RESEARCH ANALYSIS ON THE REPLACEMENT OF METALLIC BY NON-METALLIC ELEMENTS IN THE MINING INDUSTRY

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Abstract: *Taking in account the preoccupations of a great number of scientists, which works in replace the steel materials with nonmetalic materials field, the paper presents experimental results regarding the efficiency of the replacement of metallic by non-metallic elements in the mining industry. This paper contains experimental results that were obtained on some machine elements from mining machines.*
Key words: *polyamidic materials, reliability, mining machines*

1. INTRODUCTION

The fact that many installations and equipment operate under hard-working conditions is well known. Their feasibility and efficiency can be thoroughly improved using materials like polyamides in "critical points", materials that have advantageous physical and mechanical qualities and can replace metals.

With mining equipment especially, due to hard working conditions - (humid environment, corrosive, with a high content of abrasive impurities, mechanical shocks owing to the functioning principles of various equipment types, the impossibility to carry out periodical maintenance operations) - various malfunctions occur (especially in the bearing areas) leading to accidental halt. World wide, for mining equipment, they already use the so-called "metal replacements", a category in which polyamides are also included, as they have a proper behaviour under hard operating conditions.

2. RESEARCH ON THE POSSIBILITY OF USING POLYAMIDES IN MINING EQUIPMENT MANUFACTURING

The specialists at The North University of Baia-Mare and S.C. I.C.P.M. Baia-Mare have carried out a series of implementation experiments of such polyamidic materials from 1997, for two types of mining equipment used at The Mining National Company from Baia-Mare: drill hammer type PG 80 and rail trucks of $1m^3$ capacity. In both cases results have been adequate, bushings of polyamide under implementation displaying a better behaviour than bronze bushings (in the case of the drill), or than bearings (in the case of the trucks).

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The very good operation of the roto-percussion drills is conditioned, among others, by the use of the prescribed oil for the air greasers, and by its feeding with compressed air, devoid of solid impurities and with an ever reduced percentage of humidity.

Also, the non-admissible wears and clearances that occur in operation lead to the premature removal of these drills.

A sensitive point of drill PG 80 is its bushings that are made of bronze at present (CuSn12). Taking into account the above, two hammer drills with polyamidic material bushings have been equipped at EM Baia-Sprie: *ERTALYTE Tx*, of *TERAMID* respectively, replacing the original bronze bushings *Cu Sn12*.

The *ERTALYTE Tx* material is a polymer basing on polyethylenetereftalat with added polytetrafluoride of ethylene (PTFE) conferring it special self-lubricating properties and resistance to wear, being especially indicated in the case of bearings for hard conditions. Compared to the TERAMID polyamide, this material has a critical rate of the product "*p.v.*" which is higher, conferring it a better behaviour, under special conditions (without lubrication and in an environment with more impurity).

The material characteristics values, which are important in mechanical elements functioning, are: density; ultimate tensile strength; temperature range; linear expansion coefficient; flashover voltage; resilience.

The working conditions of the drill were those underground, that is:

- bushing strain at abrasive wear (a high dust and humidity environment, faulty lubrication);
- mechanical shocks due to the drill functioning principle;
- rotation of axis on which the bushings are placed : 800 rpm;
- work temperature – 5,45 °C;
- number of working hours per shift: 3h.

After about 100 working hours, measurements were made that showed higher wear than in the case of *TERAMID* bushings.

The measurements were carried out by IRD Fast Track equipment in the areas in which the original bronze bushings were replaced by *ERTALYTE Tx* bushings, *TERAMID* respectively. Both hammer drills were dismounted for revision after about 400 hours of working. The results of the vibration measurements were confirmed by the measurement of wear for these bushings; those made of *TERAMID* had wears 30-40% higher than those made of *ERTALYTE Tx*. From measurements made, and on the observation while working with drills equipped with bushings made of *ERTALYTE Tx*,, the following conclusions result:

- the reliability of TERAMID bushings is of approximately 400 hours and of those of *ERTALYTE Tx* of about 600 hours;
- both polyamides are good for manufacturing bushings for PG80 drill, having a higher durability than brass (CuSn12) at present used for the manufacturing of bushings.

As many PG80 drills display changes compared to the original manufacturing documentation, (mending level and various manufacturing versions) these bushings can be manufactured for each drill, after dismounting;

The durability of these bushings highly depends on the manner in which the adjustment between the shaft and the bushing is established and done, and bushing and case respectively.

