ANALYZE OF CUTTING FLUID USE AND DISCHARGE IN THE REGION OF JOINVILLE – SC (BRAZIL)

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Abstract. *The region of Joinville is characterized by the APL (Local Productive Arrangement) of the metal-mechanical sector ,thus the development of metal-mechanical industry in Joinville is fundamental to the region growth. Bearing in mind the environmental crisis, industries should evaluate their products and processes in order to adjust their activities to the environment. The cutting fluids are an integral part of the manufacture of pieces, and they are used to improve the efficiency and lifespan of the tools. The use of these products has been widely questioned from the environmental point of view, because it could harm the operator's health and the environment. Therefore, they should be well managed and arranged in a proper way to prevent hazards. Cutting fluids are considered as hazardous waste, and the industries from that sector should add to their production processes one more step which would be the disposal of used cutting fluid. The purpose of this study is to identify how the use and discard of cutting fluids are done in the region of Joinville-SC. In order to accomplis that purpose, a theoretical approach was made, emphasizing the cutting fluid, their preparation, maintenance and recycling, environmental impacts and legislation relevant to the subject. It was also developed a qualitative research in 68 machining industries of the region, using questionnaire and interviews as a tool for data collection. Besides, interviews were also carried out with suppliers of cutting fluids, the municipal public organ which is responsible for inspection, and a specialized company that runs the collection, treatment and disposal of the residues. The results indicate that most industries do not perform the correct allocation of cutting fluid. Considering this, it is clearly necessary for industries to be aware of the issue and its implications.*

Keywords: *cutting fluid, machining, environmental impacts*

1. INTRODUCTION

Machining is one of the oldest processes for mass production used by man. The function of the cutting fluids is to improve the machining process of metals to reduce the friction between the tool and the workpiece, for instance, in order to provide a longer tool life as well as helping to cooling the workpiece.

With the development of machines and tools to reach more productivity, it is also necessary to keep doing research on the quality of cutting fluids for a better use of cutting tool and for the protection of the workpiece. Also, they should avoid health problems to the machine operators or damages to the environment. Santos and Sales (2007) state that soluble oils degrade rapidly due to the bacterial action, which operates in the components of the fluids as well as in their contaminating remains (debris, dirt, etc.), and due to the bad behavior of operators (for instance, spitting in the emulsion and throwing cigarette butts over). Those actions contribute to the contamination of cutting fluids and can cause damages to the operators' health.

Ali (1998) says that most cases of skin illnesses in the metallurgic industry are the irritating dermatitis caused mainly, by cutting oils (mineral oils). In the metallurgic industries, there is a very common clinical case named Elaioconiosis, which affects the hair roots. The oil penetrates the hair roots and causes them obstruction, irritation and inflammation, leading to the formation of small lesions which are similar to acnes. The panorama becomes critical due to the high consumption of cutting fluids all over the world.

According to a research conducted by Glenn and Vananterpen (1998) it is consumed of 2.16 liters per year of cutting fluids, including it used in operations of forming machines and others. Following the same perspective, Souza (2008) comments that the productive processes are responsible for the environmental situation, as they cause the major transformation of materials and energy. The high consumption of fluids brings a serious problem for discard. When cutting fluid life ends, they lose their property and their recuperation or discard is a matter of planning. The whole part could be sold or treated in the plant itself by means of filtering processes.

The solutions and emulsions, which do not have almost any commercial value, must be treated by physical-chemical processes in order to break up and separate their components before they are reused or discarded. According to the CONAMA Resolution 357/05, under proper conditions, "the used cutting fluids can be reprocessed to be reused or discarded by simple techniques as deposition, composting, direct or indirect energetic utilization among others."

Sreejith and Ngoi (2000) affirm that the lubricants and cooling fluids used for cutting represent up to 20% of manufacturing costs.

Due to the high consumption of cutting fluids in the region of Joinville (SC), it is necessary to evaluate the use and discard of cutting fluids as well as their impact on the environment. This research attempted to assess how the small and medium size machining industries located in the region of Joinville perceive and treat the issue of use and discard of cutting fluids, taking into consideration the products they use and the way they prepare and discard cutting fluids.

