

# Development of new cutting fluid for grinding process adjusting mechanical performance and environmental impact

Salete Martins Alves\*, João Fernando Gomes de Oliveira

*University of São Paulo, Engineering School of São Carlos-EESC, Nucleos of Advanced Manufacturing, Brazil*

## Abstract

Many problems are identified with the use of cutting fluids, such as health and environment hazards. There has been a high demand for better adequacy of industrial grinding processes in order to meet the present requirements of safety and protection to the environment. In this scenario new combinations of fluids and grinding wheels have been tested in research projects. The application of grinding wheels using cubic boron nitrite (CBN) abrasives is a strong tendency in grinding. An environmentally friendly fluid has to accomplish some main requirements, such as should not be toxic, biodegradable and should produce low emissions when in use. But also an ideal fluid has to provide good process performance and allow low costs in the application of CBN based tools. This work presents a new grinding fluid formulation able to meet both the performance and environmental requirements. The proposed fluid is based on a sulfonate vegetable oil with high concentration in water for grinding with CBN in high speed. This way it is possible to get high lubricity and good performance on CBN grinding. The tests show that the application of the proposed formula in CBN grinding results in process performance equivalent to the obtained using mineral neat oils. The parameters evaluated were radial wheel wear and workpiece roughness. Chemical analysis shows the new fluid as to be non-toxic and have easy biodegradability.

© 2006 Elsevier B.V. All rights reserved.

*Keywords:* Grinding; CBN; Cutting fluid; Environment

## 1. Introduction

A large interest by environmental conscience of the industry has been observed due to pollution increase, development of preventive legislation and the increase interest by “green” products and process. The recent industry efforts to decrease the environmental impacts had two focuses: development of good recycling processes, especially for metals and plastics and replacement of chemical products in manufacturing processes, making them “clean process”.

Due to the growing need to adapt current safety requirements to operators and environment, new combinations of grinding wheel types and cutting fluids are being sought. As a result, the grinding process is being optimized by adopting grinding strategies that lead to a decrease in the energy expended during the cutting process and its rapid dissipation out of the grinding zone. These strategies include the use of cubic boron nitrite (CBN) wheels, which allow a larger amount of heat to be removed from cutting area through a the grain and the wheel core [1].

In addition, adopting a suitable cutting fluid reduces the coefficient of friction and specific grinding energy between grain and workpiece. In CBN grinding, a significant improvement in the process is observed, regarding the reduction of thermal damage and workpiece temperature.

This paper presents a short review about environmental impacts of cutting fluids and a study for the development of a new concept of grinding fluid to be applied in CBN grinding processes. This cutting fluid is based on a water/vegetable–oil combination. Aspects, such as biodegradability and good mechanical performance were considered. The performance of the new cutting fluid during the grinding operation was evaluated by considering the roughness and wheel wear. Different dilutions were tested to verify which one gives the best work conditions.

## 2. Environmental impacts of cutting fluids, legislation and current trends

The considerations about environmental aspects of cutting fluids are focused in impacts to health and to water resources [2]. Many chemical used in cutting fluid composition, such as biocides, anticorrosive, antifoam and others, can have bad effects on man and nature. The biocides are extremely harmful to operator

\* Corresponding author.

*E-mail addresses:* [salete.martins@gmail.com](mailto:salete.martins@gmail.com) (S.M. Alves), [jfgo@sc.usp.br](mailto:jfgo@sc.usp.br) (J.F.G. de Oliveira).

health and have high costs [3]. With the technological evolution, many new synthetic products are exposed in market and for these products there are not adequate toxicological tests, and with hard work to control them, the American Environmental Agency recommends preventive actions.

The Occupational Safety and Health Administration (OSHA) regulated some substances to be controlled in formulations of cutting fluids, such as ethanolamine, diethanolamine, hexylene glycol, morpholine, *p*-chlorine-*m*-cresol, alkaline poly chlorines from C10 to C13, nitrodiethanolamine, glycol ether, Stoddard solvent, nitrites, polycyclic aromatic hydrocarbons (PAH), chlorinated paraffin oils of short chains, barium composites, oil mist and copper composites.

The fluid that contains any one of these elements cannot be considered “clean”, although no specific effect can be verified regarding the use of these substances (EPA, 1995). However, some harmful effect had been associated to these components, thus, there is a recommendation for precaution.

According to Ignácio [4], there are many problems involved which the use of cutting fluids, which can determine the life of these products and also increase the company responsibilities. Beyond of existing causes in the preparation, the use of cutting fluids in machining processes becomes them susceptible to the attack of microorganisms, bacteria and fungi. The incorrect use, for example, can produce undesirable results that can range from process problems, operator’s health issues to the premature discarding of the product. In order to guarantee lesser impact of cutting fluids to the operator’s health and to the quality of the environment, managers and operators must know all the procedures that are indispensable in its application, following the instructions given by the manufacturer and environmental agencies. With this is possible to prevent the occurrence of undesirable results.

