OPTIONS OF REAL TIME MONITORING METALWORKING FLUIDS

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Abstract: The article is focused to describing the current monitoring systems for cutting liquids used in turning, drilling, milling and grinding operations. Based on the findings, a proprietary monitoring system is designed. The monitoring system consists of the hardware and software parts. The hardware part is a data acquisition device that contains sensors of concentration, conductivity, acidity and temperature. The device is located in the machine tank reservoir with cutting fluids. The Software section - The application displays current real-time information and a historical overview of the measured quantities. The application allows setting of limit values for monitored quantities and, if overtaken, it can alert the operator. The proposed device represents a simple way to control selected fluid properties during their life cycle.

Keywords: REAL TIME MONITORING, CUTTING / METALWORKING FLUIDS

1. Introduction

Cutting area is in process of machining surrounded by cutting ambient which is made of air, fluids, gases and unsaturated steam. For the cutting area, we consider the area near the steam of the chip (1). The physical and chemical properties of the cutting environment significantly affect the mechanism of chip formation, force and friction between the workpiece and the tool, deformation work in the deformation of the workpiece, the formation of an increase, the hardening of the machined surface, the minimum thickness of the material to be taken, the residual stress of the machined surface, The main requirements of the cutting environment include ensuring a cooling, lubricating and cleaning effect at the cutting point(2).

The most commonly used cutting environment for drilling, turning, milling or grinding operations includes cutting liquids. The influence of cutting liquids on the cutting process is determined by their lubricating, cooling, cleaning and cutting action. Depending on the machining operation and the desired properties of the machined surface, greater or lesser emphasis may be placed on some effect of the cutting fluid (5). During operation, they are aged due to oxidation, heat and mechanical stress, pollution and catalytic effects. Aqueous solutions and emulsions, that is, the media whose basic constituents are water, are subject to the most rapid changes. The water has a high degree of evaporation, and due to the evaporation which causes the salts of electrolytes to disappear from the cutting environment include ensuring a cooling, lubricating and cleaning effect at the cutting point(2).

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- the value of Ph,
- concentration
- amount of bacteria,
- impurity content,
- the content of foreign oils.

If one or more of the quantities monitored are exceeded, the cutting fluid is degraded. Degraded cutting fluid is not suitable not only for functional but also for health, because working with such an emulsion is a source of serious skin problems. It also has an adverse impact on work and the environment.

Reasons for diagnostics of cutting liquids can be classified into the following aspects: (7)

Functional point - In the case of the use of cooling emulsions, in practice, they are gradually degraded or completely microbiologically decomposed - anaerobic, aerobic or a combination of both so that after a certain period of time the cutting fluid needs to be replaced, the machine and the system cleaned and put on a new liquid. The uneven consumption of the individual components of the cutting fluid is also undesirable. Due to the higher evaporation of water, the concentration of the emulsion may fluctuate. In order to ensure the stability of the machining process, it is therefore necessary to continuously monitor and maintain the state of the cooling emulsions in the machines in the working range prescribed by the machine manufacturer and the supplier of the cutting fluid.

Ecological point of view - The development and application of cutting fluids is influenced by the ever-increasing demands of legislation. Changes in laws have led to significant changes in the composition of cutting liquids and thus to changes in their technical and application properties. Examples are so-called "alternative process fluids that harm the environment. From an ecological point of view, the application of Minimum quantity liquid machining (MQL) technology is a preferred method of machining with minimal amount of cutting fluid (8).

Health aspects - Employees in engineering companies are in constant contact with cutting fluids. Liquids must therefore be relatively non-toxic, non-volatile, non-combustible so as to maximize the health and safety risks of work (9). The vast majority of cutting liquids are not highly toxic. However, toxicity problems associated with cutting fluids are usually caused by bacterial attack, concentration change, or contamination. Cutting fluids can enter the body through inhalation (evaporation, aerosol inhalation), ingestion or absorption of the skin.

Biodegradation - Biological decomposition of cutting fluid is due to the presence of several species of bacteria and fungi (9). Contamination of the cutting liquid by these microorganisms is the main cause of liquid degradation. All cutting fluids are susceptible to microbial damage that significantly reduces their lifetime.

Diagnostics of cutting fluids

Currently, diagnostics of cutting liquids can be broken down into the following categories based on the method and frequency of the control: (4)

Unchecked - the cutting fluid is used until deficiencies related to workpiece quality, operator health problems, or machine damage have been identified.

Simple operating control without monitoring devices - assessment of appearance, liquid odor and surface appearance washed with cutting fluid. Inspection is often applied, but is not sufficient for the analysis of cutting liquids.

Operational control - laboratory or manual,

Real-time control - monitoring systems without feedback (parameter modification is performed by manual operation), - feedback systems with feedback (parameter modification is performed automatically without human intervention).
Overview of monitoring systems

The overview includes a list of existing feedback systems.

**FLUID CONDITION MONITORING AND CONTROLLING SYSTEM FOR A METALWORKING FLUID CENTRAL SYSTEM**

System designed for on-line monitoring of water-miscible cutting liquids for central distribution devices. It was patented in 1990 and includes 4 sensors that simultaneously evaluate temperature, pH, conductivity and dissolved oxygen. The measurement is performed every hour and the measured data is stored in the PC. The computer evaluates the measured data and, if necessary, corrections are made either manually or automatically by means of valves, pumps, and under (10).