The methodology used to carry out this research was the quali-quantitative method, characterized as *Survey* Method. According to Lima (2004), the *Survey* Method is the one which better represent the features of a quantitative research. Thus, the phenomenon is investigated through a field research, and data collection is conducted by means of questionnaires or formularies. The Survey Method is a suitable method for research when:

a) the questions “what?”, “why?”, “how”?, and “How much” are to be answered, that is, and the focus of interest is on “what is happening” or “how and why it is happening”,
b) there is no interest or it is impossible to control dependent and independent variables;
c) the natural environment is the best situation to evaluate the phenomenon;
d) the phenomenon occurs in the present or in an early past.

The following steps are taken when the Survey Method is used to carry out a research:

a) Definition of the objectives of the research
b) Definition of the population and the sample
c) Elaboration of the questionnaire
d) Data collection (in the field)
e) Data processing
f) Analysis of results
g) Presentation and publication of results

2. DEFINITION OF THE POPULATION AND THE SAMPLE

According to SINDIMEC-Sindicato Patronal das Indústrias Mecânicas de Joinville e Região (Mechanical Industry Union of Joinville and Region)(2008), which is an organization of the mechanical industries of Joinville and its region, the number of transforming mechanical industries is more than 500. Among them, there is a great number of tooling industries which are widely known by their heavy investments in technology, making Joinville the main pole of the transforming mechanical industry sector.

The lack of the populations’ availability and interest about the use and discard of cutting fluids in the region of Joinville, reduced the population of this research to a data bank already known and followed by the authors.

Thus, the population of this research was from the PEIEX (Projeto de Extensão Industrial Exportadora - Industrial Development and Export Expansion Project) data bank, which consists of 250 micro and small companies of Joinville and its region that take part of the metal-mechanic industry segment. The data presented in the results of the field researches are limited to the information given by the industries that took part in this research, and their anonymity is granted.

All the participant industries have machines which use cutting fluids and they were visited by an interviewer of the PEIEX Program. The participant industries did not have any system to treat effluents at the time of the interviews. Thus, specialized companies were hired to execute the discard process. 250 questionnaires were sent and 68 were answered, thus the sampling size was lower than the recommended proportional population. Therefore, the results that were obtained from the 68 questionnaires can not be used as statistical reference about Joinville and its region. However, the results show the reality of the participant industries and can be an alert concerning the disregard for the use and discard of cutting fluids in Joinville and its region. The results also show a serious scenario which poses a threat to the environment.

In order to verify the reliability of the answers to the questionnaires, interviews were carried out with three cutting fluid supplying companies, with a company which is hired to execute the discard process, and with FUNDEMA – Fundação Municipal do Meio Ambiente (an organization responsible for environmental issues in Joinville).

2.1.Elaboration of the questionnaires

Gil (1995) states that the basic difference between a questionnaire and an interview is that in the latter the questions are asked orally to participants, who also answer them orally, while the questionnaire is a technique of investigation composed of written questions. The questionnaire technique was chosen for this research due to the following advantages: it can reach a great number of participants, even if they are far from the interviewer, it has a lower cost, and it allows the participants to answer at the most suitable time for them.

The following issues were addressed in the semi-structured questionnaire used in this research:

a) Type of cutting fluid used by the industries
b) Quantity of cutting fluid which is purchased monthly
c) Description of the manufacturer of the product
d) Percentage of dilution
e) How the preparation of the cutting fluid is made
f) Criteria of charge
g) Destiny of the used fluid
h) Quantity of discarded fluid

If the questionnaires had not been returned, an interview with the person responsible for the area being studied in this research would have been conducted by telephone to grant data collection. Alves-Mazzotti and Gewandsznajder (2002) state that an interview allows to explore the issues more deeply due to its interactive aspect, and such deepness is rarely reached when other methods are used. Thus, it is possible to go deeper into aspects dealt in the revision of literature by conducting interviews.

