An Evaluation of the Characteristics of Metal Cutting Fluid Due to the Metal Chips Contamination

by

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Thank you Allah...for giving me strength to finish this project

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ABSTRAK

Kajian ini membincangkan tentang ciri-ciri "cutting fluid" kesan daripada "contamination" atau pun sebarang substrat yang tidak diperlukan dalam sesuatu cecair. Untuk mencapai objektif tersebut, satu eksperimen hendaklah dijalankan. Ia melibatkan proses mereka dan mendirikan " simple lubricity test rig". Jumlah partikel di dalam "cutting fluid" diperolehi dan keputusannya dianalisis. Nilai pemalar geseran diambil setiap kali sample diambil. Hubungan antara pemalar geseran –masa dan kandungan partikel asing di dalam " cutting fluid"-masa diperolehi .Dengan itu, hubungan antara pemalar geseran dan kandunga partikel di dalam " cutting fluid" dapat diketahui.

CHAPTER 1

INTRODUCTION

1.1 GENERAL INTRODUCTION

Today, metal cutting is a very large segment indeed in our industry .The motorcar industry, electrical engineering, railways, shipbuilding, aircraft manufacture, production of domestic equipment and the machine tool industry itself. Fluids have been important in the industry as an aid to the process. Water may have been the first fluid, followed by animal fats, vegetable oils, mineral oil, oil-in water emulsions, and in recent years, by clear synthetic chemical solutions.

Metal cutting fluids are dynamic systems due to their usage and environment. Because its characteristics are widely changing during time, the same product may have a different composition after using in different systems for enough long time periods. Therefore, cutting fluid maintenance is very important for its proper application in processes. In addition, keeping the fluid properties between the proposed limits will increase its lifetime.

In metal cutting, fluids are used to reduce heat buildup and therefore extend tool life. Usually, the proper cutting fluids also allow higher cutting speeds and feeds and helps produce a better finish on the machine part. These cutting fluids perform a very important role and many operations cannot simply carried out with any type of fluid.

1.2 BACKGROUND

Firms have tended to dispose of their coolants or metal cutting fluids as soon as they showed signs of fouling decreased efficiency. Much of the time such disposal is not necessary. A thorough management program can definitely extend the life of metal cutting fluids and is profitable for the firm. Many of the modern metal cutting fluids and coolants are designed and formulated to be environmentally safe and biodegradable.

Some of the modern metal cutting fluids are supplied in aerosol cans and are sprayed on the work piece while the machining operation is being performed. These spray-application fluids adhere strongly to the work piece and allow easier machinability while preventing corrosion on the work piece, such as rusting on ferrous materials. Considerations for choosing a quality coolant and maximizing the life of coolants are important when using the machine. Thus the aim, to recycle the metal cutting fluids is a subject matter of this project.

Metal –cutting fluids (coolants) are contaminated with tramp oils and metal chips with use, and tramp oil contamination leads to the growth of anaerobic bacteria that shorten coolant life. The existing metal working fluids recycling or treatment methods are not cost-effective because they generate huge volumes of waste coolant. The ever increasing disposal cost has been of great concern among metalworking facilities, and the industry has been looking for ways to reduce coolant-related costs in their machining operations.

1.3 OBJECTIVES

The objectives of this final year project is to evaluate the performance of metal cutting fluid due to metal chips contamination in terms of lubricity, pH, odor and temperature.

To obtain these objectives, lab experiment will be carried out properly. It involved the design and construction of a simple lubricity test rig. The experiment will be explained in chapter 4. While the pH, odor and temperature were taken in every alternate day over a period of two weeks.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter looks into previous research and analysis that has been done by other researchers. The main topic that will be stated are the characteristics of metal cutting fluid, the functions and impacts of cutting fluid.

2.2 DEFINITION OF METAL CUTTING FLUIDS

Metal –Cutting Fluids are engineering materials that optimize the metal cutting process. The fluids must provide a layer of lubricants to act as a cushion between the work piece and the tool in order to reduce friction. Cutting fluids are also called coolants and lubricants .The role of a cutting fluid as a coolant or lubricant is very sensitive to the cutting speed. Generally, Metal-Cutting Fluids that work hard on the machine and soft on the skin. Metal-cutting fluids of various compositions have always been used extensively in machining operations. Most machine shops show that some cutting operations are carried out dry, but

in many cases, a flood of liquid is directed over the tool, to act as a coolant and/or a lubricants.

