Serbian Tribology Society

# SERBIATRIB '11

12th International Conference on Tribology

Faculty of Mechanical Engineering in Kragujevac

Kragujevac, Serbia, 11 – 13 May 2011

# BEHAVIOR OF THE SINTERED CARBIDE PINS UNDER SIMULATED WORK CONDITIONS - EXPERIMENTAL STUDY

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***Abstract:*** *The pins are sub-assemblies of tree-cone drilling bits used to dislodge the rock. Pin head may have different shapes (chisel, hemisphere, etc.) according to the intended nature of the rock. The pin body has a cylindrical shape and serves to hold (embed) them into the body rolls. The pins are made by sintered carbide that combines the best contradictory properties such as hardness and toughness. Because the sintered metal carbides break after suffering a very small plastic strain, they are classified as brittle materials. In the following, the authors present results of studies conducted under conditions that partially reproduce the actual conditions (lack of drilling fluid however acute test conditions), on the cutting structures of the three-cone drill bits for making it clear that in these subsets, the tensions while working at the base of the drilling hole do not exceed the strength of materials that they are made of.*

***Keywords:*** *three-cone drill bits, cutting structures (pins), strength, sintered carbide, simulated conditions*

## 1. INTRODUCTION

The latest types of three-cone drill bits used teeth (pins) shapes that are of upright design, made of sintered carbides, tougher and more resistant to wear buttons with elastomeric seals watertight, small tolerances and high resistance in conformity with requests, adding a robust package of protection jaw and cone bits, all that characteristics providing the equipment integrity both during drilling operations and rotary table at the bottom engine [1], [2].

The implementation of new types of drill bits have in advance a program of research and testing in order to examine the design and composition, cutting structures, in terms of increasing the reliability/durability of such complex machines.

The technological redesign of the three-cone drill bits, as a result of laboratory tests and production, has adopted five major changes:

- use of new types of sintered carbides denture;
- protection with pins made of the same types of carbide sintered cone surface, counter-cones and crown pins;
- new forms of teeth recovered from the cones;
- new design flexibility at the baseline of the crown;

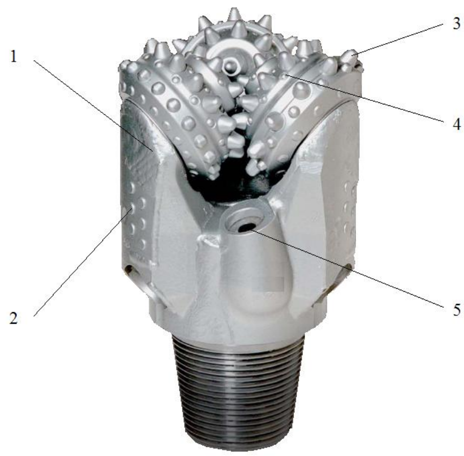



**Figure 1.** Three Cone Drill Bit
*1. Loading jaws with sintered carbide for limiting the influence of wear while keeping integrity; 2. Jaw protecting with sintered carbide pins; 3. Change the shape of pins recovery; 4. Protective pins for cones surface and counter cones with crown pins protection; 5. New nozzles geometry for drilling fluid circulation.*

- choosing a new geometry of positioning to the nozzles for drilling fluid circulation.

The studies have been performed on the cutting structures (pins), for roll 3, from a drilling bit type

SM - 8 3 / 8 KGJ, crowns II and III (Figure 2), C - 12 x 14 type (Figure 3).

The rolling pins are made from a mixture obtain by tungsten carbide powder and cobalt powder as a binder.

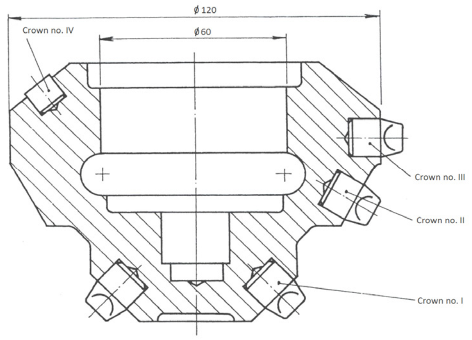



**Figure 2.** Role no. 3 from Three Cone Drill Bit

Given the multiplicity of tests performed on these cutting structures, from the sintered carbides types: K30-ISO; TIZIT WC-Co-TaC/87,75-12-0,25 type; TIZIT WC-Co-TaC/90,25-9,5-0,25 type; UGINE-CARBONE WC-TiC-Co/87,7-0,3-12, type the latest version of powder was chosen for this study because the subassemblies made by its sintering procedures, have the highest resistance to time requests.