3. DISCUSSION AND RESULTS

As already mentioned, 68 questionnaires were answered. The questionnaires aimed at constructing a profile of the consumption of cutting fluids, taking into consideration their use and discard by the participant industries. The several types of cutting fluids used by the participant industries were identified as they are primary information for the treatment and discard processes, that is, the treatment and discard processes are determined by the type of cutting fluid used by the industries.

"Fig. 1" represents the distribution in percentage of the types of cutting fluids. Straight oil is used by 15% of the participant industries. Most industries follow the trends detected by Glenn and Vananterpen (1998), and they use cutting fluids which are soluble in water (66%). It can be noticed that synthetic cutting fluids are favorite, although they do not have good lubrication. Among the industries which use soluble fluids, 56% have a preference for the use of synthetic cutting fluids.

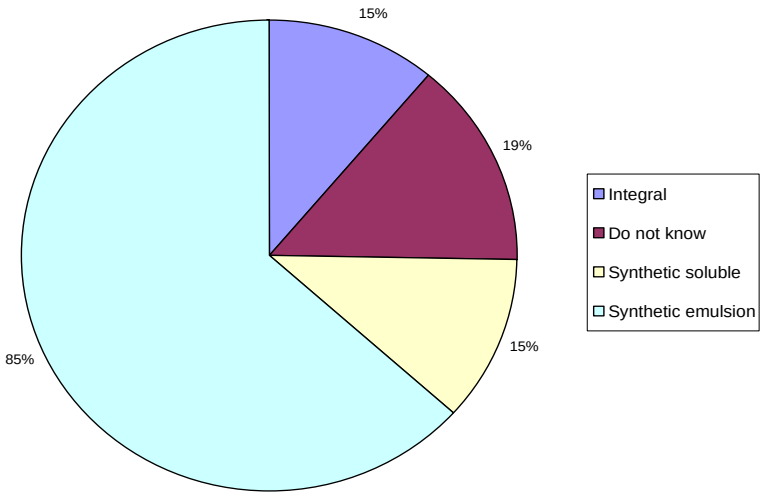

Figure 1. Types of used cutting fluid

A problem raised in this research is that 19% of the participant industries answered that they are not acquainted with the type of cutting fluid they use. Another problem is the lack of knowledge by the users. When they were asked what product they used, several participants informed the name of the manufacturer or the representative instead of informing the name of the product. For instance, some participants answered they used Germânia cutting fluid, however "Germânia" is the retailer. Therefore, it is possible to conclude that the people responsible for machining cooling and lubrication processes are not concerned about the product used in those processes.

Considering that the responses were not enough to be analyzed, new interviews were carried out with the industries and with their main suppliers. Thus, it was possible to verify that 34% used products made by Castrol, mainly Syntilo 9902, 24% used products made by Fuchs, mainly ECOCOOL MH100, and 42% are not loyal to a given brand or manufacturers as Petronas, Yushiro, Micro-química, etc.

In relation to the quantity of cutting fluids acquired per month, it was noticed that most industries buy quantities lower than 20 liters. Such information is presented in "Fig.2" and is related to the size of the industries, that is, most participant industries are small size companies.

