Tribological Journal BULTRIB, Papers from the Conference **BULTRIB '12**
under the hosting of the International Scientific Conference **FIT 2012**
October 18-20, 2012, Sofia
Compiled by: Dr. Mara Kandeva, Society of Bulgarian Tribologists

COPPER FRICTIONAL COATINGS UNDER CONDITIONS OF SELECTIVE TRANSFER

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Abstract: The paper deals with the studies, knowledge and practices carried out in the Laboratories of the Department „Tribotechniques" at the Higher Technical Schools in Chemnitz and Zwickau, Germany, under the guidance of the Head of the Department Prof. Dr. sc. Dr. Gottlieb Polzer. It focuses on the possibilities of the tribotechnologies in saving materials and energy by means of friction and wear reduction by frictional coatings and selective transfer of material.
Key Words: *frictional coatings, selective transfer, no-wear effect, hydrogen wear*

1. INTRODUCTION

It is well known how small is the part of human knowledge, especially of the knowledge in tribology, which is used in practice. Extremely serious is the situation of application in practice of principally new knowledge, such are the cases with the effect of the selective transfer and the hydrogen wear mechanism in the frictional coatings. Wear reducing frictional coatings obtained under procedures of **selective transfer of material** between the contacting surfaces are of great importance for practical applications.

In 1966 D.N. Garkunov and I.V.Kragelskii have registered as a scientific discovery the selective transfer of material from one contacting specimen to the other under special conditions [1]. Of particular interest, both in theory and practice, were the studies of the No-wear friction and the hydrogen wear [2].

2. SELECTIVE TRANSFER OF MATERIAL

D. N. Garkunov and G. Polzer are of the first researchers in theory and practice of the selective transfer of material during friction of Cu-containing contact surface with special surface-active substances, the corresponding formation of the "servovite layer" (notion adopted as per analogy with the contact in animal/human articulation), and the resultant high reduction in friction and wear [1, 2, 3, 4]. Prof. Garkunov was awarded the 2005 Tribology Gold Medal for his "achievements in tribology, especially in the field of selective transfer". Beside the mentioned references, the phenomenon of selective transfer is observed and commented in various tribological studies [5, 6, 7, 8, 9].

Characteristic for the process of selective transfer of material between the frictional surfaces is the formation of secondary layer with low shift resistance in the contact. This protective layer cannot accumulate dislocations and is highly antifrictional. The self-organization phenomena in this case depend on the interface energy and the material exchange. Generation of that layer requires special combination of materials of the contact surfaces, as well as special lubricant between them (e.g. glycerol). Synergy effect in the forming of new contact structures in the contact between surface materials and lubricant is desirable as optimization of the contact couple. Here, synergy is available, as two or more agents (contact surface material and lubricant), working together, produce a result not obtainable by any of the agents independently.

3. FRICTIONAL COATINGS UNDER CONDITIONS OF SELECTIVE TRANSFER

3.1. Overall consideration

The paper focuses in the procedures of obtaining brass and copper frictional coatings in the case of nonabrasive treatment of steel surfaces. Procedures of the study of copper or brass frictional coatings through selective transfer of materials are considered.

Tribologists have the task to keep the destruction as small as possible or to stop it, in order that the system comes to the equilibrium process between destruction and regeneration. Exactly this happens in the processes of selective transfer. This phenomenon is assisted by the rubbing of brass under the special conditions of selective transfer of material. A steel shaft to be coated is both subjected to rotation and to the pressure of the brass stick in the presence of a special lubricant. Some results of the basic studies and application in the area of copper frictional coatings are presented below. Based on equation of the theoretical physics, Prof. Polzer [3] had formerly derived equations of self-organization at friction. Always when destruction problems are available in nature, there are two possibilities for the whole system:

- There is simultaneous growth processes, which involve equilibrium between destruction and regeneration, or
- Most often destruction leads to exponential destroying of the whole system, in our case the tribological couple.

3.2. Experimental work

The phenomenon of direct coating deposition is assisted by the rubbing/deposition of brass under the special conditions of selective transfer of material. The principle scheme of the assembly is shown in Fig 1.

