SERBIATRIB`07
10th International Conference on Tribology
and
WORKSHOP`07
Sustainable Development in Industry by Apply Tribology Knowledge

THE INFLUENCE OF COOLING FLUIDS TYPES ABOVE CUTTING TOOLS DURABILITY

RAZVAN G. RIPEANU[1*], ADRIAN C. DRUMEANU[1], GEORGETA MATEI[2], MARCEL LUCA[2]

1- University Petroleum-Gas of Ploiesti, Romania
2- I.C.E.R.P. S.A. Ploiesti, Romania
***- E-mail: rrapeanu@upg-ploiesti.ro**

ABSTRACT
Paper presents the tests made on 4-balls machine on cooling fluids with different additive types and concentrations, in order to establish the proper composition. In the presence of selected cooling fluids, on Amsler machine, were determinate the tribological behavior of linear couple's carbon steel- high speed steel. The obtained friction coefficient and wear curves for tested materials couple were used to evaluate EP proprieties for proposed oil cooling fluids samples.

KEYWORDS: *cooling fluids, wear, cutting tools, friction coefficient*

1. INTRODUCTION

From manufacturing processes, cutting leads at severe friction regimes and cooling-lubrication of chips formation zone is different from classic lubrication.
Lubricants used as technologic mediums in metal cutting processes should complete some main specific demands as:

- reduce friction between working piece and cutting tool and between cutting tool and chips in order to rise tool durability and to improve machined surface;
- remove the heat and the material resulted from the cutting zone;
- assure lubrication in limit condition between cutting tool, piece and chips;
- to be stabile (chemical and structural);
- to be, as possible, environmentally friendly;
- to not react with materials and even to assure a short corrosion protection till the next operation;
- resistance at microorganisms which develops in cutting medium and to assure a small toxicity;
- to be, in special cases, compatible with the other machine-tools lubricants;
- to be chopper.

Each cutting operation type is characterized by some specific factors and so cutting fluids must complete specific demands and, as a result, there are many cutting fluids types.
Depending of cooling and lubricating proprieties the cutting fluids could be divided in two main groups [1, 2].
First group are water soluble fluids characterized by small viscosity and great values for specific heat and thermal conductivity.

Second group are oil based fluids with very good lubricating, deforming and detaching chips proprieties. As surface active additives which form adsorption resistant films at high pressures, reduce friction coefficient and enter in microcracks making cutting easier are used stearic and oleic acids and organic compounds containing sulfur, chlorine or phosphor. As synthetic based oils are mostly used esters and poly-alpha-olefins [2, 3]. Because cutting oils are in contact with operator skin, the toxicological proprieties are very important. Very important are also oil thermal-oxide stability. At cutting electro-chemical potential of machined material became more electropositive and cutting fluids should contain also anticorrosive additives. Antioxidant additives such as phenols, amines and anticorrosive additives such as zinc dithiophosphates or dithiocarbamates, esters, fat amides, amides of dodecilsuccinic acid, fatty acid derivatives etc. are mainly used [2].

This paper presents a part of tests made in order to formulate a cooling fluid for cutting and rolling.

2. EXPERIMENTS

Lubricating cooling fluids proprieties were considered as a main criterion. In this order the 15 selected esters were tested on 4 balls machine presented in Figure 1.

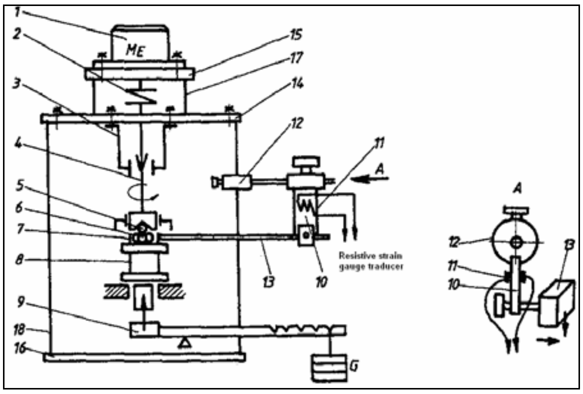

Figure 1: 4 balls machine
1- engine; 2- pin coupling; 3- bearings body; 4– main ax; 5- upper ball; 6- lower balls; 7- box with lower balls; 8- step bearing; 9- load system; 10- elastic blade; 11- strain gauge; 12- support for elastic blade; 13-arm fixed on box with lower balls; 14- intermediate plate; 15- upper plate; 16- base plate; 17- upper rods; 18- lower rods.

The rotation speed of upper ball was 1375 r.p.m. In Table 1 are presented the obtained results.