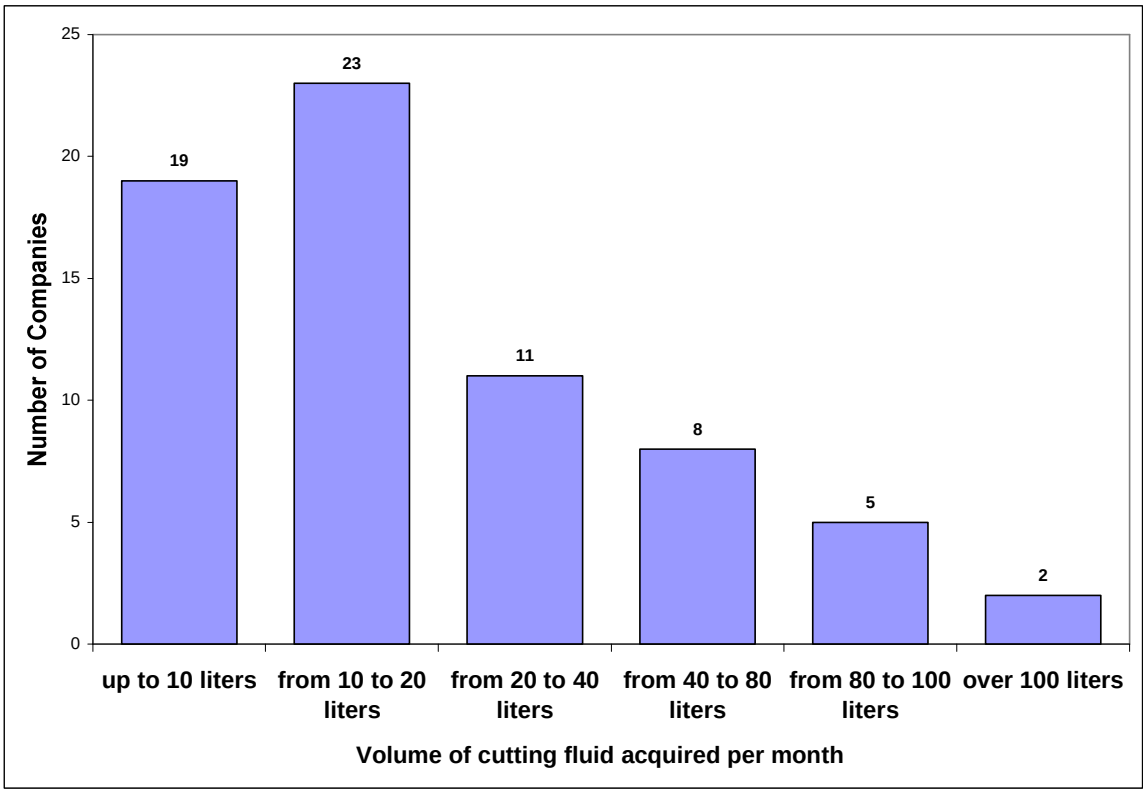

Figure 2. Acquisition of cutting fluids per industry per month – Soluble

"Fig. 3" shows the results about the preparation and dilution of soluble cutting fluids. The results indicate a high variation and also a lack of knowledge on the ratios of dilution used by the participant industries. The suppliers of the two most consumed products for cutting fluids recommend ratios of 1:20 and 1:40 for the first dilution. Among the participant industries, 28% of them use the recommended ratio of dilution, 25% use different ratios and 28% of them are not acquainted with the ratio of dilution they use. This fact might occur because the suppliers' technical assistance prepares the solution and controls the process. However, the users are expected to be concerned and acquainted with the products being used in the processes in their industry at least.