The steel shaft to be coated is both subjected to rotation and to the pressure of the brass stick in the presence of a lubricant. Different processes result with following peculiarities. In the contact zones emerges reactive coating deposition with special properties:

- Copper is rubbed on the steel friction surfaces with totally different electro-chemical potential.
- Not only the content but also the structure in the friction surfaces is being changed.

The press forces at the rotation of the brass stick involve great pressure in the contact zone between stick and basic material due to the relative small contact surface, hence a positive gradient of the shear strength in depth direction of the friction surface according to I. V. Kragelsky [10].

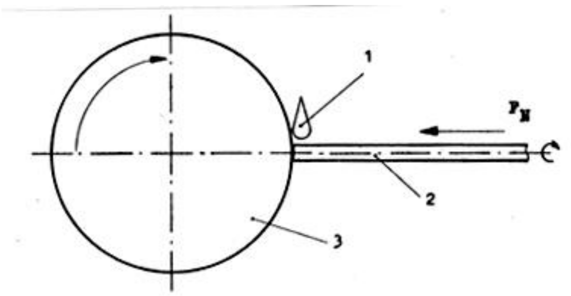


Fig. 1. Principle assembly for brass deposition on a shaft *(1 – surface active liquid; 2- brass rod; 3- shaft to be coated)*

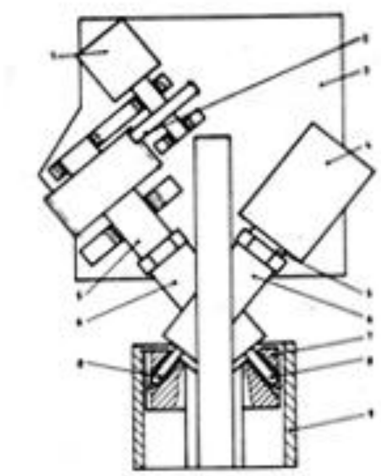


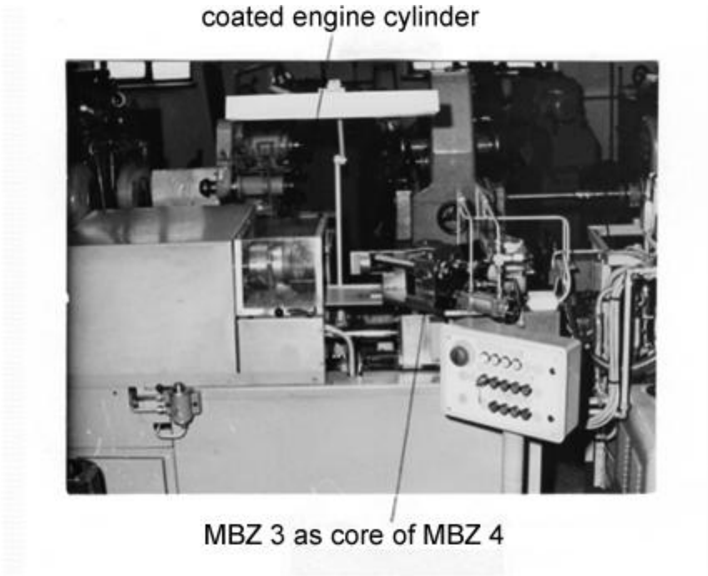
Fig. 2. MBZ 3A Brass-coating device for sliding bushes (application in lathes)

As a result, a tribological system appears which can bear higher loads at the influence of various processes. Different machines were designed and constructed at the Department Tribotechnik in Zwickau' Higher Technical School, corresponding to the principles of the frictional deposition and the ideas of the selective transfer. Many pieces of the devices „MBZ 1 B" for shaft coatings and „MBZ 3 A" (see Fig.2) for application in rotating machines were manufactured, e.g. the „MBZ 3 A" for engine cylinders was produced in 30 items. Unfortunately there is not sufficient use of the advantages of the deposition of copper frictional coatings in the overall practice.

Various applications of the brass-coating device are given in Figs. 2, 3, 4, 5.

The principle scheme of a device for deposition on cylinders of copper frictional coatings is given in Fig. 6.