Table 1: 4 balls machine results

Sample	Ester type	Normal force, before welding, N	Friction torque, before welding, Nm
1	Monoester of oleic acid with isodecylic alcohol C13	536,5	0,656
2	Monoester of oleic acid with isodecylic alcohol C10	536,3	0,225
3	Monoester of oleic acid with 2 etoxylated p-nonylphenol	536,5	1,379
4	Monoester of oleic acid with 2 o- secondary butyl phenoxyethanol	1223,2	0,164
5	Monoester of oleic acid with 1 o-secondary butyl phenoxyethanol	765,7	0,400
6	Monoester of caprylic acid with isodecylic alcohol C13	536,5	0,492
7	Monoester of caprylic acid with isodecylic alcohol C10	536,5	0,480
8	Monoester of caprylic acid with 2 etoxylated p-nonylphenol	765,7	0,656
9	Monoester of caprylic acid with 2 o- secondary butyl phenoxyethanol	2070,8	0,820
10	Monoester of caprylic acid with 1 o- secondary butyl phenoxyethanol	2070,8	0,175
11	Monoester of butyric acid with isodecylic alcohol C13	994,5	0,187
12	Monoester of butyric acid with isodecylic alcohol C10	994,5	0,673
13	Monoester of butyric acid with 2 etoxylated p-nonylphenol	2070,8	0,525
14	Monoester of butyric acid with 2 o- secondary butyl phenoxyethanol	2553,5	0,350
15	Monoester of butyric acid with 1 o- secondary butyl phenoxyethanol	994,5	0,656

Figure 2 present a histogram of maximum normal force applied on 4 balls couple before balls welding.

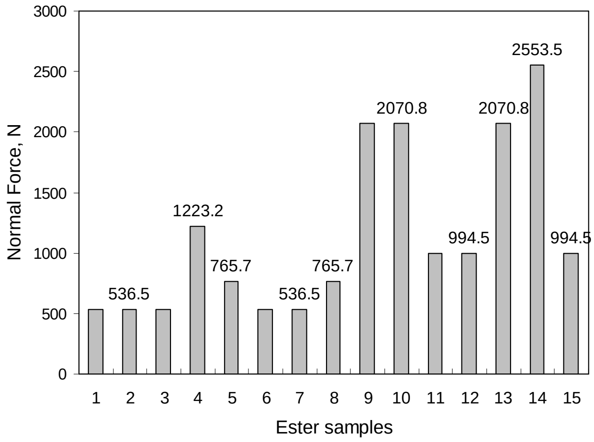

Figure 2: Histogram of normal force

The 5 ester of soybean and oleic acid type samples 4, 9, 10, 13 and 14 (with the best results so it is shown in Fig.2) were selected to produce 5 cooling oil with min. 70% biodegradability according to CEC L-33-T-82.

The 5 oil cooling fluid samples were tested on Amsler A135 machine to establish the tribological behavior of linear couple's carbon steel- high speed steel. In Figure 3 are presented the dimensions of samples [4]. Cylinder material was carbon steel with hardness 190HB2,5/187,5 and disk plate of high speed steel with hardness 68,5HRC.

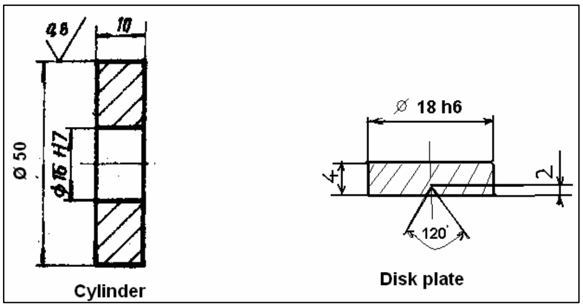

Figure 3: Sample dimensions

For sliding speed 0,523 m/s the friction coefficient variation with normal load for the 5 oil cooling fluid samples is presented in Figure 4. Oil cooling sample number:

- 1 contains monoester of butyric acid with 2 o-secondary butyl phenoxyethanol;
- 2 contain monoester of caprylic acid with 1 o-secondary butyl phenoxyethanol;
- 3 contains monoester of butyric acid with 2 etoxylated p- nonylphenol;
- 4 contains monoester of oleic acid with 2 o-secondary butyl phenoxyethanol;
- 5 contains monoester of caprylic acid with 2 o-secondary butyl phenoxyethanol.

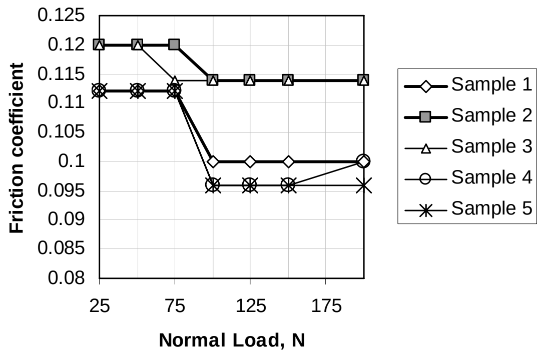

Figure 3: Friction coefficient vs. normal load

In the presence of oil cooling fluid samples number 1, 4 and 5 were made wear tests at normal load 1000 N and with sliding speed 0,523 m/s. In Figure 4 is presented the volumetric wear curves for HSS disk plate.