Cutting fluids play a significantly role in machining operations and impact shop productivity, tool life and quality of work. The primary function of cutting fluid is temperature control through cooling and lubrication (Aronson, et al., 1994). A fluid's cooling and lubrication properties are critical in decreasing tool wear and extending tool life. Cooling and lubrication are also important in achieving the desired size, finish and shape of the work piece. A secondary function of cutting fluid is to flush away chips and metal fines from the tool/ work piece interface to prevent a finished surface from becoming marred and also to reduce the occurrence of built-up edge (BUE).

The chips of some metals have a tendency to temporarily weld onto the top surface of the toolbit. This built-up edge is an unstable condition since it is continually formed and released. This is generally undesirable because it result in greater power consumption, poorer finish, and possible cratering of the toolbit. Although cutting fluids are only remedy for this problem, they are widely used to reduce friction and heat, which in turn reduces the formation of a built –up edge on the toolbit

The term coolant was coined by researchers soon after F.W. Taylor reported that tool life could be improved by applying water. The term lubricant originated with the introduction using oils. Combination cutting fluids and coolants are being produced which may be used for most of the high-speed machining operations afforded by the advanced cutting tool materials. With the advent of universal-type cutting/coolant combination fluids, the

inventory of cutting fluids and coolants can be kept to a minimum within a manufacturing facility or machine shop. The general recommendations for cutting fluids for machining are stated in the table 2.1

Material	**Type of fluid**
Aluminum	**D, MO, E, MO +FO, CSN**
Beryllium	**MO, E, CSN**
Copper	**D, E, CSN, MO+FO**
Magnesium	**D, E, CSN, MO+FO**
Nickel	**MO, E, CSN**
Refractory	**MO, E, EP**
Steels (Carbon and low alloy)	**D, MO, E, CSN**
Titanium	**CSN, EP, MO**
Zinc	**D, MO,E,CSN**
Zirconium	**D, E, CSN**

Table 2.1 : General Recommendation for Cutting fluids for Machining

CSN, Chemicals and Synthetics

D, Dry

E, Emulsion

EP, Extreme Pressure

FO, fatty oil

MO, Mineral Oil

2.3 CHARACTERISTICS OF METAL CUTTING FLUID

Cutting fluids has the following six characteristics. It can be divided into two categories ; lubricants and coolants. The machinist must understand cutting fluids characteristics and be able to choose the one best suited to a particular job.

1. *Lubrication.* The cutting fluid must prevent or reduce formation of built-up edge on tools or cratering and lubricate some of the working parts on automatic screw machines and similar tools.

2. *Cooling capability.* The cutting fluids must be able to reduce the temperature of the tool and the work piece to extend tool life and allow higher cutting speeds and feeds rates.

3. *Rust and residue prevention.* The work piece and the machine must be protected from rust and the formation of scum

4. *Safety.* The cutting fluids must be nontoxic and nonflammable under normal working conditions. It should not cause skin irritation.

5. *Stability.* The cutting fluid should not support bacterial growth (become rancid) in use or in storage , and its characteristics should not change with age.

6. *Compatibility.* The cutting fluid must be compatible with other lubricants used on the machine.

2.3.1 Coolants for Metal Cutting

The metal cutting process creates much heat and friction. If the heat and friction are not reduced, the tools used in the process are quickly damaged and destroyed. Also, the quality of the product made is diminished because of inefficient tools and damage to the product while it is being manufactured.

In order to increase metal removal rates, feeds and speeds must be increased. These increases cause elevated temperature which is the most critical limitation to tool life. The cutting fluid will carry the heat away and as the result the temperature will be decreased. Coolants reduce friction at the tool / substrate interface and transfer heat away from the tools and the material being processed, reducing the time to process the metal, increasing the quality of the workmanship, and increasing tool life. The ability to transfer the heat away from the metal cutting process is why metal cutting fluids are often called coolants.

Almost all the work that goes into machining is dissipated as heat of deformation in 75% while 25% is due to the friction. About 80% of the total heat produced goes into chip, 10% into tool and another 10% into work piece.

2.3.2 Lubrication

The term lubrication in relation to cutting fluids is used to describe action by the fluid at the interface which reduces the tool forces and amount of heat generated. Cutting fluids that acts as a lubricant will reduce the coefficient of friction between the cutting tool and the chip, and between the cutting tool and the work piece.

A major objective of the use of lubricants is to improve the life of cutting tools but under some circumstances they cause an increase in the rate of wear. By reducing friction and wear , tool life and surface finish are improved. Improved surface finish is accomplished by restraining the formation of a built-up edge (BUE) on the cutting tool. A lubricant reduces the BUE by producing a thinner, less deformed, and cooler chip.

