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PROPERTIES OF WATER MISCIBLE CUTTING FLUIDS IN THE CUTTING PROCESS

Eva BURANSKÁ, Peter POKORNÝ, Ivan BURANSKÝ

Abstract

Article discusses the diagnostics and possibility of monitoring cutting fluids and proposes a solution: on–line monitoring system. In regard to verify the possibility of using various methods to identify changes in the cutting fluids were carried out experiments to measure electrical parameters

Key words

cutting fluids, machining, properties, monitoring

Introduction

During machining, the cutting fluids are longer under the influence of their oxidation thermal and mechanical load, contamination and catalytic effects of metals. Various physical and chemical parameters are observed to consider the state of the cutting fluids (1). The main parameters are:

- value of pH, - concentration, - amount of bacteria, - temperature, - etc.

The operation control of aging of the cutting fluid must be simple. It is limited to the consideration of design and the smell of the surface which is washed with cutting fluid. The change of quality in emulsion fluids is the easiest to recognize. For the successful using of fluids regular monitoring and maintenance are important (3).

Control and diagnostics of cutting fluids

Today, diagnostics of cutting fluids can be classified according to the method and control periodicity into the following categories (1):

Ing. Eva Buranská, PhD., Doc. Ing. Peter Pokorný, PhD., Ing. Ivan Buranský, PhD. – Institute of Production Technologies, Department of Manufacturing and Assembly, Faculty of Materials Science and Technology, Slovak University of Technology, Paulínska 16, 917 24 Trnava, Slovak Republic, e-mail: eva.buranska@stuba.sk, peter_pokorny@stuba.sk, ivan.buransky@stuba.sk

a) no control – emulsion is used until there are no problems connected to the quality of workpieces, health problems of maintenance or damage to the machine,
b) simple operation without monitoring equipment – consideration of design, smell of fluid and look of surface which is washed with cutting fluid operation control:
   - laboratory control,
   - manual processing with monitoring equipment (e.g. manual optical refractometry, pH records, test for determination of water and nitrite hardness),
c) real –time control:
   - monitoring systems without feedback (modification of parameters is manual),
   - monitoring systems with feedback (modification of parameters is automated).

Fig. 1 shows the hierarchic arrangement of currently applied methods of control and monitoring of the state of cutting fluids. Also, today there are still companies which put the issues of cutting fluids in the last place and they do not pay attention to the control of their state. Simple operation control is very often implied and this cannot provide appropriate analysis of the cutting fluids properties. The larger companies apply the operative attitude (laboratory control), however this method is very slow, and in many cases, there are changes of sample properties from the moment when the sample was accepted and analyzed which can cause a faulty explanation of results. At the top of the hierarchy of currently applied methods of control and monitoring of cutting fluids state is the so-called real-time control which is based on on-line monitoring systems, which can evaluate the actual state of cutting fluids in real time and adopt the measurements for modification of measured properties.

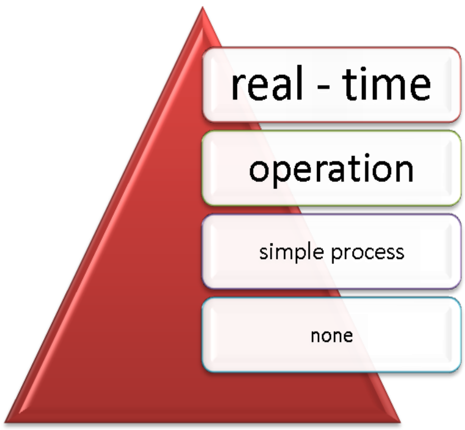

***Fig. 1** Hierarchy of methods for control of the cutting fluids state*

Online monitoring system

The main aim was to design our own on-line monitoring system, which differs from the existing ones in:

- the access to measurement method of the cutting fluids concentration,
- the concentration measurement is simpler,
- costs are lower.

Firstly, the most important parameters which could characterize the actual status of the fluid were defined. Based on the experiment of change defining selected parameters of cutting fluids, the following parameters were chosen:

- **Concentration** – a cooling effect sinks with the growth of the structure of the oil, tool life-cycle is reduced, foamability grows and an appropriate space for microorganism growth is created. So–called "tramp oils" can have a negative influence on the results. The optimal concentration of emulsion is conditioned by the concentrate character and cutting process. For measuring of cutting fluids concentration, electrical parameter of conductivity was used. The conductivity of emulsion measured in high frequencies depends on the concentration of emulsion; that means concentration is increased by a higher frequency (experiment of dependence defining specific electrical conductivity on concentration of cutting fluids).

- **pH** – parameter of pH is defined as the negative decadic logarithm of activity of oxygen cations. The labeling of the hydrogen exponent $pH = -\log C_H^+$ was implemented to define the grade of acidity or alkalinity. The acid range has the value $pH<7$, for a neutral solution $pH=7$, and alkaline solution has $pH>7$. The risk of skin irritation is higher with a growing pH; a decline of pH weakens anticorrosion protection and the danger to microorganisms and nitrosamines is increased.