Research on the replacing possibilities of bearing at truck wheels

At present, in the mining area of Mining National Company from Baia-Mare, for the transportation of ore underground, they exclusively use one-cubic-meter fixed-box mine trucks, whose sensitive point is the premature destruction of bearings at the wheel trains.

The low durability of bearings has as main cause the precarious state of rail transport tracks (pronounced dishevelment at track joints, non-parallel tracks, lack of traverses and track-fixing elements, many portions covered by mine water), and also their weak tightening. Due to these conditions, in the rolling-friction bearings, supplementary shock strain occurs and at high axial loads, which combined by the penetration of impurities in the bearing area, lead to their rapid deterioration.

To solve these problems, the bearings at the wheel trains were replaced by conical bushings of polyamide of the TERAMID type. This replacement of bearings was done at three trucks, one at EM Baia-Sprie, one at EM Săsar and one at EM Borşa.

The testing was made under specific working conditions:

- Temperature of environment 0-40 C,
- Humid environment with a high dust content,
- Mass of empty track: 560 kg,
- Mass of truck load: 1850 kg,
- Moving speed: 30 km/h,
- Track width 600 mm,
- Operating running diameter 350 mm.

At the bushings of the truck wheels at EM Baia Sprie, made of polyamide of the TERMAID type (bisulphide of molybdenum added), after a drive of about 300 km, the wheels were dismounted for checking, normal wear of bushings being observed. The bushing wears were within the limit of 0,4-1,2 mm, being higher at the conical bushings in the exterior of the wheel. The clearance formed could be removed by tightening the control crown nut.

In the case of the truck at EM Săsar, the wheels were dismounted for checking after a drive of about 300 km. It was observed that the lubricating vaseline was impregnated with mine water and mud, that explaining the hard rolling of wheels. Also, they observed normal wear on bushings. That can be eliminated through the crown nut control system.

At EM Borsa, the materials used for the bushings of the truck wheel were: *TERAMID* nature – for two wheels and *ADDED TERAMID* – for the other two wheels.

After a drive of approximately 400 km, the wheels were dismounted for checking and control, and the wear of the four wheels was also measured. After the measurements, the added material confirmed the better properties of self-lubrication, the wear of the bushings made of this material being more reduced. On the basis of measurements carried out, and taking into account the fact that the maximum limit of radial wear of the bushings is about 2 mm, the durability of a bushing set of *TERAMID* nature is about 500 km, and of the bushings

of *TERAMID* added of about 700 km, this duration being highly dependent on the working conditions.

As a conclusion, taking into account the results obtained, we consider that the bushings of *TERAMID* polyamide type will be successfully used to replace the bearings of the wheel trains at one cubic meter trucks.

3. PERSPECTIVES OF USING POLYAMIDE MATERIALS IN MINING INDUSTRY

The new discoveries in the chemical industry can be successfully used in mining domain for the manufacturing of elements for the digging equipment, creating a safe protection of the equipment and the support with anti-corrosive qualities, which will contribute to the increase of work safety and improvement of working conditions.

At present there is research on:

- replacement of extraction cables with synthetic materials for deep mines, as at these depths the influence of weight specific to metallic cable limits its application range;
- replacement of metals with polyamides, for:
  - construction of recipients for mining transports (cages, skips), of pulleys, drums and winches. The use of polyamides provides the possibility to increase productivity 1,5 times at the same power of the driving motors.
  - loading equipment with pneumatic drive of the MIS 1P and MIT 1P type. The reliability of these loading machines is good in conditions in which they are adequately maintained. There are yet a series of problems, among them - the rapid wear of blades of pneumatic motors. The good functioning of pneumatic motors is conditioned by the use of air oilers of the oil prescribed and feeding of the machine with compressed air, without solid impurities with a minimum humidity percentage. The used blades at present have a good behaviour in the conditions previously mentioned, on the contrary case gripping in the rotor, caused by excessive humidity of the compressed air, by the presence of impurities in the air of the too thick oil used. The use of performance plastic materials of the polyamide type for the manufacturing of these blades, would lead to the increase in durability and to the reduction of the gripping risk in the rotor channels.

These new types of materials present convenient mechanical characteristics, the working temperature range being very wide, they are stable from a thermal point of view and hygroscope point of view, have good self-lubricating properties and a low specific weigh. These materials can be worked with universal machinery and conventional cutting tools.

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