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The Methodology for Evaluating the Resistance of Materials to Erosive Wear

Miruna Băltăreţu Iancu*, Vlad Ulmanu**, Anton Hadăr*

* University "Politehnica" of Bucharest, Splaiul Independenţei 313, Bucharest
e-mail: mirunabaltaretu@yahoo.com
** Petroleum-Gas University of Ploieşti, Bd. Bucureşti 39, Ploieşti

Abstract

This paper presents the methodology used to evaluate the materials resistance to erosive wear, from the needed equipment to the steps to be followed during experiments. In order to choose the correct method for wear testing and to design the needed equipment, it is necessary to study the wear tests available on the market. The equipment and the methodology for erosive wear assessment, presented in the paper, have been designed and completed for mud pumps components and, after preliminary tests regarding the efficiency of the method, it can be applied for various hardened materials subjected to intense wear in operation.

Key words: *erosive wear, mud pump, gas-blast test, sandblasting*

Introduction

In the oil industry, where time and money are the main constraints, increasing the service life of high wear parts and decreasing downtime associated with repairs or replacements, have great importance. Current market requirements are turning to more efficient drilling operations, which involves the completion of a drilling well in a shorter time and with less cost.

For drilling rigs, reliability and operational parameters of the mud pumps are influenced directly by the resistance to wear of their vital components.

High-pressure mud pumps are used for circulation of drilling fluid (mud) on the drill string and back through the annulus, at high working pressures (up to 500 bar). Mud pump parts are affected by erosive wear caused by suspended solids (sand, gravel) contained by the drilling fluid that is being pumped.

In order to increase the service life of mud pump parts, working surfaces are hardfaced using different methods of surface treatments and coatings. To determine the wear resistance of the hardened surface is necessary to use methods that can reproduce the working environment of the part that is being studied.

The difficulty is in choosing the correct wear test suitable for the studied surface, considering the depth of the surface treatment (thin or thick coatings), the influence of the treatment on the bulk material and the method used to measure the wear.

The paper presents the methodology used for evaluating the materials resistance to erosive wear, for mud pump parts. In order to establish the correct wear test for mud pumps working conditions, a theoretical study of the wear tests that are already developed and used on the market is needed.

Current Methods for Evaluating Abrasive and Erosive Wear

Nowadays, specialists use different methods for evaluating the abrasive and erosive wear.

The material loss of the specimen is influenced by the tribological conditions of the tested surface and by the response of the material to them. Usually, wear is measured as the loss of mass per time unit. As a quantitative coefficient it is called tribological intensity. The tribological conditions and the wear surface can be constant or can vary during different wear tests [4].

The abrasive and erosive wear tests, classified according to the tribological intensity, are presented below.

Abrasive wear tests with constant tribological intensity

Polishing and grinding tests are considered wear methods in which the tribological intensity remains constant over the tested surface. Generally, a plane sample moves with a certain speed on a larger flat surface, pressed with a nominal force, in the presence of abrasive particles.

Taber Abraser Test (or Rotary Platform Dual Head Tester) represents another wear method in which the tribological intensity is constant over the worn surface [6]. A plane sample is mounted on a rotary table, which rotates about a vertical axis with a certain speed (1 r/s), under two abrasive wheels. The composite abrasive wheels rotate independently about a horizontal axis, that does not intersect the vertical rotation axis of the sample being tested [4].

Another abrasive wear test, in which the tribological intensity remains in theory constant, was developed by *N. Axén* et al. [2]. A hollow cylinder rotates about an axis perpendicular to the sample surface, being in contact with an abrasive slurry. The specimen surface is continuously supplied with abrasive particles and contribute in maintaining constant the tribological intensity [4].

Abrasive wear tests with variable tribological intensity

Rubber-Rimmed Wheel Abrasion Test is a method to evaluate wear, in which a flat sample is pressed against a rotating wheel that has a rubber rim. The abrasive particles are added in the interspace between the sample and the wheel, thus reaching the contact area.