The normal pH for emulsion is between 8.0 and 9.3. Cutting fluids containing amines have 8.5 as a lower limit, under which their functional properties are quickly worsened. Cutting fluids without amine can today work without problem at a pH of 8.0. In the case of decline of this value under 8, the emulsion should be conserved (or replaced).

- **Temperature** – the cooling effect sinks by the increase of temperature and an appropriate room for fast microorganism growth is created over 30 °C.

Determination of dependence between concentration and specific electrical conductivity

The conductivity method, based on measurement of solution conductivity, was selected for an indirect observation of the concentration of cutting fluids. The experiment was processed with using HIOKI 3522-50 device in frequency intervals from 0.1 to 100 000 Hz and by one direction field. This device is a fully automatic electrical bridge reaching measurement accuracy in dependence on the used measurement frequency and size of electrical resistance in an extent from 0.6 to 0.2 % (2). During the experiment, the sample of constant volume (fluid) was poured to a prepared glass container while the flat copper electrodes were used in all measurements (Fig. 2). Measurements were processed at the laboratory temperature. We recorded values of electrical resistance by sample R and also capacity of C sample. These parameters were especially used for the dimensions of the fluid sample in the container to determine specific values of electrical and dielectrical parameters: electrical conductivity, loss factor, real and imaginary part of complex permittivity, complex electrical module and impedance (1).

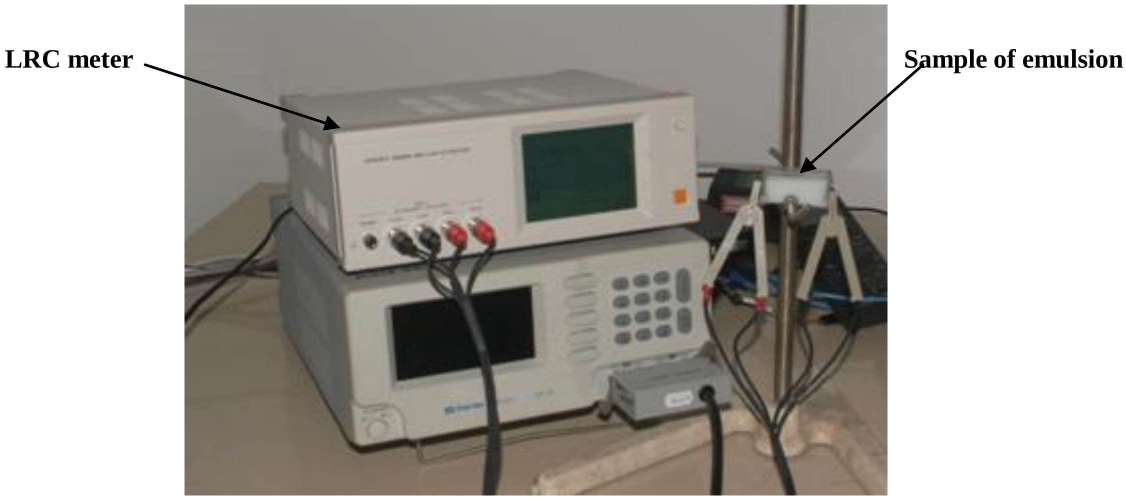

Fig. 2 *Measurement device for selected electrical parameters of cutting fluids*

The experiments showed that the highest sensibility of all sample groups were observed at a frequency of 100 000 Hz (Fig. 3 and Fig. 4).