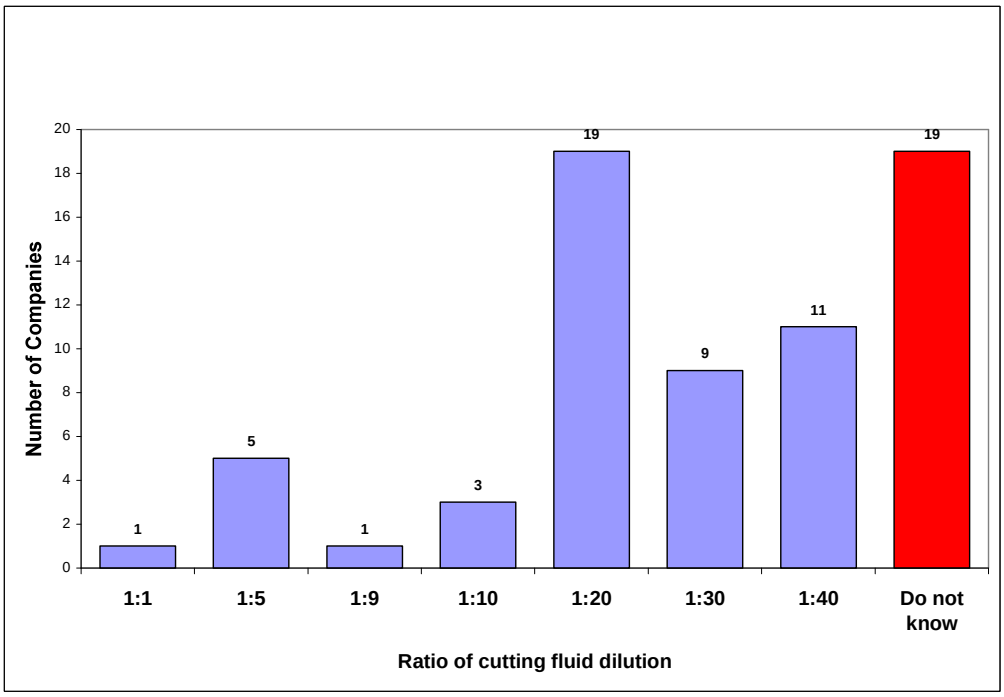

Figure 3. Ratios of dilution of cutting fluids

The criteria of dilution used by the participant industries are adopted at random. Some of them follow the suppliers' instructions; others follow what is indicated on the product package; and others use criteria based on the workers' experience mainly. The literature also indicates a variety of dilution ratios. Baradie (1997) states that a ratio dilution can be from 1:5 to 1:100, Dick e Foltz (1997) mention a ratio from 1:10 to 1:50, and Trent (2000) recommends from 1:10 to 1:60. The lack of a parameter of dilution can result in product waste or in its low process efficiency.

The way of preparation is not clear as well. The industries were asked about to preparation of cutting fluid solution. Their answers were classified in 5 groups as shown in Fig. 4. In the first group are those who use oil first and then water. The second group is those whose use water first and then oil. The third group uses an automatic system. The fourth group represents those who have the dilution prepared by their suppliers, and the fifth group is not acquainted with the way of preparation. Besides, 11.86% of the participant industries indicated more than one way of preparation.