Improved surface finish is a major objective of cutting lubricants. In this respect they are particularly effective at rather low cutting speeds and feed rates in the presence of a built-up edge.

A lubricant perform 6 basic functions as stated below :

(i) Reduce friction

(ii) Reduce Wear

(iii) Absorb shock

(iv) Reduce temperature

(v) Minimize corrosion

(vi) Seal out contaminants

2.3.2.1 Reduce Friction

Primary function of a lubricant. It does this by separating the two contact surfaces and allowing them to move over one another . Figure 2.1 shows an elevation cross section of how the two surfaces would appear if greatly magnified.

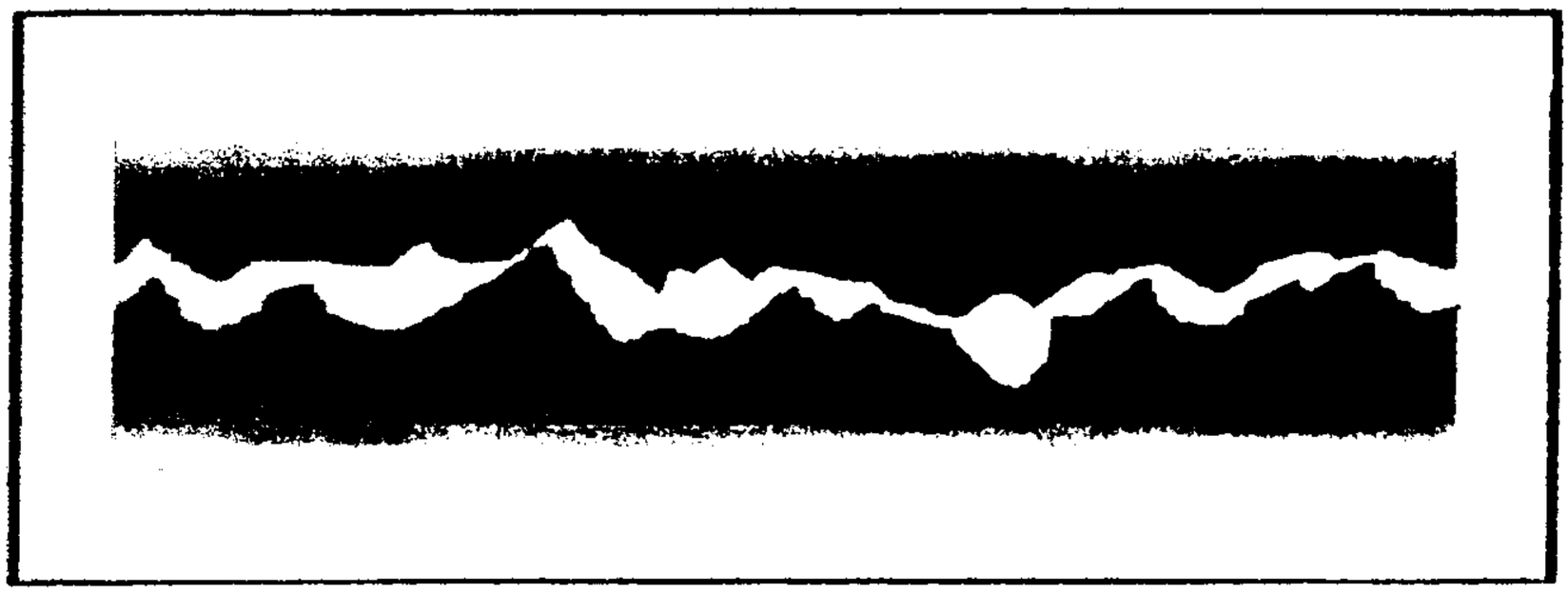

Figure 2.1 Metal surfaces greatly magnified under a microscope with no lubrication.

