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SOME RESULTS EXPERIMENTAL TEST FRICTION AND WEAR BETWEEN AL ALLOYS AND TOOL MATERIALS

BOGDAN Nedić, Faculty of mechanical engineering, Kragujevac, Serbia

GORDANA Lakić-Globočki, Faculty of mechanical engineering, RS, BiH

ABSTRACT

Continuous development and application of new materials, tools and cutting fluids and enlarged application of calculations, simulations and modeling in area of metal cutting asks for the knowledge of friction coefficient between these materials and cutting tool materials.

In this paper some results of experimental test of friction and wear processes between Al alloy and different tool materials like HSS and HSE.E with and without coatings, hard metals with and without coatings and cutting tool ceramics on "Block on disc" tribometer are presented in this paper.

KEYWORKS*: Al alloys, friction coefficient, cutting inserts, tribometer*

1. INTRODUCTION

The cutting process takes place in conditions of high pressures between contact surfaces, large amount of heat generated in cutting zone and intensive tool wear.

Menaging cutting processes demands great knowledge of tribological characteristics of cutting tools as well as arability of workpiece. Development and application of new tool materials lead to apperance of new generation of materials that are resistent to vibrations, wear, high temperatures and enable machining without agents for cooling and lubrication. They also enable the application of high speed tehnology (machining with extremly high cutting speed)

In recent times, the application of aluminium and its alloys is becoming widespread in all fields (cars production, aeroplane industry, and civil engineering) due to the fact that aluminium has smaller density than steel, it is well resistant to corrosion and it has good mechanical and recycling properties.

This application is especially prominent in car and aviation industries, because the application of aluminium parts provides smaller fuel consumption and at the same time it reduces production costs. Aluminium and its alloys are used for production of engine heads, engine blocks, cases for gearbox and differentials, carrying frame, car body panel etc. The following aluminium alloys are most widely applied for the aforementioned purposes: *Al-Mg-Si* alloys which are heat hardening, weldable *Al-Zn-Mg* alloys, cold formed sheet metals based on *Al-Mg* and *Al-Mg-Mn*. (e.g. Audi A2 has 37% *Al*, Audi A4 16% *Al*, Mercedes Benz C - class 11%). According to some predictions, the share of light alloys in passenger car production will reach 80% by the year 2010. It is believed that the current aluminium alloys used in car industry will be replaced by Al-Mg-Li and Al-Cu-Li-Mg alloys in the following years, because these alloys have smaller density and higher elasticity module, which is very important for good welding properties.

The best known *Al* alloy is *AlSi12* which has excellent mechanical properties and relatively high corrosion resistance. It is applied for medium stressed thin-wall castings for general purposes in car and aircraft industries. It is not thermally-hardening. *Al-Si* alloys which are most widely applied in car and aircraft industries are:

- *AlSi12Cu2Fe* - for car engine parts,
- *AlSi5Mg* - for castings of engines and vehicles exposed to impact load in the course of operation,
- *AlSi10Mg* - for tense thin-walled castings resistant to vibrations,
- *AlSi12CuMgNi* - multi-component alloy for cylinders of internal combustion engines,
- *AlSiCu4* - for castings of higher hardness,
- *AlSi6Cu2* - for the most loaded parts of internal combustion engines.

As the development of new tool materials recently is evident, which specially refers to ceramic materials and coatings on hard metals, it brings the need for fast investigations of tool material influence on tribological characteristics of contact pair tool – workpiece. With that purpose investigations of tribological characteristics of tribological contact pair block on disc, where disc is made of workpiece material, and block of tool material are welcome.

2. TRIBOMECHANICAL SYSTEM IN CUTTING ZONE

As it takes too much time to develop the new tool, tool material and find its application in industry, as for obtaining first results of application, we must develop fast and light, but also reliable methods for determination of tribological characteristics of tools. That way, the time needed for development of tool materials would be significantly shortened. Tribological investigations in phases of development of new tool have the main purpose to determine the influence on cutting wear intensity of tool material, cutting contact temperature, cutting fluid and cutting friction between elements in contact.

For many years, in the Laboratory for metal forming and tribology at Faculty of Mechanical Engineering in Kragujevac efforts have been made and significant results accomplished in developing tribological methods and modern equipment for tribological investigations. With that purpose, several tribometers have been designed and developed.

Tribological processes in cutting zone take place both on front and back tool surface due to the contact of front tool surface and chippings and back tool surface and formed surface of the formed piece. The cutting processes shown in figure 1 can be presented with main tribomechanical system which consists of cutting wedge of tool (1), chippings and formed piece (2) which are placed at the setting which consists of agent for cooling and lubrication (3), figure 1.