The system is able to monitor properties on multiple devices at the same time. The computers of these devices are connected via a modem to the central system via a telephone network. The central system is connected to the modem network. It includes a central computer, a monitor, a printer, a keyboard and a data repository. Four sensors are connected to the computer module on the device. They are a temperature sensor, a pH sensor, oxygen solubility sensor and a conductivity sensor. Through these sensors, through the inlet, the cutting fluid that is being monitored is passed. The cutting fluid simultaneously passes through the machine and returns back to the cutting fluid reservoir. The computer module records measured data from sensors, stores them in a data repository and into a control mechanism which evaluates these values. The control mechanism will, if necessary, take measures to modify the properties of cutting liquids by adding additives or by adding a different liquor to the cutting fluid. The additive and correction cutting fluid is fed into the reservoir via a line. The system can produce graphic outputs based on the measured values.

**ORACLE**

System designed for cutting and cutting fluids for CNC machine tools. The device consists of temperature, pH, conductivity and concentration sensors. The sensors are connected to the control device which contains the additive container and the concentrate container. The device is located on each machine individually. The system automatically evaluates the condition and amount of cutting fluid and is able to automatically correct the change of quantities by adding the concentrate, water or additives. All measured values and addition records of the concentrate and additives are sent to the server. The user can access and monitor the state of the cutting fluid through the interface (website) to this data. In addition, the tolerance ranges for the variables can be changed. The working environment is shown in Fig. 2.

**CASTROL SYSTEM RT**

System designed for real-time cutting of cutting liquids for metal cutting systems with central cutting fluid distribution. The system automatically monitors quantities such as concentration, pH, conductivity, temperature and biological activity of water-miscible cutting liquids. On the basis of the measured values, it is possible to adjust the cutting fluid, which helps to reduce the changes in the concentration. The working environment is shown in Fig. 3. In Fig. 4, the system itself can be seen.
2. Design of monitoring system

The monitoring system consists of a hardwire and a software part. The hardware part consists of a probe placed in the machine's cutting fluid reservoir, which automatically evaluates the selected properties using built-in sensors. The software part is an application that displays the properties and state of the cutting fluid based on the measured values.

Probe

The core of the probe is an electronic circuit consisting of an energy saving communication module ESP 8266. The communication module provides two-way communication between the hardware and the application. The advantage of the used model is that it contains 18 I/O pins for the connection of digital and analog peripherals. The module also has an analogue/digital converter that is replaced by an external 8-channel 10-bit MCP 3008 transducer due to multiple negative facts. Communication between the external transmitter and the communication module takes place via the SPI bus. Analog / digital transducer is connected to pH and concentration sensors. As a pH sensor, an unbreakable pH probe based on ISFET technology is used. Sensing the concentration is provided by a digital refractometer. As a temperature sensor, the DS18B20 digital thermometer is used to communicate with ESP 8266 using a 1-wire interface. The block diagram of the system is shown in Fig. 5. The electronic circuit, together with the sensors, is located in a closed, water-resistant container. The container is placed in a container of cutting liquids.

![Fig. 5 Simplified block diagram of the probe.](image)

The capture of variables takes place at intervals that are defined by the user in the application. Intervals can be set within arbitrary limits. Measured values for each dimension are sent using the HTTP GET request. Data is evaluated using the application and stored in the database.

Application

The application is a simple tool for managing measured data. The main window shows individual machines that are equipped with a data collection device. Provides a brief overview of measured data on individual machines (Fig. 6).

![Fig. 6 Main page of monitoring system.](image)

After clicking on the button "more" will call up the details window (Fig 7), which is divided into 4 basic sections. The first part contains information on the cutting fluid used, the date of filling and the recommended replacement date. Also, additional information on the total volume used and the like may be given in this section.

The second part (Actual data) contains information about the actual values of the monitored properties of the cutting liquid.

The third section (History) contains a graphical overview of the monitored values in the past. The entire historical overview can be clearly divided into smaller time slots such as months, weeks, days, and so on. The selected period can be exported to a spreadsheet or as a photo.

In the fourth section (Settings), it is possible to edit maximum and minimum boundaries for each monitored property. It is also possible to select the method of treating the cutting fluid. When selecting "manual", the system only monitors the individual quantities and alerts the operator when the limits are exceeded (if the Notification box is selected.) When selecting the mode automatically, the system itself is able to take corrective action. If the limit values of one or more of the monitored quantities are exceeded, the system will automatically take the necessary steps to replenish the fluid, to add additives, and the like.

![Fig. 7 Page with details of cutting fluid.](image)

3. Conclusion

The article contains a summary of the liquid cutting environment information. It points to the negative phenomena associated with the use of liquids in the machining process in the absence of care for cutting liquids. To prevent premature degradation of the cutting fluid, it must be inspected and maintained at regular intervals. The second part of the article contains a description of the current monitoring systems and their main advantages and disadvantages. The proposed system is an effective tool for cutting liquids. It allows you to get a quick overview of the current state of the cutting fluid and extends its lifetime by corrective measures.

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4. Literature


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