There are various abrasive wear tests which leave a certain wear mark on the specimen corresponding to the machine used [4]. The „Ball-Cratering" Test is one of these methods, in which a hard contact sphere is pressed and rotated on the surface of the sample in the presence of abrasive suspensions [5]. The wear mark of the hard sphere on the surface being tested has a spherical shape.

Erosive wear tests

For erosive wear tests, the tribological intensity is directly proportional to the flow of erosive particles, if their speed and angle of contact remain constant. The speed of the particles has greater influence on the tribological instensity value [4].

During Gas-Blast Erosion Test erosive particles are accelerated in a gas stream (usually air) along a nozzle. The nozzle can have a cylindrical shape (typical) or a more complex shape. The sample is set at a predetermined distance from the end of the nozzle [1].

The Centrifugal Erosion Accelerator, using rotation, accelerates particles placed in the center of the rotor and produces a stream of particles horizontally. The particles are being evacuated through radial channels and hit the contact surface of specimens mounted around the circumference.

Wear tests are used in the process of characterization of materials. It can be created a „tribological profile" of a certain material, which is of great importance in choosing materials used for manufacturing parts from different industrial sectors.

Wear tests are used, also, for determining the behavior of materials subjected to wear during operation. The tests can evaluate wear resistance of hardened coatings and layers. Using the wear tests results, there can be selected bulk materials and hardening methods for various applications.

Equipment for Erosive Wear Evaluation

In order to evaluate the resistance to erosive wear of mud pumps parts, there can be used as a wear test the gas-blast erosion test, which can better mimic the real working conditions.

For conducting experimental research, it was designed and developed a wear test equipment, by adapting a sandblasting machine, coupled to a dosing equipment for the pressurized gas (compressed air) and to an industrial vacuum cleaner for the dust released during operation. A compressor supplies the sandblasting machine with pressurized abrasive particles, from the container of the sandblasting equipment [3].

The sandblasting machine used for the gas-blast erosion test is an injection sandblasting cabinet manufactured by Kema Technik. It is characterized by the following:

- injection blasting head with hard metal nozzle;
- access door on the cabinet side;
- illumination system with blast protection;
- coupling system for the auxiliary blower equipped with residual dust filters;
- closed system with rubber lining for recovery and recycling of the abrasive material;
- on/ off foot pedal.

Technical specifications for the sandblasting cabinet are:

- cabinet interior dimensions: 600x840x630 mm;
- air consumption: 450-750 l/ min;
- variable working pressure: 4-8 bar;
- main power system: 220 V, 50 Hz;
- secondary power system 12 V;
- weight: 50 kg.

The sandblasting cabinet is fueled by injection. The air entering the blasting head draws the abrasive particles inside it, where it is formed a mixture of air and particles, and through the nozzle the abrasive jet heads perpendicular to the tested surface.

The operating diagram of the equipment used for the erosive wear test is presented in Figure 1.