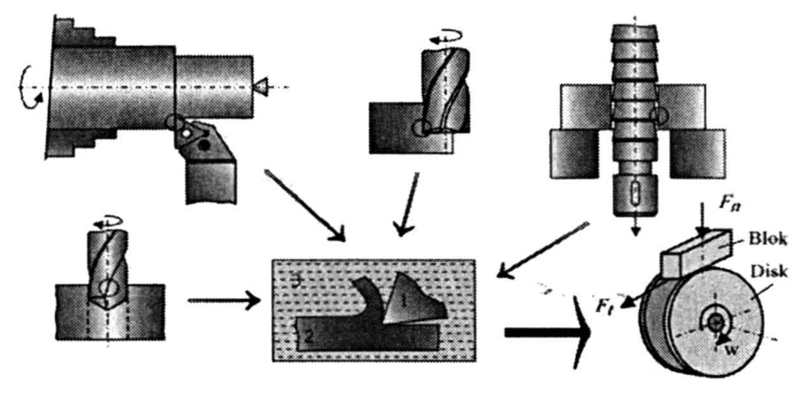

Fig 1. Main tribomechanical system in cutting process

In the presented tribomechanical system, chippings slide against front surface of tool at speed v_s, at normal loading F_{N1}, and back surface slides against formed surface at speed v at normal loading F_{N2}. Figure 2 shows the model of the cutting process. Since, in most cases, the intensive wear processes take place on the back surface of tool, the basic model of cutting process can be represented as shown in figure 2b, where sliding speed represents the cutting speed, and normal loading F_{N2} is a radial component of the cutting resistance. This means that "block on disk" block on the tribometer represents the tool, while disc is of formed object material.

In this work as a block were used cutting inserts of hard metal with or without coating and ceramic cutting inserts. The width of all inserts was 4 mm. For investigations HSS and HSS.E of tool materials with and without coating special 4 mm wide inserts were made and coated in Institute for Copper – Bor

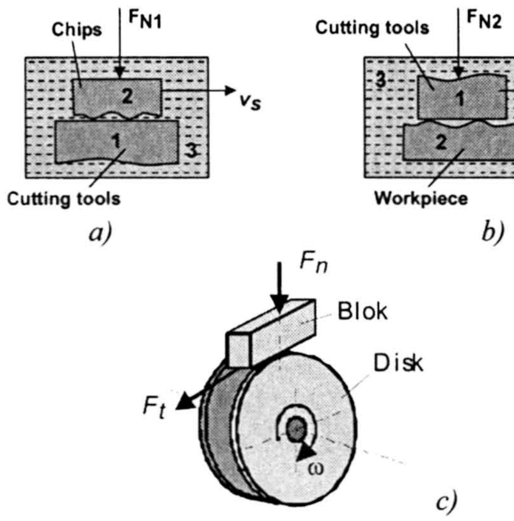

Fig 2. Tribological model of the cutting process

3. SOME INVESTIGATION RESULTS

By preliminary investigations in forming by scraping, the cutting resistances were measured with the aim of determining the normal loading in investigations on tribometer. These investigations were realized within particular range of cutting regimes which correspond to rough forming. Thereat, the values of radial component of cutting resistance of about 50 - 100 N were obtained. Investigations were carried out at cutting speed 180 m/min (3,0 m/s).

Based on these information, investigations on tribometer were conducted at sliding speed 2,7 m/s (160 m/min) and normal loading of 60 N, during 15 s, and then 100 N before strong vibrations appeared. The disc of Al alloy AlSi12CuMgNi of width 50 mm and hardness 130 HB. Block was made of different tool materials (Table 1.)

Investigations were conducted without cutting fluid, with the aim to identify real values of friction coefficient, and the investigations were abborted after appearance of strong vibrations in measuring system.

By realized investigations on tribometer, the basic experimental documentation was formed, which contains information on conditions of experiment execution: block and disk material, hardness, topography of contact surfaces and conditions in which contact is realized (loading, sliding speed, lubrication, temperature). The investigation results contain information on the following: friction coefficient and change of friction coefficient within time of contact realization.

Values of friction coefficient, according to table 1, measured in first 15 s of investigation period, during first contact period and normal loading of 60 N, are presented on picture 3, and middle values of friction coefficient after 20 s at the same sliding speed and normal loading of 100 N are presented on picture 4. Significant differencies between these values can be noticed.

The lowest values of friction coefficient are measured during contact of Al disc with block of fast cutting steel without coating and hard metal without coating.

Due to relatively fast sedimentation process on insert surface with loading of 100 N, it came to constant increase of friction coefficient, so the presented results present middle values before appearance of strong vibrations.

Table 1.