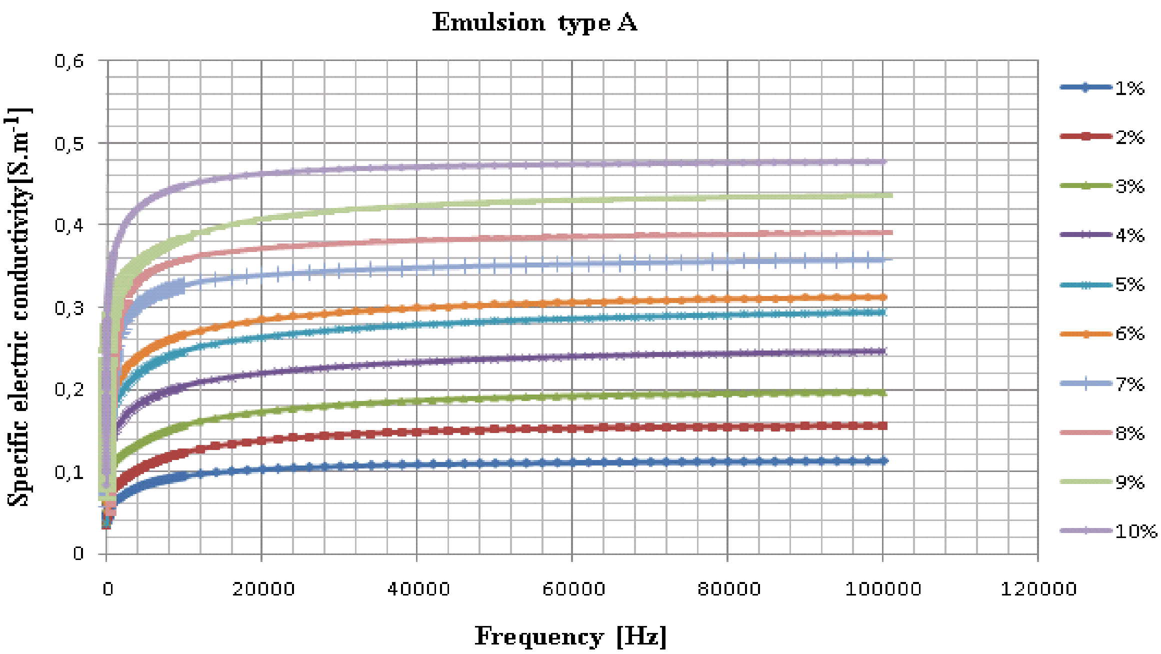

Fig. 3 *Dependence of conductivity on concentration of emulsion type A*

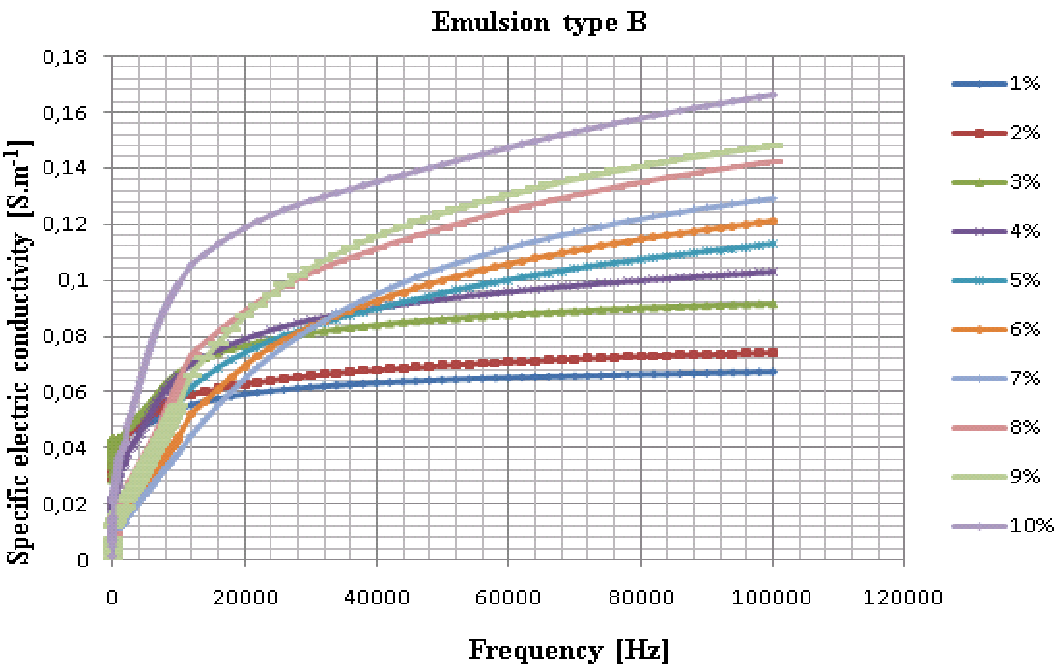

Fig. 4 *Dependence of conductivity on concentration of emulsion type B*

Fig. 5 shows there is linear dependence of specific electrical conductivity and concentration of cutting fluids at the high frequencies around 100kHz.