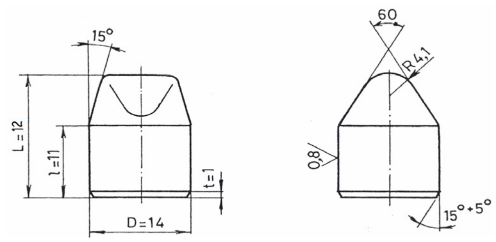



**Figure 3.** Pin type C - form and dimensions

The mixture of metal powders (UGINE-CARBONE type WC-TiC-Co/87,7-0,3-12 subtype) is ready for pressing and its technical characteristics are, as follows:

- Chemical composition:

- ➢ total carbon = 5,37 %;
- ➢ free carbon = 0,01 %;
- ➢ cobalt =11,40 %;
- ➢ titanium = 2 %;
- ➢ iron = 0,04 %;
- ➢ tungsten carbide = balance

- Physical-mechanical characteristics:

- ➢ powder will be ready for pressing granular grain size = 120 μm;
- ➢ the conventional of average Fisher size = 1,25μm;
- ➢ specific weight = 14,32 g/cm$^3$;
- ➢ Vickers hardness = 1050 HV;
- ➢ bend strength = 2250 N/mm$^2$;
- ➢ material strength = 2850 N/mm$^2$;
- ➢ paraffin content = 1,5%;
- ➢ pressing load = 115 N/mm$^2$;
- ➢ pre-sintering temperature = 900 $^0$C;
- ➢ sintering temperature = 1410 $^0$C;
- ➢ contraction = 23 %.

The manufactured pins, in full compliance with manufacturer specifications and parameters for the sequence of technological operations, were the study subject realized at the test stand conducted by the Petroleum-Gas University from Ploiesti.

It has also been observed the way of fits achieved between the pins that were tested and the clamping device testing stand (made from the same steel as the body screed – 17NiMo14-2 according to EN 10027-1:2006), thus simulating real restraint of body roll pin in the three-cone drill bits.

The stand construction, the testing methodology and the way of data acquisition is presented in the next chapter.

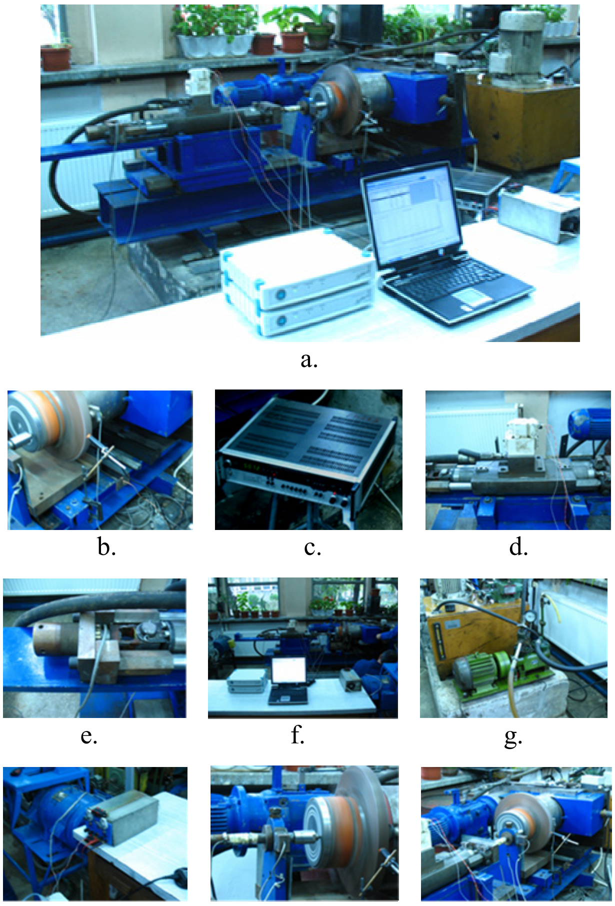
## 2. EXPERIMENTAL STUDY UNDER SIMULATED EXPLOITATION OF SINTERED CARBIDE PINS

The stand, shown in figure 4, can be used to study behaviour in simulated conditions similar to those while in operation, of the sintered carbide pins used at three-cone drill bits by using a system of reading and recording data, the request levels where those are subject to check .

The stand construction depends of the specific operation in the sintered pins drilling wells (figure 4.a), namely:

- ➢ the rotation motion is performed by the rock sample, the rotations number being checked with a tachometer (figures 4.b, 4.c) and fixed pin is mounted on a shaft (figure 4.i) performing with a hydraulic system (figure 4.g) for the advance and retreat movement that simulates its contact with the foot probe;
- ➢ variable speed range is being done by a lever system (figure 4.j) controlling the support of electric drive motor speed where the rock sample is fixed (and the rock is chosen properly to the type of drilling- low-medium hardness);
- ➢ the pin application on the workload is performed using a tensioning bolt axis (figure 4.e), while the force is applied towards the axial direction (given the remoteness and the proximity to the rock sample) using a hydraulic system acted by a solenoid (figure 4.d);
- ➢ the frequency of advance and retreat movements on the longitudinal direction is given by an adjustable signal generator connected to a 24 volt power source (figure 4.h), acting the solenoid (figure 4.d);
- ➢ the acquisition data for the controlled parameter values (pressure on the pin F ≅ 30000 N,

the action pressures for the cylinder that provides an reciprocating movement of the shaft where is fixed the pin and the axial tensions $\sigma_x$, $\sigma_y$, $\sigma_z$) is created using strain marks connected to a computer through two SPIDER 8 acquisition systems connected in series, and as interface uses the licensed software CATMAN 5.0. Those two products are genuine and were purchased from the German concern HBM®.



a. b. c. d. e. f. g. h. j. k.

