bit shrinkage varies with both materials and method and generally are within a range of between .004" and .008" per O.D. inch of bit size . This shrinkage tolerance is included in each mold so as to fit the demanding API bit tolerances . For example; depending on the manufacturer , a nominal bit size of 8.500" may require a mold size of between 8.534" and 8.568" on the two extremes. Positioning of gauge cutters not integral to the bit gauge must take this requirement into consideration .

Note: Glues used to hold detail pieces in place until powder loading are common hobby type such as one might use for building model planes .

9714 LANWARD
DALLAS, TEXAS 75238
214 - 348-5300

DIAMOND SETTING

After the mold is formed and bit face details are added , a glue is placed into each recess that diamonds or other cutting elements are to be placed. The most commonly used glue is a latex product made specifically for diamond setting , although common "Elmer's" glue has been used for years without any adverse effect . The glue is meant to hold the diamonds in place only until the powder is loaded . Once the heavy powder is in place , its weight will hold the diamonds in securely even through cycle of vibration . Care must be taken to fit each stone snugly to bottom of each recess so "flashing" of molten binder will not cover the diamond during infiltration . Diamond to recess shape and size must be as nearly perfect a match as possible to assure correct fit .

9714 LANWARD
DALLAS, TEXAS 75238
21[illegible] - 348-5300

POWDER AND BLANK LOADING

After all details are in place and diamonds are set in the mold , the Tungsten Carbide powder is slowly poured into the mold using a common scoop normally made of non-ferrous alloy . Care is taken not to "dump" the powder into the mold which might dislodge the diamonds or other details. Sufficient vacuum ventilation should be used to remove carbide dust or breathing protection should be used . It should be mentioned that some fabricators , when assembling the less dense matrices, wet the face powder with "Poly-G" or common turpentine and tamp the powder mix into place . This is most commonly used when diamond powder or small mesh stones are to be impregnated . In normal loading the powder is brought first to a level that corresponds with the desired bottom of the blank . An amount of powder is added that is roughly equal to the settling that will occur during vibration. The blank is then placed onto the face powder and aligned axially and laterally with the mold . The remaining face powder is added in the same manner as before . Some bit fabricators use the same powder throughout the bit , including the gauge , while others will use a special gauge mix . Usually gauge powder mixes contain additives of Nickel or soft Tungsten powder to promote shrinkage and to inhance metallurgical bonding to the blank . A mix using reclaimed powder is sometimes used to reduce

9714 LANWARD
DALLAS, TEXAS 75238
214 - 348-5300

costs . In any case all fabricators complete the gauge loading before compaction is done , so it is vibrated in the same manner as the face mix .

POWDER COMPACTION (VIBRATION)

The intent of this step is to consistently compact the powder grains to a desired density . Too little compaction will result in a large capillary system and an excessive percentage of binder in the finished matrix . This will result in a soft matrix without the desired ear resistance . Too much vibration can result in a matrix too brittle to withstand the rigors of normal oilfield drilling practices .

Normally , correct compaction will cause the blank to settle from 1/4" to 1/2" during vibration . Correct powder levels must be reset after this step and a soft cap of Tungsten powder added to allow machining at the matrix/blank interface . Depending on the infiltration method to be used , binder may be preloaded at this point. A "Funnel Ring" is added to the mold to position the binder directly above and concentric with the mold . Binder is added according to the weight of powder used and is in the range of 40 to 100% of the total weight of all powders . It should be noted that some fabricators rely on the molten hydrostatic head of binder to force infiltrate

9714 LANWARD
DALLAS, TEXAS 75238
214 - 348-5300

SHORT CUTS

IN DIAMOND DRILLING TECHNOLOGY

when a blind , non-stepped furnace cycle is used with large diameter bits . In this case the funnel ring must be tightly threaded onto the mold to prevent molten binder leakage during infiltration .

9714 LANWARD
DALLAS, TEXAS 75238
2[illegible] - 348-5300

INFILTRATION FURNACING

Two basic furnace types are currently used for infiltrating diamond bits , the resistance element type and the electric/magnetic induction. The forced air gas furnaces used in very early bit production is , for all practical purposes, obsolete .