Num.	Cutting insert	Friction coefficient	
		Fn 60 N	Fn 100 N
1	HSS.E, without coating	0,056	0,10
2	HSS, without coating	0,054	0,097
3	HSS with TiN coating	0,22	0,25
4	HSS with (TiZr)N coating	0,21	0,24
5	insert SNMG 120412 hard metal P20, without coating, S25M	0,1	0,14
6	insert SNMA 120412 hard metal P15 with coating P-415	0,2	0,33
7	insert SNUN 120412 hard metal P15 with coating AC211	0,18	0,37
8	insert SNUN 120412 hard metal P15, without coating, P15/K15C	0,19	0,26
9	insert SNMG 120412 hard metal P25 with coating, KC810	0,25	0,38
10	insert CNMG 120412 hard metal P35, without coating, P35	0,13	0,31
11	insert CNMG 120412 hard metal P25 with coating, GC3025	0,125	0,28
12	insert SNMG 120404 hard metal P15 with coating, PGP 431	0,22	0,35
13	insert CNMG 120412 hard metal, without coating, V0-5	0,22	0,33

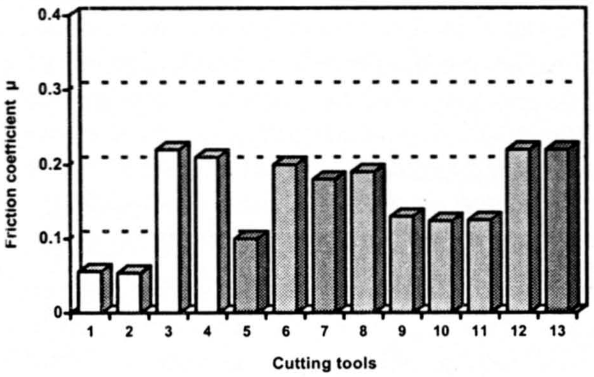

Fig. 3. Middle values of friction coefficient during first 15 s of investigation with Fn=60 N

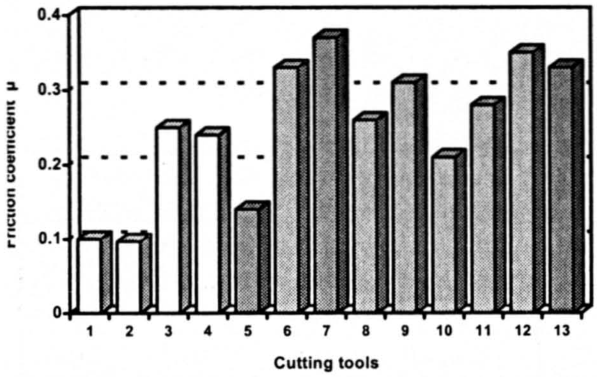

Fig. 4. Middle values of friction coefficient with Fn = 100 N

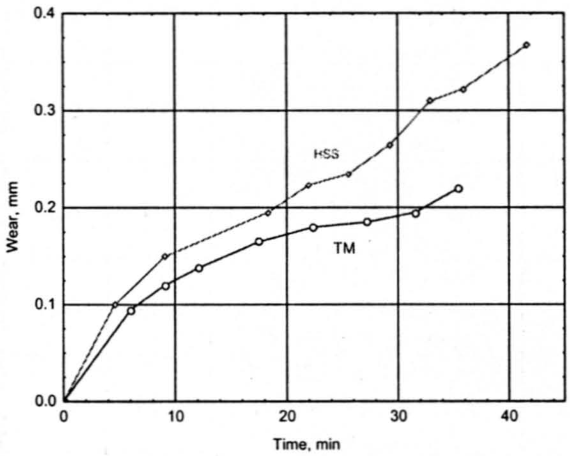

Fig. 5. Wear - time cutting -

- HSS, without coating (num 2)

- insert SNMG 120404, hard metal P15 with coating, PGP 431 (num 12)

v=55m/min, a=1 mm, s=0.112 mm/o

4. CONCLUSIONS

Due to limited space, in this work is presented only part of realised investigations. Based on comprehensive investigations it can be noticed that there are significant differencies of measured friction coefficients on 'block on disc' tribometer between disc of Al alloy and lateral surface of cutting insert that represented block on tribometer.

Measured values can indicate the course of investigation with the aim of selection of cutting tool material, the surface layer of the tool that would be used for Al alloy machining. High values of friction coefficient lead to inappropriate machining due to sedimentation, increased temperature in cutting zone, increased temperature of agents for cooling and lubrication and increased tool wear.

Measured values of friction coefficient can be used for mathematical calculations with the aim of modeling and simulation of processes running in the cutting zone.

LITERATURE

1. *Ivkovic, B.,* Simulation of tribological processes in cutting zone on tribometer "block on disk", Tribology in Industry, Vol. 20, No3, 1998
2. *Nedić, B.,* Simulation of cutting processes on tribometer in the function of developing new cutting fluids for aluminium alloys machining, Journal MVM, Secial edition, Vol 30. Kragujevac, 2004.
3. *G. Lakić-Globočki*, Identifikacija triboloških procesa u zoni rezanja grupe teškoobradivih materijala i aluminijumskih legura, doktorska disertacija, Banjaluka, 2004.
4. *B. Ivković, G. L. Globočki, P. Dugić,* Some results of Friction and Wear Tests in the HSS and Al Alloy Contact, Conference Manufacturing Engineering and EUREKA Partnerig Event, Greece, 2002.
5. *B. Nedić, G. L. Globočki,* Results of Measurement of Friction Coefficient Between Al Alloys and Tool Materials, The Coatings and ICMEN Conference, Greece, 2005