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TEMPERATURE AND RELATIVE SPEED INFLUENCE ON FRICTION FORCE FROM KINEMATIC JOINTS

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ABSTRACT: The paper introduces the apparatus and the procedures of wear determination in complex friction processes - i.e. the wear of the cinematic couplings at high temperatures for different mechanisms in the steel industry.
KEYWORDS: friction, wear, kinematic coupling

INTRODUCTION

The relative translational motion of two bodies in direct contact needs to overcome the resistance due to sliding friction, resulting additional power dissipation. The friction determines the appearance of friction forces, which oppose to the moving tendency of the bodies and produce a mechanical work that leads to heat releasing and to wearing the surfaces in contact.

If the level of the active forces does not exceed those of the friction forces, the friction takes place in a state of rest.

Wear is defined as being a time-progressive modification phenomenon of the sizes of the bodies, due to the friction that takes place during their functioning.

The friction-wear process is a complex molecular, mechanical and energetic phenomenon, which appears between the surfaces in contact that are in a state of relative movement and subjected to obverse (reciprocal) pressure forces. The assembly of bodies in relative motion forms a friction coupling.

The mechanical work of the friction forces will turn mostly into heat, determining the elements of the coupling to heat. The rise in temperature causes a series of phenomena, such as structural transformations of the surfaces, material dislocations by breaking the welding bridge, gripping and plastic deformations, which affect negatively the functioning.

The study of the friction-wear process taking place inside the coupling has a great practical importance, because knowing them allows us to find the most suitable solutions regarding the nature of the materials, the processing and the heat treatment.

This paper shows the study, on an experimental stand, of wear rate of an element of the crane tongs mechanism of handling ingots inside of rolling mills.

The diagram of the tongs of gripping ingots is shown in figure 1 (1 – ingot; 2 – jaw; 3 – slot guide; 4 – gripping point; the proper gripping point being shown in figure 2.

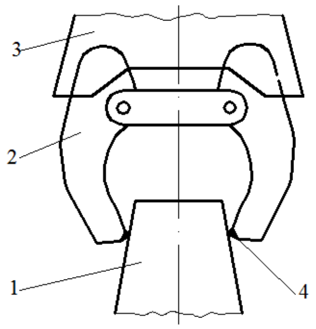

Figure 1. Crane tongs

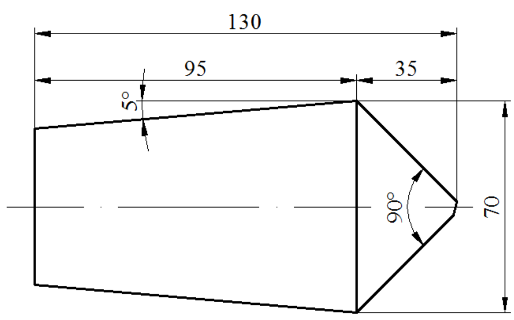

Figure 2. Gripping point

The cinematic coupling, consisting of the gripping points and the lifted ingot, insures its handling; this is why the reliability of gripping has such a great importance. Because of the plastic deformation due to high temperatures and heavy loads, as well as because of the wear, the gripping points (4) wear out, needing frequent replacing.

THE EXPERIMENTAL INSTALLATION

The experimental installation shown in figure no.3 was built in order to study the friction-wear phenomenon; it consists of a special dynamometer in the form of a motor with a tiltable stator, having a device attached to it that includes the friction coupling elements and the system of measuring the temperature inside the coupling. The installation allows the motor speed rate to be regulated, in both ways, from 0 to 3000 rotations/minute.

The specimens are made in the form of cylindrical pieces, as shown in figure 4. The two $\phi 2$ mm orifices serve for introducing the thermocouple in order to measure the temperature. The measured temperature is shown on the temperature indicating devise (11).

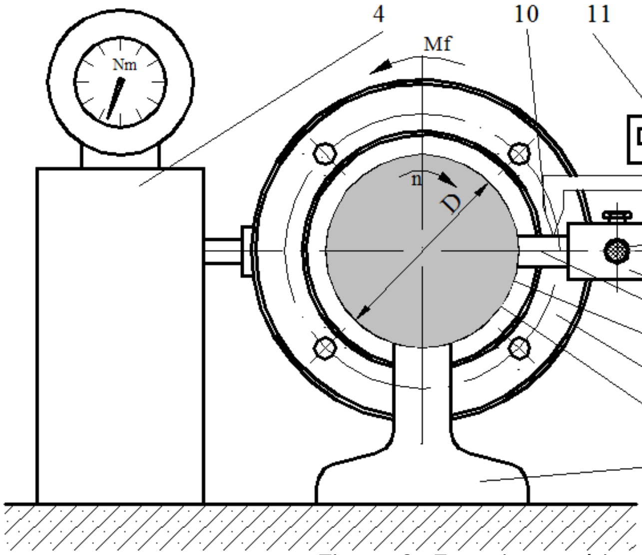

Figure 3. Experimental installation

Figure 3 shows: 1 – the stand; 2 – the machine rotor; 3 – the tiltable stator; 4 – the coupling indicating mechanism; 5 – the rotating wheel; 6 – the test specimen; 7 – the specimen holder; 8 – the loading lever; 9 – the cup; 10 – the thermocouple; 11 – the temperature indicating device; 12 – the specimen heating system (electrode);

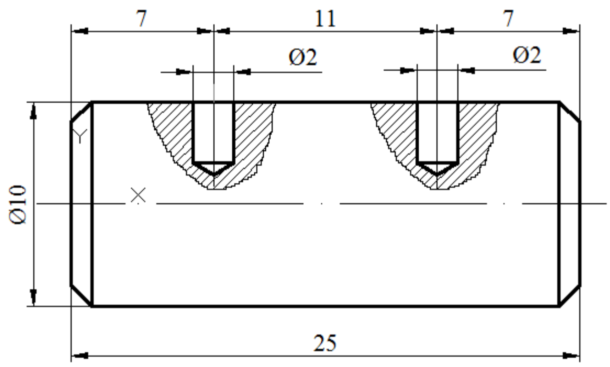

Figure 4.