The resistance element or glowbar furnace is the most common and is most often referred to as a box furnace . The heat chamber or box is usually elevated above working level with the mold assembly or product being raised into it on a thermally sealing load car or fixed block . The box is lined with fire brick or some similar heat retaining material so as to store the heat produced while the furnace is idle . This gives the furnace a heat capacity greater than just the 80 or 90 KW power produced by the resistance elements . Glowbar furnaces must be idled at or near production temperature because of their long start up time . Two basic furnace cycles are commonly used with this furnace type, "Hot Box" or non-controlled cycle and "Stepped" cycle . In the "Hot Box" cycle the box temperature is set at the maximum desired product temp., the product inserted and monitored at its coolest point(IDTC) until it equalizes with the box temp. . In some extreme cases of non-control the

9714 LANWARD
DALLAS, TEXAS 75238
214 - 348-5300

an IDTC is not used and the bit is cooked according to a prearranged time according to the total mass of the product . The danger of this method is that in bits with large mass the IDTC can lag greatly behind the outer portions of the product. In some extreme cases the centermost powder will not reach a hot enough acceptance temp. bfore the binder has melted , causing the binder to divert around the cooler powder and not infiltrate fully. On the other extreme the "Stepped" cycle as used in a box furnace requires that the box temp. not exceed binder melt temp. until the IDTC reaches a suitable acceptance temp. (usually within 100F of binder melt temp.) . The box temp. is then increased to the maximum desired soak temp. and the binder allowed to melt as the entire mass equallizes with the box temp. . Although about 25% longer in total furnace time than the "Hot Box" cycle , the "Stepped" cycle assures correct infiltration regardless of product mass . The use of a controlled atmosphere such as Hydrogen or Nitrogen or a mix of both , although certainly not new , has become more commonly used in the last six years mainly because of the rise in popularity of PDC's . Drilling & Service,Inc. in their original Dallas plant wih an Induction furnace and Williams Diamond Bits with a glowbar furnace in 1964 and 1968 respectively , incorporated controlled atmosphere in the standard production of all diamond products . This practice continued until both companies were bought .

9714 LANWARD
DALLAS, TEXAS 75238
2[illegible] - 348-5300

The reduction of oxides is beneficial both in the protection of the diamond elements and as an aid in binder infiltration . Because of the large volume of most box furnaces atmosphere control can only be accomplished with the addition of a muffle or bell chamber in which the product is contained. Since it is exposed to elevated temperatures the seal of such a bell must be cooled , requiring water jackets and their associated high maintainence . Another disadvantage is the inability to accelerate cooling after infiltration with a water mist , a step used by most bit fabricators .

Electric/magnetic induction furnacing of diamond bits has been done , at least on a small scale , since the 1950's , but only since the mid 1970's has its use gained considerable popularity . Common furnace units are made up of a power supply , a capacitor or heat station and a water cooled copper coil made to size to accept a given size range of bits . Rated power of most full production models ranges from 175 to 375 KW. The mobility of the coil is almost unlimited and it is usually moved vertically onto and off of the product . Since the coil itself does not generate heat , very little insulation is needed (usually about 1/2" refractory cement) and its inside diameter can be kept very close to the product size . The product is usually set on a non-magnetic moveable cart which is topped by refractory brick or similar heat sheilding material . Atmosphere control can be easily facilitated either by the addition of a sand sealed bell or by capping the graphite mold/funnel ring assembly itself and containing the atmosphere solely within the product , the latter being the more efficient of the two methods . Without a controlled atmosphere the induction furnace has the advantage of visual inspection during infiltration . The two biggest disadvantages to the induction furnace is initial equipment cost and required operator skill . The advantages of the induction method are too numerous to list , with infinite temperature control and set up versatility being the most important .

9714 LANWARD
DALLAS, TEXAS 75238
214 - 348-5300

SHORT CUTS
IN DIAMOND DRILLING TECHNOLOGY

CONTROLLED COOLING

Since, generally , the steel blank will shrink faster than the matrix material , a problem can develop if the direction and rate of cooling is not controlled in that the blank can shrink away from the matrix , causing a poor bond between them . Most fabricators use a method in which the product is first cooled slowly under an insulated hood until the binder is slightly under molten temp. and then a water mist is applied to the bottom of the mold to promote rapid cooling of the matrix from its largest cross section . The bit , in most cases, is allowed to cool to a safe handling temperature of below 200F before it is removed from the mold . Extreme care should be taken not to water quench or otherwise thermally shock the bit head directly as cracking can occur . Bit head cooling is often safely accelerated by vacuum .