Fig. 3. View of the brass-coating device MBZ 3A



4. The brass-coating device applied in automatic machine

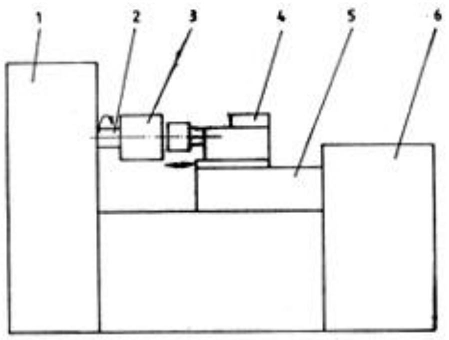


Fig. 5. MBZ 4A The brass-coating device with automated frictional coating process

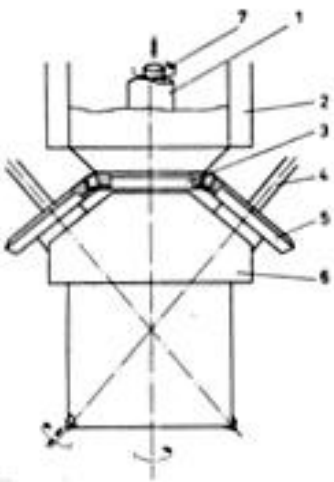


Fig. 6. Brass-coating device for cylinder-bushing by boring machine

Further, some diagrams referring to basic new results are presented. Fig. 7 shows the content of Cu and Zn in the brass in the shadowed zone for Cu Zn 37, as well as coated surfaces in depth.

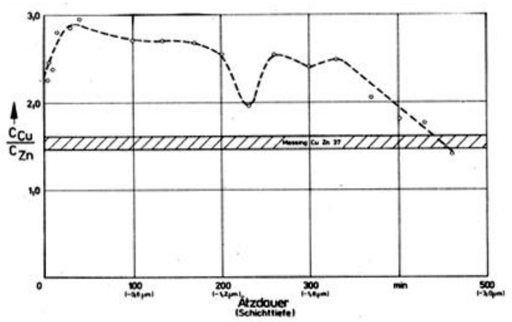


Fig. 7. Ratio of Cu and Zn in brass in the coating in different depth of the surface

In Figs. 8 and 9 is given the variation of hardness in depth; so we can obtain the strengthening also at different rotation speeds.

Figs. 10 and 11 show the percentage of the improvement (improvement of the wetting ability) in the usage of oil B for different lubricants and coated surfaces.

It is highly important for practical applications that the inclination for welding between the friction surfaces is significantly lowered under conditions of selective transfer.

