Dennis Tool Company has developed a full line of products for Fixed Cutter PDC Drill Bits. These products are available in all standard diameters from 8mm to 19mm. Patented non-planar interface geometries have been designed to maximize diamond content while maintaining necessary impact strength. Proprietary Microwave Sintered carbide substrates are utilized to support the diamond layer in ways not possible with conventional carbide materials.

In-house manufacturing of the Microwave Sintered carbide has reduced the development time of new products by several weeks or months and has enabled Dennis Tool Company to develop grades that are specifically designed for PDC cutter applications.

In addition to standard cylindrical geometries, Dennis Tool specializes in the manufacture of special geometries of parts that may be proprietary to our customers. Drawing on many years of experience in oilfield drilling applications, Dennis Tool can also assist customers in improving performance of their products.
Dennis Tool Company makes specialty bearing products used in many applications such as Oilfield Drilling Tools. In many oilfield applications, PDC Thrust Bearings directly replace Roller or Ball Bearings. PDC bearings are able to carry much higher loads and can operate in the harsh downhole environment without protection. PDC bearings operate in mud, air, or air mist environments without seals. This enables them to be used in high temperature applications up to 1600°F. Use of PDC Thrust Bearings results in lower reactive torque than roller or ball bearings, which creates less power losses in the tool. The typical life improvement of PDC Thrust Bearings vs. standard Roller or Ball Bearings is usually about 10-20 times or more.
Dennis Tool Company specializes in developing new applications for superabrasive and carbide products by developing new materials as well as finished tools that effectively use them. In many cases, prototype tools are designed and built entirely at Dennis Tool for evaluation purposes. Specialized assembly techniques are often required, and Dennis Tool Company has the in-house capability to produce a wide variety of tool types. Once feasibility is established, the manufacturing technology may be transferred to the customer or production may remain at Dennis Tool on a contract basis.
WHY SHOULD WE MICROWAVE SINTER CARBIDE?

• SHORTER SINTERING TIME YIELDS LESS CHEMICAL AND PHASE CHANGES IN THE COBALT BINDER PHASE

• THROUGH HEATING CAN BE ACHIEVED FOR MORE UNIFORM SHRINKAGE AND COBALT DISTRIBUTION

• SHORTER SINTERING TIMES DECREASE GRAIN SIZE CHANGES, YIELDING MORE PREDICTABLE AND CONSISTENT WC GRAIN STRUCTURES

• ABILITY TO UNIFORMLY COOL PARTS QUICKLY AFTER SINTERING FOR STRESS MANAGEMENT AND METAL BINDER PHASE CONTROL

• MORE EFFICIENT ENERGY TRANSFER DUE TO DIRECT HEATING
MICROWAVE SINTERING DEVELOPMENT

- Initial conceptual work done at Penn State Materials Research Labs

- Dennis Tool developed MW applicators for sintering cemented carbide and other materials

- Dennis Tool developed raw material specifications and processing parameters for carbide grades

- Dennis Tool manufactures and services all MW sintering systems
PROPERTY IMPROVEMENTS OF MW CARBIDE

• HIGHER IMPACT STRENGTH FOR A GIVEN HARDNESS
• VERY HOMOGENEOUS AND CONSISTENT HARDNESS
• VERY CONSISTENT MAGNETIC PROPERTIES
• HIGH CORROSION RESISTANCE
• HIGH EROSION RESISTANCE
IMPROVED EROSION RESISTANCE OF MW SINTERED CARBIDE