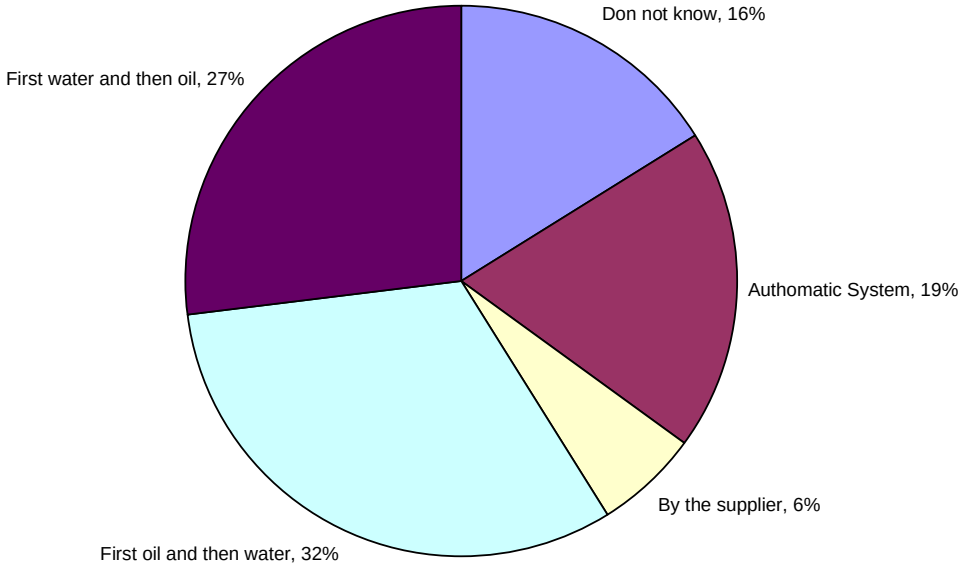

Figure 4. Ways of preparation of cutting fluids

The University of Northern Iowa (2003) developed a handbook on cutting fluids, and they mention that the correct way of preparing the emulsion is by adding the concentrated product to the water. Many industries recorded a low performance of the fluid and a waste of the concentrated product due to the incorrect mixture. In order to reach the adequate performance of the cutting fluid, the water and the concentrated product should always be very well mixed in a container out of the reservoir, following the instructions of the manufacturer thus ensuring a good mixture for a great performance of the fluid. Although mixing the concentrated product and the water straight in the reservoir is a fast and easy process, it also results in an incomplete, inadequate mixture which is harmful to the fluid performance. It is important to follow the correct order of the items, thus using water first and adding the concentrated product afterwards.

According to Runge and Duarte (1990), it's important to discuss the fluids handling methods with the suppliers. Such strategy is fundamental to avoid inconveniences for both the supplier and the consumer in terms of cutting fluids application, such as:

a) workers with dirty clothes and hands
b) workers with dirty habits
c) Inadequate equipments
d) inefficient direction of fluid flow
e) reuse of incompatible fluids
f) irregular concentration (poor mixture)
g) irregular addition of biocides
h) quality and quantity of water
i) inverted mixture (water in the oil)
j) inefficient mixture shaking
k) lack of or inadequate control and records.

When the above items are not observed, there might be contamination of the cutting fluids and thus a higher incidence of bacteria.

3.1. Cutting fluids discard and criteria of change

Concerning the discard and criteria of change of used cutting fluids, as presented in “Fig 5”, the results show that 22% of the participant industries use chemical analysis as criteria of change, although they did not inform which type of analysis is done. Another criteria used is time of use, thus 21% of the participants industries informed they change the cutting fluid using that criteria, however the time frame mentioned by them varied from every fifteen days to a year. That fact shows a total lack of knowledge about the correct criteria for the discard and change of cutting fluids. Some participants industries (27,5%) use empirical forms as the operator’s experience, appearance of the fluid to do the change or they change when the fluid is dirty. However, 29,5% of the participant industries, that is, most of them, pointed out that they only do replaced