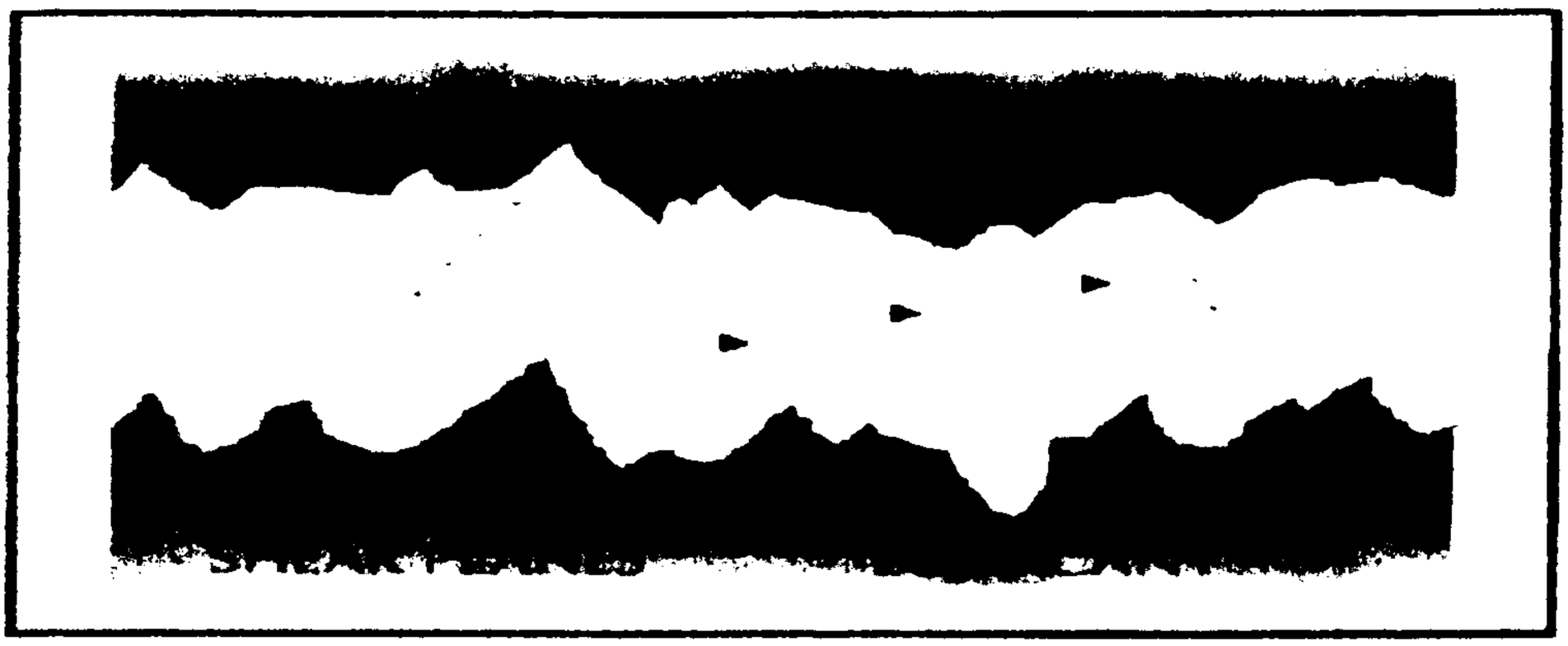

Figure 2.2 Lubrication separates moving parts.

2.3.2.2 Reduce Wear

With lubricant, the wear element particulates are significantly reduced and component life is extended.

2.4 WASH THE CHIP AWAY FROM THE CUTTING REGION

The cutting fluids helps removing chips from the hole as the coolants flows out through the flutes of the drill. Thus it will prevent metal pick-up on the both the tool and the work piece by flushing away the chips as they are produced. The surface finish of the work piece will be improved.

2.4.1 Prevent Corrosion

Corrosion of a metal is the deterioration of a material because of a reaction with its environment. Some coolant has additives to prevent and cure problems regarding corrosion. It will provide a protective coating. Antioxidants additive prevent oxygen from attacking the fluid.

2.5 CATEGORY OF METAL CUTTING FLUID

There are four major categories of cutting fluids : straight oils, chemically treated oils, soluble oils, and chemically –water compounds.

2.5.1 Straight Oils

Straight mineral oils are used extensively in machining nonferrous metals and free –machining steels. They are not chemically active and do not stain the machined parts. Straight mineral oils have relatively good lubricating qualities, but they are not very effective coolants. They are very stable cutting fluids and can be reused many times if properly cleaned and filtered.

2.5.2 Chemically Treated Oils

These cutting oils are chemically active at relatively low temperatures(200 to 300◦F) and have very good lubricating properties, particularly when chlorine and sulfur are added.

There are three general categories of chemically treated oils:

2.5.2.1 Sulfurized mineral oils

Sulfurized mineral oils are used almost exclusively with tough low-carbon and low-alloy steels. The oil becomes chemically active at relatively low temperatures and stains any copper base alloys. The sulfur content usually below 1.0 percent in the oil reacts with ferrous metals when the cutting oil is exposed to the temperatures and pressures produced by the metal cutting process. An iron sulfide film that resists high pressures and prevents galling is formed between the tool and the chip.

2.5.2.2 Sulfurized and chlorinated mineral oils

Sulfurized and chlorinated mineral oils are recommended for cutting tough metals and for severe machining operations , such as