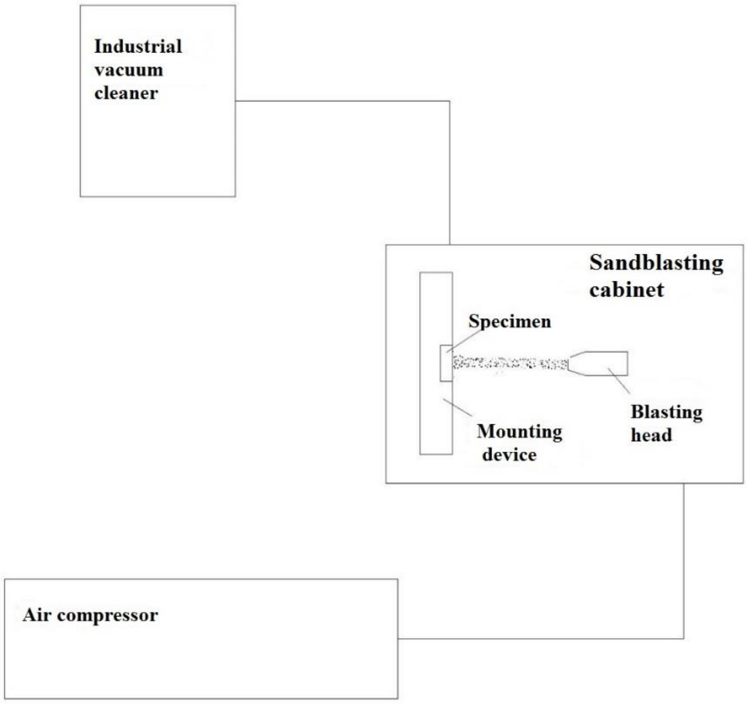

Fig. 1. Wear test equipment

The wear test equipment that can be used for evaluating the resistance of hardened samples (mud pump parts) is shown in Figure 2.

Fig. 2. Erosive wear test equipment (gas-blast erosion test)

Methodology for Evaluating the Resistance of Materials to Erosive Wear

The methodology used for evaluating the resistance of materials (hardened coatings) to erosive wear covers the following steps [3]:

1. Preparing samples (fig. 3) for the wear test involves the following operations:

- mechanical cutting;
- sampling;
- dimensional machining;
- finishing by grinding the active surface of the sample.

2. For each tested material there should be prepared two samples, for results comparison.

3. The sample is mounted in a device (made in the laboratory), which leaves free only the tested (hardened) surface. The other active surfaces are covered using fixed and movable walls of the device. Next, the sample is mounted with the locking mechanism in the sandblasting cabinet.

4. The blasting head is secured into the cabinet in a direction perpendicular to the hardened surface that is being tested. The abrasive jet (abrasive particles and air) is bombarding directly (perpendicular) the tested surface.

5. Samples are submitted to the erosive wear test, interrupting regularly for weighing and measuring surface roughness of the samples being tested. The experiments can be interrupted every 10 minutes to record changes during the wear test.

6. Before weighing and measuring roughness, samples are cleaned with compressed air and degreased to remove remaining particles after testing.

Fig. 3. Sample prepared for erozive wear test

When conducting the erosive wear test should be considered the influence of:

- abrasive material granulation;
- abrasive jet flow;
- abrasive jet pressure
- abrasive particle impact on the sample;
- abrasive jet speed (speed measuring device).

The weighing of the samples during tests should be made with a high precision balance to register the slight changes in mass and the roughness of the tested surfaces can be measured with a portable roughness tester.

Conclusions

In order to choose the correct wear test suitable for different materials that are operated in various working conditions, it is necessary to study all the methods that are already used on the market.

For the oil industry and especially for mud pumps parts, that have hardened active surfaces, the wear test that can provide accurate information is the gas-blast erosion test. For the experimental activity, it can be used a special equipment designed and developed for the tests, as the one presented in this paper.

The methodology for evaluating the resistance of materials to erosive wear can be successfully used for mud pump parts, with hardened active surfaces.

The preliminary research regarding the erosive wear test shows promising results, with changes in the weight and roughness of the tested samples. The proposed equipment and methodology, presented in the paper, can be used to evaluate the materials resistance to erosive wear, from bulk materials to high-hardened surfaces.

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Metodologia de evaluare a rezistenţei materialelor la uzarea erozivă

Rezumat

Această lucrare prezintă metodologia utilizată pentru evaluarea rezistenţei materialelor la uzarea erozivă, de la echipamentul necesar până la etapele de urmat în timpul experimentelor. Pentru alegerea metodei corecte de încercare la eroziune şi pentru proiectarea echipamentului necesar, este necesar să se studieze metodele de încercare la uzare disponibile pe piaţă. Echipamentul şi metodologia de evaluare a rezistenţei materialelor la uzarea erozivă, prezentate în lucrare, au fost concepute şi realizate pentru componentele pompelor de noroi şi după încercări preliminare privind eficienţa metodei, aceasta se poate aplica pentru diferite materiale durificate supuse uzării intense în exploatare.