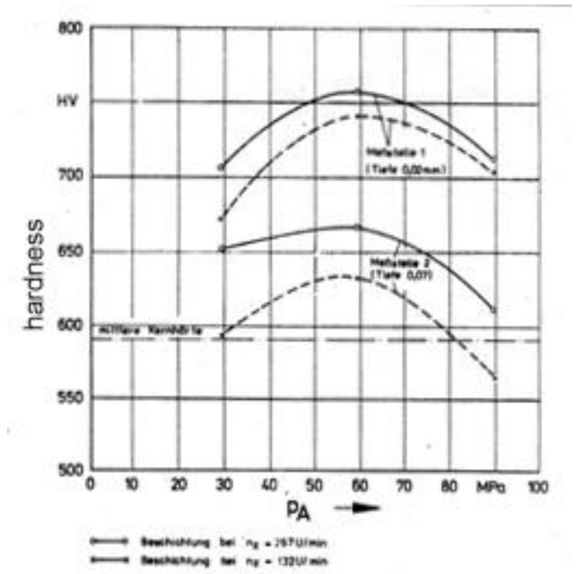


Fig.8. Hardness in different depth after frictional coating deposition on steel

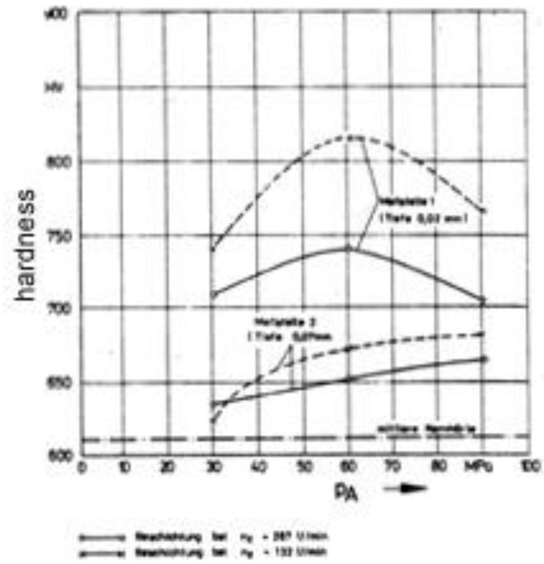


Fig.9. Hardness in different depth after frictional coating deposition on GGL25

Fig. 12 shows the reduction of hydrogen concentration of the friction surface in depth. By means of brass frictional coating, it can be obtained in different constructions of steel and cast iron not only the 10 - 20 % lowering of friction force, but also a changed wear distribution, which is to be seen, e.g., for the upper death point in engine cylinders of 2-cylinder-twotact-Ottomotors after various completed paths (see Fig. 13).This was the reason that the brass frictional coatings were successfully applied in the practice of the company Peißig in Zwickau especially in highly loaded race motors for more than 20 years.