In the last decades, the environmental agencies and the public authorities have worried in making possible the harmony between industrial activities and the environment, due irrational consumption of natural resources, air pollution and industries waste. On the other hand, to the competitiveness, globalization of the economy and more rigid environmental legislation have done pressure to industries in order to adjust its processes searching to take care of the three more important aspects for its survival: technological, economic and environment.

In Brazil, there is no legislation for cutting fluids, but there are two laws related to lubricants in general: CONAMA 362/05 and DECREE 50.877/61. These laws only classify the lubricants as dangerous waste and give instructions about disposal and recycling.

Currently, there is a world-wide trend, mainly in Europe, for reducing the cutting oil use, due to the high cost, but mainly for the risks to operator health and environment. This set of situations becomes undesirable the use of refrigeration systems in the production. Some alternatives have been studied to substitute the traditional methods of refrigeration, such as minimal quantify of lubricant, dry machining and the use of environmental friendly cutting fluids (air, polymeric fluid, biodegradable fluid, etc.). In grinding the last option is the most realistic since the process requires a high refrigeration in order to avoid part and tool dam-

age. Following is presented a new fluid that search for a balance in meeting the technological and environmental requirements.

### 3. Methodology

#### 3.1. Formulation of the new cutting fluid

For the preparation of the cutting fluids, some steps were followed:

1. Selection of components: it is necessary to consider if the chosen components are not problematic, dangerous for the environment or health.
2. Mixing of components: firstly add oil in water and mix for 2 min. After the additives are added, all components are mixed together for 15 min, in order to verify if the emulsion form a solution. The emulsion must repose for 24 h, to verify if the emulsion is stable.

Materials used in the formulation:

1. Sulfonate castor oil 80%.
2. Water.
3. Bactericide derivate of triasine.
4. Anticorrosive—composition of synthetic ester.
5. Emulsifier agent—polyglycol of synthetic ester.

#### 3.2. Physical and chemical characterization

Some analysis, chemical and physical, were made to evaluate the quality of new cutting fluids. Following are described all analysis:

- pH  
The cutting fluids pH was determinate by digital PHmeter. Always before the measurement, the PHmeter was calibrated with standard solutions. The cutting fluid pH should be between 9 and 11.

- Viscosity  
A ball viscosimeter was used to determinate the viscosity of the cutting fluid. This method is very traditional and simple. The equipment consists of a tube with two marks, where the cutting fluid is put, and a ball that, depending on fluid viscosity, have a specific fall time. By Eq. (1) it is possible to calculate the fluid viscosity.

$$\eta = t(\rho_1 - \rho_2)K \quad (1)$$

where  $\eta$  is the dynamic viscosity (MPa s),  $\rho_1$  the ball density ( $\text{g}/\text{cm}^3$ ),  $\rho_2$  the fluid density ( $\text{g}/\text{cm}^3$ ),  $t$  the fall time of ball between of two marks of tube (s) and  $K$  is the ball constant ( $0.13 \text{ MPa cm}^3 \text{ g}^{-1}$ ).

- Corrosion  
Corrosion is a reaction of a metallic material and the environment. This reaction causes a measurable changes in the material surface properties.

This test consists in measuring the corrosion grade of cutting fluid by its contact with cast iron. Some grams of cast iron chips, previously washed in acetone and dried, were placed on a piece of filter paper in a Petri dish. The chips were evenly spaced around the filter paper, prevented from contacting one another and humidified in 2 ml of the test cutting fluid. The chips were left in the covered Petri dish for 2 h. At the end of 2 h, the iron chips were discarded and the filter papers were rinsed in acetone.

The corrosion grade of the cutting fluid is measured by observation how many spots appeared in the filter paper surface. The objective of this analysis is to determinate the anticorrosive characteristics of soluble cutting fluids.

Table 1 shows how the corrosion grade can be determinate.

- Biodegradability  
The method used to investigate the cutting fluid biodegradability was Ready Biodegradability: 301B CO<sub>2</sub> Evolution Test adopted on 1992 (OECD), 1997.

In this test a system of aeration of continue flux, in order to filter the air various flashes with sodium hydroxyl were used. The test was carried out in dark, under 20–25 °C and during 28 days.

The cutting fluid biodegradability was evaluate by CO<sub>2</sub> evolution that was absorbed by Ba(OH)<sub>2</sub> solution during test period. The CO<sub>2</sub> evolution was determinate by titration with HCl.

Download English Version:

<https://daneshyari.com/en/article/791994>

Download Persian Version:

<https://daneshyari.com/article/791994>

[Daneshyari.com](https://daneshyari.com)