9714 LANWARD
DALLAS, TEXAS 75238
214 - 348-5300

MACHINING

In the machining step a common heat treated tool joint or upper section is added to the mild steel blank after it has been prepared by the removal of excess binder and alligned axially and circumferencially with the bit head . Normal pre and post heating is done to allow the steel around the weld to normallize . Although the post heat temp. reaches 1200F at the steel portion of the bit , the matrix face usually does not exceed about 500F . Air cooling must be done to room temp. to avoid matrix cracking and /or steel embrittlement .

It should be noted that in rare cases Electrode Discharge Machining (EDM) of the matrix is done to correct small errors but is not used in standard production to create or change bit face details . Some cosmetic grinding is routinely done but is limited to face cleanup or small gauge size adjustments .

9714 LANWARD
DALLAS, TEXAS 75238
2[illegible] - 348-5300

SHORT CUTS

IN DIAMOND DRILLING TECHNOLOGY

MATRIX MATERIALS DESCRIPTION

The two most commonly used matrices are known as ;1. Crushed Cast Carbide infiltrated with a Copper/Nickel (Bronze) alloy binder , and 2. the microcrystalline Kennametal powder mix infiltrated with a Copper/Nickel/Zinc (Brass) binder alloy that is high in Manganese content . Most bit fabricators dictate their own proprietary mesh size mix and rarely buy off the shelf mixes . However , their seems to be very little , if any , difference in the general distribution of grain size with the norm being less than 5% plus 80 and about 30% below 325 . The two off the shelf powder mixes are typical of the custom mixes in use today and are Alloy Metal's "80 Down" Crushed Cast Carbide and Kennametals' "P-90" . Their typical sieve size analysis is :

80 Down	
plus 80	less than 5%
80-100	15-25%
100-200	15-25%
200-325	20-30%
-325	30-35%

P-90	Range	Norm
plus80	trace to .8%	.5%
80-170	29-33%	31%
170-325	33.5-39.5%	36.5%
-325	29-32%	31%

9714 LANWARD
DALLAS, TEXAS 75238
214 - 348-5300

A typical range of binder alloy content is as follows :

Bronze Binder	Soft,Lower Melt	Harder
COPPER	70%	65%
NICKEL	15%	20%
ZINC	6%	11%
TIN	8%	0
IRON	both less than 1%	
melt temp	about 1725F	about 1925F

BRASS BINDER	Soft,Lower Melt	Harder
COPPER	50%	48%
MANGANESE	25%	24%
NICKEL	13%	20%
ZINC	12%	8%
IRON	both less than 1%	
melt temp.	about 1780F	about 1950F

Typically the Crushed Cast Carbide matrix relies on a high Nickel content in the binder to increase erosion resistance . The particles in the drilling fluid impact into the powder/binder capillary structure and , of course , dislodge the softest material first . The softest material being the binder . The softer the binder and the more binder is contained in the matrix strcture , the quicker it will erode .

The Kennametal "Micro-crystalline" powder mix is said to have a more uniformly rounded grain structure and is said to compact more densely than

9714 LANWARD
DALLAS, TEXAS 75238
2[illegible] - 348-5300

the more conventional crushed grain product . It is also claimed that when used with the high Manganese content Brass binder that a certain amount of carbide is taken into solution with the binder and results in a carbide to carbide bond . This is said to occur at above 2100F , thus requiring a high temperature soak cycle . In practical field tests carried out by NL Hycalog in 1976 and 1977 , Brass binder infiltrated Kennametal matrix showed an increase of almost 30% in erosion resistance over the most wear resistant crushed carbide / Bronze binder matrix bits . It is this expected 30% increase in bit life that has waranted the investment in more accurate furnaces and skilled labor that is required to correctly produce the finished product . Very little in the way of technical metallurgical information is readily available from either of the suppliers mentioned in this report . It is expected that a more established customer or bulk user of these materials would have a better response to their inquiries than did the author .