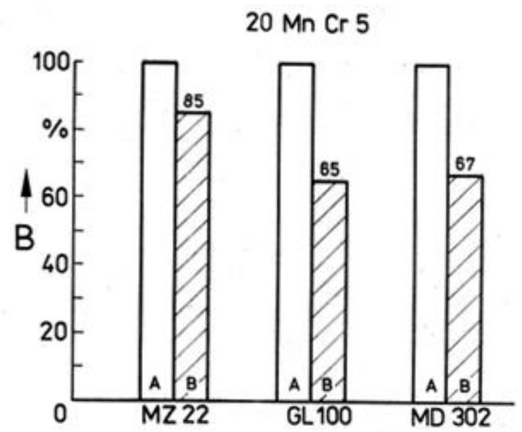


Fig. 10. Improvement of the oil-wetting for different oils by steel

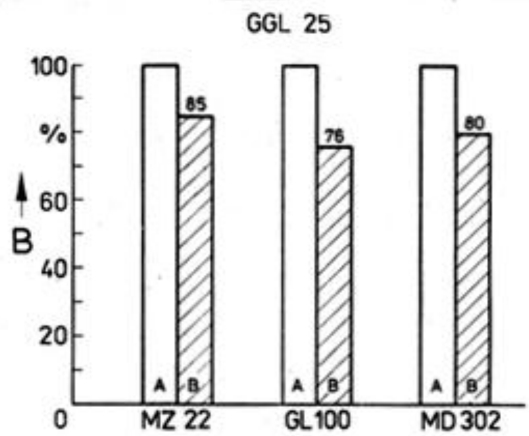


Fig. 11. Influence of the frictional coating on the wetting ability by cast iron

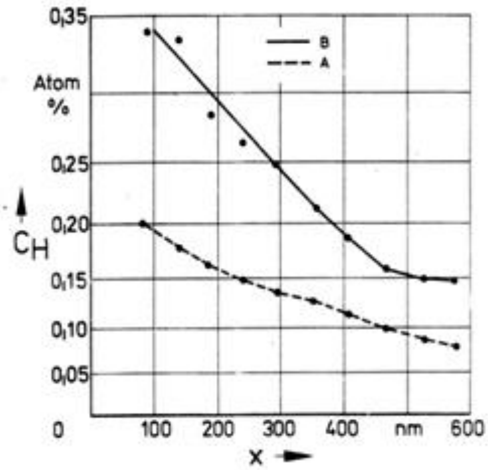


Fig. 12. Reduction of H_2 concentration at the frictional surface in depth

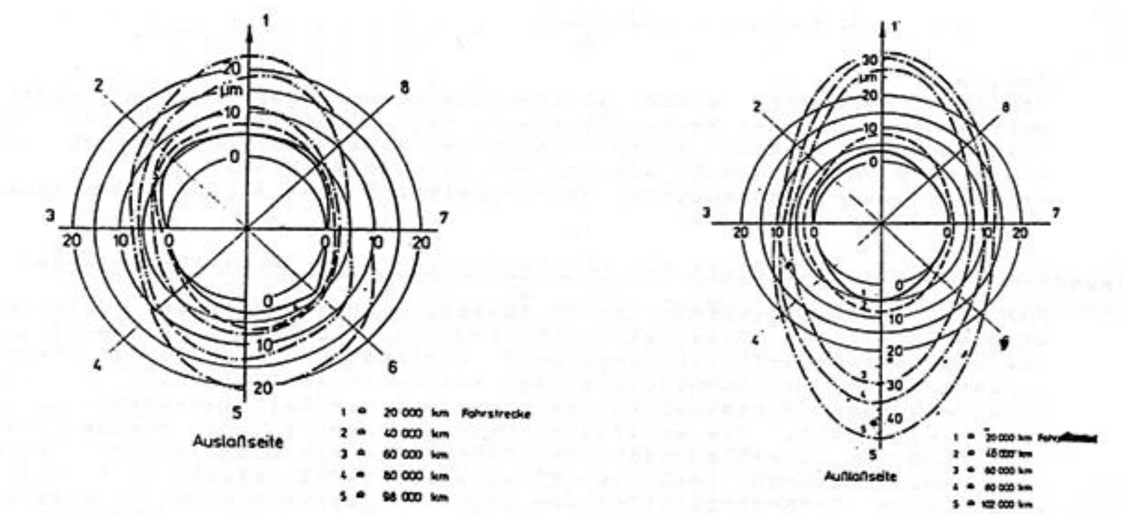


Fig. 13. Wear distribution in upper dead point of engine cylinder after different sliding paths: for cylinder with frictional brass coating (left) and without coating (right)

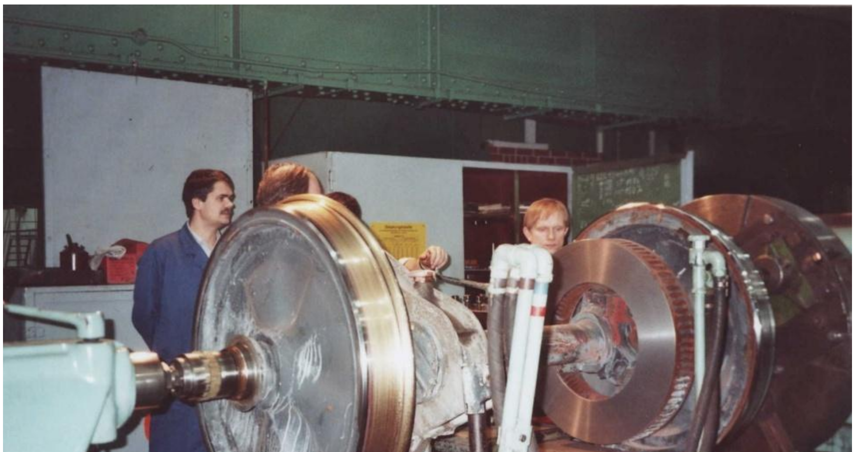


Fig. 14. Frictional coating of big wheels

4. CONCLUSION

In above tribological study, a self-organization in the system brass-glycerol-steel is observed and the obtained film – a designed or programmable coat with significant change of wear-resistance – is linked to the concept of a coating deliberately manipulated to influence its properties during friction. Major result is the low wear of components coated under condition of selective material transfer mode with wide practical application. Important is the reduction of the concentration of hydrogen at the frictional surface and, respectively, the lower hydrogen wear. It is highly important for practical applications that the inclination for welding between the friction surfaces is significantly lowered under conditions of selective transfer. A considerable practical result is the possibility for dismantling-free restoration of worn units/couples.

The practical implementation of brass-copper frictional coating is of extreme importance and was realized in Germany, Russia, Kazakhstan, etc.

The interdisciplinary character of the study and application of technologies for frictional coating formation, layer growth techniques, surface texturing, etc. involves intervention by specialists of different sciences. The work and collaboration between scientists of Russia, Germany, Poland, Bulgaria, Mongolia and Vietnam in this field was carried out by the International Council for Selective Transfer and Frictional coatings, established in 1990 in London.

INTERNATIONAL COUNCIL
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