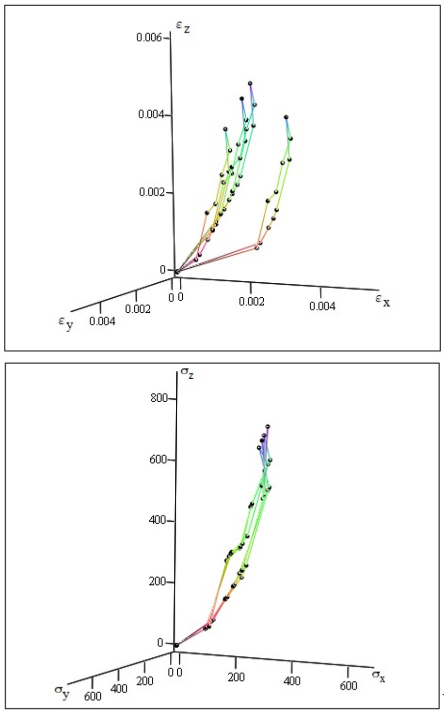
**Figure 4.** Testing Stand for Sintered Carbide Pins

Stand operation can be described briefly as:

- it is mounted on the bench with a driving steel shaft 17NiMo14-2 (Figure 5), by pressing pin carbide sintered to achieve full compliance with the conditions prescribed for fit (they were mounted in order to raise the minimum and maximum levels for more pins of the same type);
- hydraulic piston is actuated at the actuation pressure required (20 bar). The previous stroke is tensioned by a threaded rod to a force of about 30000 N, force which is usually recorded on pin in the process of drilling. The solenoid is actuated using a signal generator to simulate the rock numbers of contacts per time unit (contact frequency is 6 contacts/minute).
- the rotation motion whose speed is adjusted using a lever operated system, is performed using an electromotor and transmitted by a chain attached to the device where the rock sample is fixed. For the experiment we adopted the same rotational speed like in the real case, 50 rot/min.

**Figure 5.** Fixture of sintered carbide pins

- the only stand disadvantage is represented by the lack of drilling fluid as a coolant between the sintered carbide pin and the rock sample. For this reason, after about 30 minutes of operation, it no longer shows the fit tight, the main cause is the defects appearance (shock cracks in the pin fastening device). In future, we shall adapt a system of drilling fluid cooling circulation, with a precise role of cooling the pin.




a.

b.

**Figure 6.** Tri-axial displacements and strengths (absolute values)
a. Displacements [mm]; b. Strengths [N/mm$^2$].

In figures 6a, 6b it is presented in graphical form, the results and summary from the resulting files generated by CATMAN 5.0 for tests on the bench for a C 12 x 14 pin-type, chisel, manufactured of sintered carbide under normal operation conditions of the drill bits, described above. It should also be noted that, when presented results we used data from a sample of four consecutive rotations (of the approximately 6000 turns of the experiment), full-catcher (equivalent to four turns of the drill bits), corresponding to the highest values of stress and strain recorded [3], [4].

After carrying out tests on several cutting structures the conclusions presented below have been highlighted.

## 3. CONCLUSION

Using the stand presented before, which can be studied under simulated conditions of the similar behaviour to operation conditions (less presence of the drilling fluid) of the sintered carbide pins, equipping the three cones drill bits, we examined the level of stress undertaken. Also, using appropriate fixtures other parts made of sintered carbides can be studied, which are imposed by the construction and operation conditions of the stand.

The demands faced by the cones are variable, and the dynamic load varies in a short period of time, due to shock characteristics, which led to the conclusion that the same phenomenon is presented at all sintered carbides pins. It was developed the similar way of pin performance at the test stand as for those working during the real operating process.

During working experiments, under the similar drilling conditions, it was noticed that the wear teeth are working on the central shock and they are bending under the action of the body which teeth are forming by compressive stress and tensile. For this reason it has been shown that tooth are developing wear due to cyclic stresses to shock and abrasive wear.

As a result of the experiments it was also concluded the fact that tooth is developing wear due to the plastic deformation of the surface with detachment particles from the teeth surface, coming together with the sliding wear pins on the well foot.

The sintered pins in contact with the drill hole are not uniformly strained, the main cause being stresses combined with shocks.

When the pushing force is taken by a single sintered pin under intermittent contact with the foot probe, the resulted maximum effort value at which it is tested is about 1450 N/mm$^2$.

Studying the average values of the recorded efforts on the stand for sintered carbide pins, which are as follows:

- static test - 950 N/mm$^2$ and
- dynamic test - less than 900 N/mm$^2$,

it is observed that none of the values are exceeding the materials strength values that the two components of the fit are designed for.

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