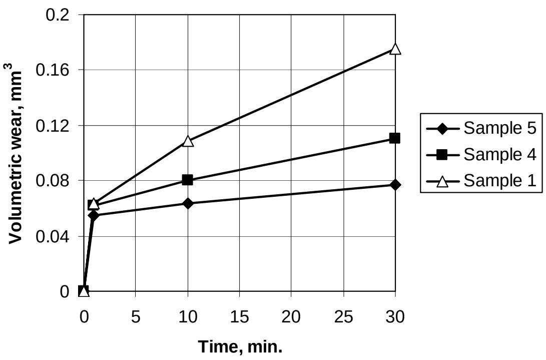

Figure 4: Volumetric wear curves for disk plate

In Figure 5 it is shown the volumetric wear curves for carbon steel cylinder.

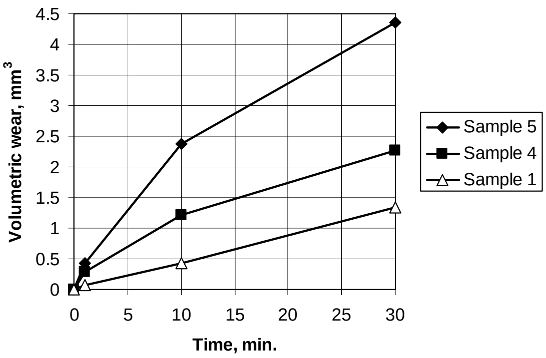

Figure 5: Volumetric wear curves for cylinder

3. CONCLUSIONS

The proposed oil cooling fluids are designed for use in moderate to severe machining operations. These cutting oils are available in different EP levels and viscosity grades to cover a wide variety of machining operations and metals. The oils will be used as metalworking neat oils for industrial applications: deep hole drilling, broaching and tapping, gear cutting and shaving, grinding, honing and lapping, turning, planning, shaping, milling e.g.

The cutting oils contain unique synergistic extreme pressure additive systems that readily react at chip-tool interface to form extremely effective lubricating films which reduce frictional heat and prevent meta-to-metal contact between the tool and workpiece and chip. The cooling fluid samples were made with various percent from soybean oil, low esters of soybean oil, oleic acid esters, sulfurized soybean oil and additives. The tests presented in this paper were made to select the proper oil cooling fluids sample and composition in order to obtain good EP proprieties which are important for the metalworking process.

Tests on 4 balls machine for the initial 15 ester samples let us to conclude that monoester of butyric acid with 2 ortho secondary butyl phenoxyethanol is the best.

In Fig.3 could be was observed that the additive effect begin at different loads for the 5 oil cooling fluids samples presented. For oil samples 5 and 4 were obtained the smallest values of friction coefficient. This means that formulas with monoester of butyric acid with 2 ortho secondary butyl phenoxyethanol and formulas based on monoester of butyric acid with 2 etoxylated para nonylphenol are better than the rest.

From Fig. 4 of HSS wear it could be observed that oil sample 5 assure the smallest volumetric wear values. In the mean time for the workpiece, similar with carbon steel cylinder the wear should be maximum values. In fig. 5 it is shown that oil sample 5 assure the greatest wear values.

These results obtained for oil cooling fluid samples on universal machines testing machines shows that formula for oil sample 5 is better than the rest of oil samples.

With this oil sample the tests will be continued on cutting machines with special devices [4, 5, 6] in order to establish axial cutting force, cutting torque and cutting tools wear.

REFERENCES

[1] Aelenei, M., Gheghea, I., “Problems of cutting-machines and cutting”, Technical Publ. House, Bucureşti, 1985(in Romanian);

[2] I. Tudor and R.G. Ripeanu, “Corrosion Engineering”, Ploiesti University Publ. House, 2002 (in Romanian).

[3] Flueraru, F., Ripeanu, R.G., Luca, M., Popescu, D., *Future trends in corrosion protecting coatings used in manufacturing processes*, Journal of the Balkan Tribological Association, Vol.12, No.4, 2006, pp.572-580;

[4] Ripeanu, R.G., Tudor, I., Tache, A., *Research regarding the influence of cutting parameters above drills durability*, Proceedings of the 7th International Symposium INSYCONT’06, Cracow, 14-16thseptember, Poland, 2006, pp.305-313;

[5] Ripeanu, R.G., Tudor, I., Tache, A., *Establishment of the durability of some hard PVD coated drills*, Journal of the Balkan Tribological Association, Vol.12, No.3, 2006, pp.267-271;

[6] Tudor, I., Popescu, A.A., Ripeanu, R.G., Balaceanu, M., Braic, V., Braic, M., *Tribological characteristics of superhard Ti(C,N) coating deposited on milling cutters*, Journal of the Balkan Tribological Association, Vol.11, No.3, 2005, pp.404-408.