MICROWAVE SINTERED

CONVENTIONALLY SINTERED
IMPACT STRENGTH VS. HARDNESS

Impact Energy at Fracture, Joules

Hardness, HRa
FUTURE PROSPECTS FOR MW SINTERED PRODUCTS

- TOUGHER, MORE WEAR RESISTANT MATERIALS
  - SUBMICRON CEMENTED CARBIDE GRADES
  - MIXED CEMENTED CARBIDE GRADES
  - LAYERED CEMENTED CARBIDE GRADES
  - DIAMOND IMPREGNATED GRADES
  - SUBMICRON CERAMIC/CERMET GRADES
- LONGER LIFE NOZZLES
- LONGER LIFE WEAR PARTS
- LONGER LIFE BEARING MATERIALS
RADIAL BEARINGS UTILIZING MW SINTERED CARBIDE TILES
A drilling tool having a pilot bit on an end of a main shaft is surrounded by outer shafts having mills on their ends. The bit and mills employ cutters with PDC. The pilot bit rotates in a direction opposite the direction of rotation of the mills. A transmission for rotating a main shaft, on which the pilot bit is mounted, and several secondary shafts, on which the mills are respectively mounted, is carried within a housing using diamond thrust and radial bearings. Power is applied to the main shaft and transmitted to the secondary shafts through diamond hardened gears. Drilling fluid is used to cool and lubricate the bearings and gears.

14 Claims, 8 Drawing Sheets
PDC TEMPERATURE VS WEAR

[Graph showing estimated cutter temperature and rotary speed vs gage cutter speed for different rock types and sizes.]
• 3-5/8” PDC pilot bit rotating at 900 rpm (right hand) drills center hole

• Three 2-7/8” PDC satellite mills rotating at 1200 rpm (left hand) drill
  • with kerfing action for cooling and cleaning

• Kerfing cutters mill rock in unconfined state for efficiency

• Counter-rotating heads

• No elastomer seals or parts

• Field replaceable components (including cutting heads)
ROCK MILL VS PDC BIT - AMOCO CATOOSA, OK

ROCK MILL TEST
AMOCO-CATOOSA, OK

WOB (000 POUNDS)

DEPTH

rock mill
pdc bit
ROCK MILL TEST
AMOCO-CATOOSA, OK
ROCKMILL DEVELOPMENT STATUS

• DRILLING STABILITY GREATLY IMPROVED OVER FULL-HOLE BIT
• WOB REQUIREMENTS MUCH LESS THAN FULL-HOLE BIT
• RELIABILITY OF GEAR DRIVE IS MAJOR OBSTACLE
• COULD REPLACE GEARS WITH INDIVIDUAL MOTORS FOR EACH MILL OR BIT
  • RELIABILITY OF CURRENT SMALL MOTORS NOT SUFFICIENT
  • NEED TO DESIGN A COMPACT, RELIABLE SMALL DIAMETER MOTOR
  • TWO DIFFERENT TYPES OF MOTORS ARE BEING DEVELOPED FOR OILFIELD
• LENGTH OF TOOL LIMITS APPLICATION
• DIRECTIONAL CONTROL NEEDS DEVELOPMENT
COUNTER ROTATING TANDEM MOTOR DRILLING SYSTEM (CRTMDS)

- O 2.750" LEFT-HAND PILOT BIT
- O 2.125" 1:2 LOBE LEFT-HAND PDM
- O 2.688" STABILIZER
- O 2.875" 5:6 LOBE RIGHT-HAND PDM
- O 3.500" RIGHT-HAND REAMER
- O 2.750" LEFT-HAND PDM
INTERVAL ROP
Dennis Tool 2-5/8” CRTMDS Test at RMOTC 09-01-05

FLOW RATE 35 GPM
FLOW INCREASED TO 40 GPM
REACTIVE TORQUE DATA - 3.500" CRTMDS
CATOOSA MARCH 2007

INTERVAL TORQUE (FT-LBS)

DEPTH (FT)
CSTMDS DEVELOPMENT STATUS

• COUNTER-ROTATION GREATLY IMPROVES DRILLING STABILITY
  • REACTIVE TORQUE CAN BE REDUCED SIGNIFICANTLY
  • COILED TUBING DRILLING COULD BE IDEAL APPLICATION
  • DESIGN INCREASES DRILLING STABILITY
  • IMPROVES ROP IN HIGHLY VARIABLE FORMATIONS

• UNRELIABILITY OF SMALL MOTORS IS A MAJOR OBSTACLE
  • NEED TO DESIGN A COMPACT, RELIABLE SMALL DIAMETER MOTOR
  • TWO DIFFERENT TYPES OF MOTORS ARE CURRENTLY BEING DEVELOPED FOR OILFIELD

• LENGTH OF TOOL WITH CURRENT MOTORS LIMITS APPLICATION

• DIRECTIONAL CONTROL NEEDS DEVELOPMENT