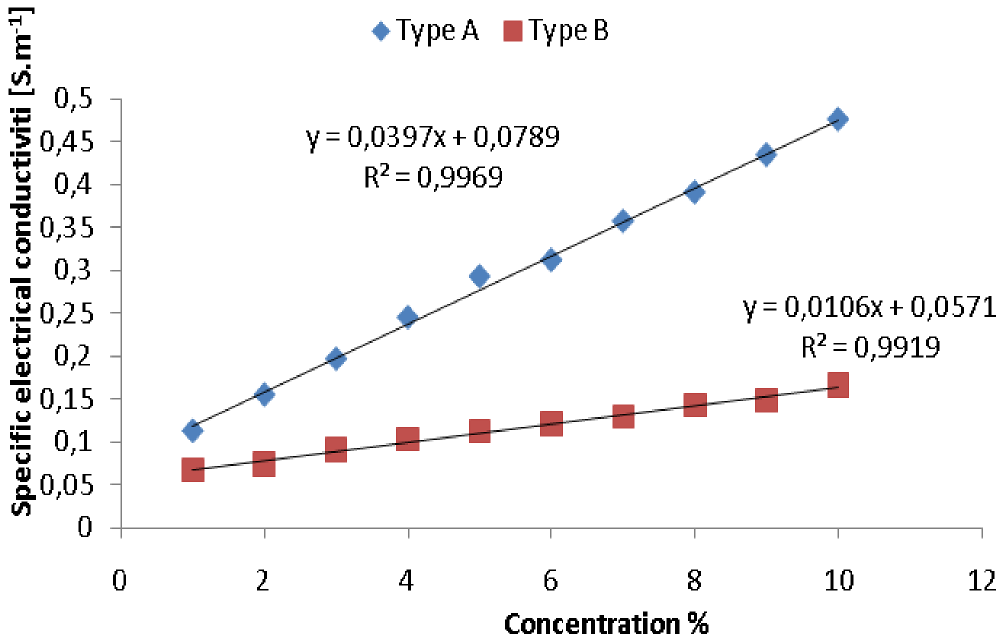

Fig. 5 *Dependence of specific electrical conductivity on concentration of emulsion type A and type B at frequency 100kHz*

On-line monitoring system

The system is formed with scanners of conductivity, pH, temperature and other measurement devices and PC with software which can evaluate the measured data in selected time intervals (1). The advantages of on-line monitoring system are that the measured data inform about actual states of cutting fluids, they show changes in real time which happen there, they enable the making of early modifications for efficient preservation of the properties of cutting fluids, and it will prevent an accelerated degradation of fluids, the loss of their capacity, and consumption and operation cost will be reduced. These and other aims and advantages of this system will be visible from the following description of the block scheme in Fig. 6.

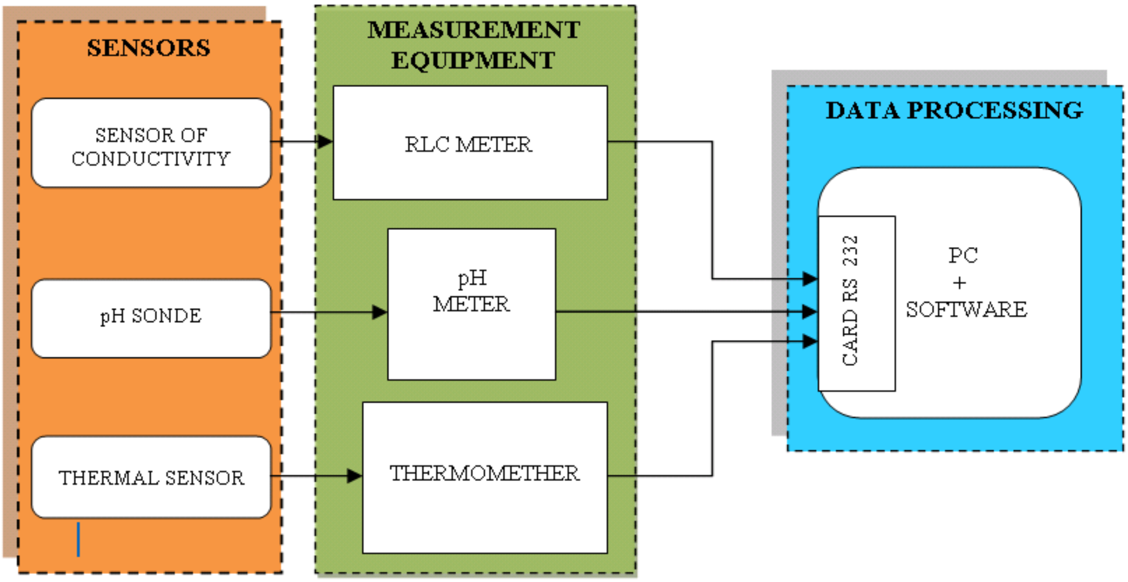

Fig. 6 *The block scheme of the on-line monitoring system*

The central monitoring system unit formed with sensors located in the container with the cutting fluid and regulation unit can be connected with PC and software processing measured values via Internet in or out of controlling room. Sensors can be located individually into every machining device or into a central distribution container of cutting fluids. The last possibility is to apply a monitoring system of fluid together with software and regulation units system of machine. This way provides a control of cutting fluids status to operation worker with which he/she works right now or will work.

Summary

Cutting fluids play an important role in engineering operation, and therefore it is very important to use fluids with good properties, conditions and to known the changes which proceed in the system and the causes of their formation. Monitoring system which is described in this article is simple to use and allows to reduce changes of fluids properties,and improve production with reduction of cutting fluids waste.

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