The rotating wheel (5) and the specimen (6) are the elements of the friction coupling in question. Both the wheel (5) and the specimen (6) can be made of various materials. Practically, an unlimited range of coupling materials can be tested that way. By regulating the motor speed rate there can result a wide range of relative speeds between the elements of the coupling in question.

The specimen was heated to the test temperature by using a graphite electrode system in direct contact with the specimen holder (7).

The normal pressure force (F_3) inside the coupling is created by using a loading lever (8). By choosing the $l_1/l_2 = 10$ ratio, there can result forces 10 times higher than the test weights placed on the cup.

The friction force (F_f) between the elements of the coupling will be:

$$F_f = \mu \cdot F_a \qquad (1)$$

- μ sliding friction coefficient

The wheel friction moment (M_f), which will be shown on the dynamometer scale disk, will be:

$$M_f = F_f \cdot \frac{D}{2} \qquad (2)$$

D - wheel diameter.

Knowing the wheel diameter (D = 270) and the friction moment shown on the scale disk, the friction force from inside the coupling can be obtained.

Comparing the mass of the specimen as it is before and after the couple had operated for 120 seconds, it results the wear (m_i - m_f), in fact the weight decrease, which, in relation to time, will determine the wear rate (V_{uz}), measured in mg/h, respectively [x 10^{-6} kg/h].

$$v_{uz} = \frac{m_i - m_f}{t}\left[\frac{mg}{h}\right] \quad (3)$$

- m_i and m_f are the masses of the specimen before and after the test; and t is the testing time measured in [h].

PERFORMING THE TESTS

The tests were performed in the following order:

- *The specimen was weighed and its initial mass determined. The specimen was then placed on its holder and heated to the preferred temperature;*
- *The installation was turned on and the peripheral speed established.*
- *The test weights were placed on the cup in order to determine the pressure force F_a, and the contact between the elements of the coupling was established.*
- *The own losses of the installation, which were initially determined, were deducted from the value of the global moment shown on the scale disk, resulting the coupling friction moment (M_f).*
- *The specimen was weighed again and its final mass determined.*

The test result is shown in Table 1 and Table 2 and the temperature dependency of the friction forces and of the wear rates is shown in figures 5a and 5b.

Table 1. The wear rate variation whit temperature

No.	The friction coupling materials		The initial mass m_i [x10^{-3} kg]	The final mass m_f [x10^{-3} kg]	The wear m_i - m_f [x10^{-3} kg]	The temperature [°C]	The friction moment M_f [N.m]	The friction force F_f [N]	The wear rate v_{uz} [mg/h]
	Specimen	Disk							
1.	Flaked graphite cast iron	OLC45	13,946	11,892	2,054	20	8,4	62,2	61,6
2.			13,412	11,833	1,579	100	7,75	57,4	47,37
3.			13,185	11,514	1,671	200	8,8	65,18	50,13
4.			13,492	11,654	1,847	300	7,9	58,61	55,41
5.			13,605	11,567	2,038	400	7,25	53,70	61,14
6.			13,517	11,893	1,624	500	7,24	53,6	48,72

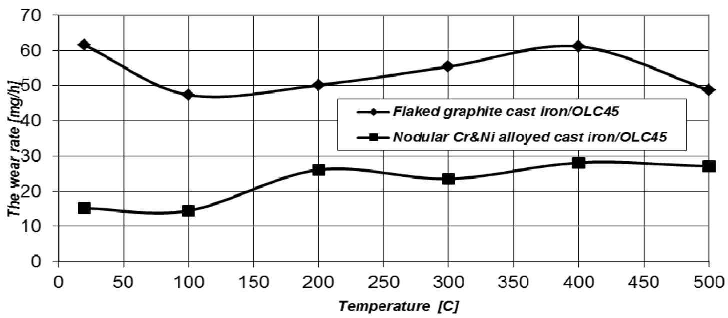

Figure 5a. The wear rate variation whit temperature

Table 2. The friction force variation whit temperature

No.	The friction coupling materials		The initial mass m_i [x10^{-3} kg]	The final mass m_f [x10^{-3} kg]	The wear m_i - m_f [x10^{-3} kg]	The temperature [°C]	The friction moment M_f [N.m]	The friction force F_f [N]	The wear rate v_{uz} [mg/h]
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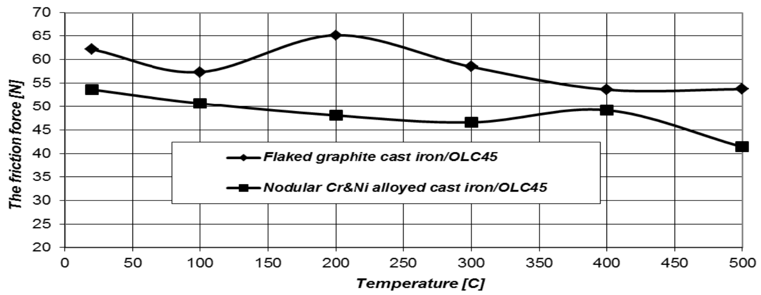

Figure 5b. The friction force variation whit temperature

CONCLUSIONS

The tests, performed on a large number of couplings made of various materials that are mostly used in practice, allowed us to determine a few couples of materials, which are capable of producing cinematic couplings having the lowest wears in a high temperature environment and at various relative speeds.

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