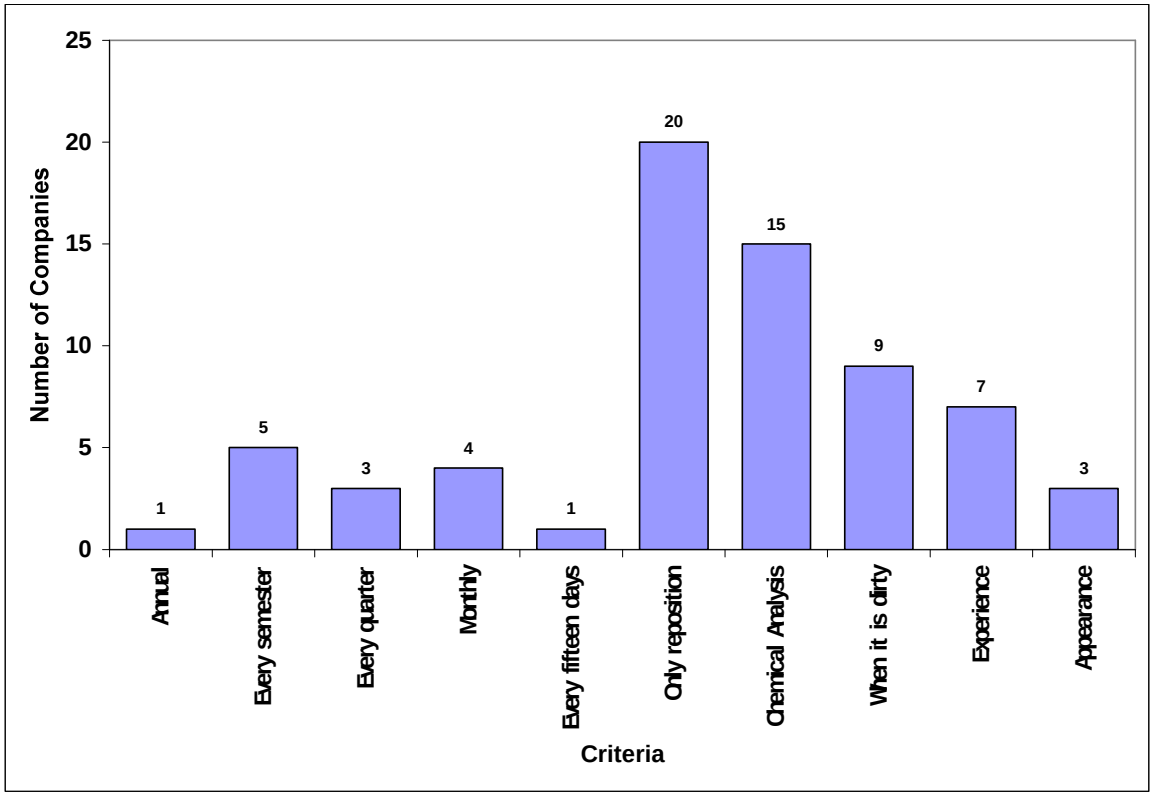

Figure 5. Criteria of change

Baradie (1996) says that when a company does replacement only, the following incorrect practices are developed:

a) contact of cutting fluids with lubricant oils of the machine components
b) sedimentation of debris and other impurities at the bottom of the system
c) accumulation of oil dregs on the walls of the system
d) bomb do not work properly
e) lack of aeration
f) inefficient process of the system clean
g) Replaced of cutting fluids in systems infected by bacteria
h) lack of efficiency of the cutting fluid

Therefore, replacing cutting fluid only is not recommended. As already mentioned, every cutting fluid has a life time, and it is influenced by the type of maintenance.

According to Silva (2000), when the life time expires, the cutting fluids lose their properties and their recuperation or discard is a matter of planning. Integral cutting fluid can be sold or treated in the company itself. Solutions and emulsions, which have almost no commercial value, should be treated by using physical-chemical process so that their components be broken up and separated. Only then they will be reused and reprocessed according to the regulations, by means of simple techniques as deposition, composting, direct or indirect energetic utilization among others, as already cited.

“Fig. 6” presents the distribution and destiny of cutting fluids, thus 63% of the participant industries informed that the discard is done by the companies which treat the cutting fluid, 29% reported that they are not acquainted with the kind of distribution and destiny of cutting fluids, and 8% said that they do the discard at random.

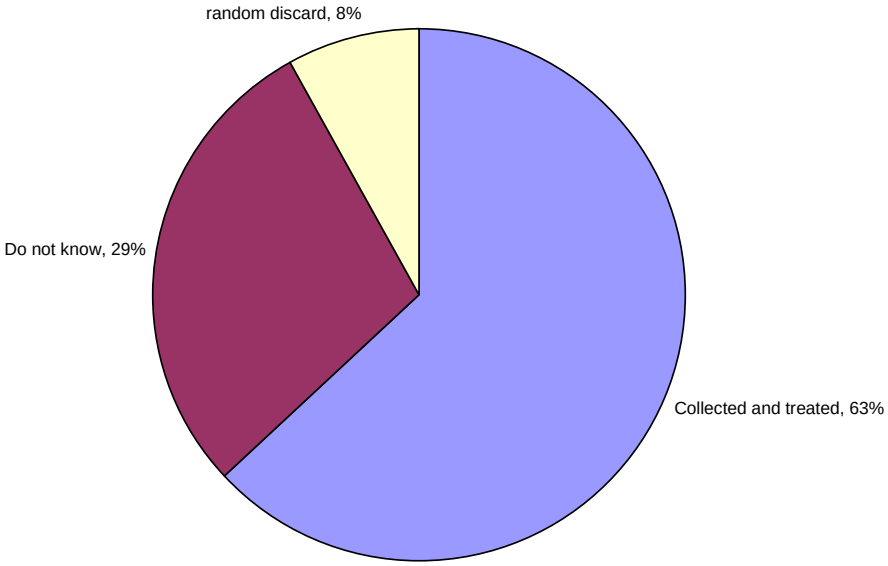

Figure 6. Destiny of cutting fluids

In order to validate the data obtained from the questionnaires, suppliers and companies that collected the residues for treatment were interviewed. The interview with the company that treats cutting fluids in the region of Joinville showed that only 24% of the industries which reported that they send cutting fluids for treatment and collection do that in fact. As results, it is possible to affirm that 76% of cutting fluids are discarded at random. Another relevant fact identified in the interviews was the difference of quantity of generated residues which do not match with the reported dilution, that is, an incorrect dilution is likely to exist and it can cause irreparable hazards to the environment. Such impact on the environment happens due to de lack of knowledge by the metal-mechanic industry segment about ways of cutting fluids treatment, lack of knowledge about the legal implications as well as lack of entrepreneurial commitment.

The separation process is simple and most treatments are based on the separation of oil and water, by physical or chemical means. The more soluble in water the addictives are, the more difficult the separation and the treatment will be. The fluid will remain aqueous even after the treatment and it will generate an effluent with high chemical demand on oxygen as well as biochemical demand of oxygen, which is inadequate for discard.

There are some factors that could contribute to the reduction of that number, as for instance, losses of cutting fluids during machining due to evaporation and contact with workpiece. Besides, the acquired fluid could be used to keep the concentration of work, and the cutting fluids are used for about six month. However, those factors could not sharply reduce the quantity of generated residues as it was stated in the interviews. Thus, it is possible to assume that the industries omitted the real quantity of generated fluids.

The high cost of treatment is one of the reasons why the companies do not properly discard their residues, which can pose risks to the correct destiny of residues. Presently, the discard cost per liter varies according to quantity and distance for collection, ranging from R$ 0,80 to R$ 1,00 per liter.

The environmental procedures are regulated by law and controlled by several environmental organizations as IBAMA, the Brazilian Institute for environmental issues, which is linked to the Federal Government of Brazil; FATMA, which is an environmental foundation and is linked to the Government of Santa Catarina State; and FUNDEMA, which is also an environmental foundation and rules the city of Joinville.

Some emails were sent to FUNDEMA and a visit was made. FUNDEMA issue the environmental certificate for companies in Joinville. FUNDEMA informed that they evaluate every item ruled by legislation under their attribution, for instance noise, solid residues, soot, particles, and effluents. However, they do not have technical staff, tools and facilities to fiscalize this particular issue as deeply as it deserves.

The lack of supervision, allied to high costs of cutting fluids treatment and the lack of conscientiousness and knowledge about preparation and maintenance of fluids by users of the metal-mechanic segment show a total negligence towards the environment.

4. CONCLUSIONS

The data and information which were obtained for this study demonstrate the relevance of the issue discussed here as well as the importance to create mechanisms for the control of cutting fluids in the participant industries from Joinville. The environmental rules and regulations are clear, however the organs responsible for their execution are neither acquainted with them nor have suitable equipments or laboratories to analyze and monitor the industry activities.

During the interview with FUNDEMA, it was suggested to put forward a motion to make a specific municipal law about the use and discard of cutting fluids in the region of Joinville to improve the control of such residue.

It was noticed a lack of commitment with the environment due to ignorance about the issue or economic interests that can lead to serious environmental problems due to the inappropriate use and discard of cutting fluids by the metal-mechanic industries in the region of Joinville.

The results of this study are relevant and can be used for analysis by the entrepreneurs and by the society concerning the situation of cutting fluids use and discard in the region of Joinville. The theme is serious and should be discussed in order to find solutions to the problems raised here so that the impact of inadequate cutting fluids use and discard on the environment may be mitigated or even eliminated. The data of this study were obtained from the whole chain, formed by suppliers, users and the companies which are responsible for the final treatment and destiny of cutting fluids, and all of them are equally responsible for the solutions since they themselves and their families are the ones to be reached by every threat or care towards the environment.

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