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Review

Machining with Minimum Quantity Lubrication and Nano-Fluid MQL: A Review

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Abstract

Machining processes hold a pivotal place in the sphere of modern manufacturing. Thus, constant advancements to enhance their efficiency and sustainability are warranted. This review paper discusses the recent advancements in machining with Minimum Quantity Lubrication and a combination of Nano-Fluids with Minimum quantity lubrication (Nano-Fluid MQL). Recent developments are assessed with particular emphasis on critical parameters such as cutting temperatures, tool wear, and surface quality. In addition, the environmental and economic aspects of using MQL in combination with nano-fluids are discussed. This combinatory approach is evaluated as a sustainable solution in machining. This paper also presents the literature survey of nano-fluids and the application of nano-fluids in MQL.

Keywords

nanofluids, MQL, sustainable manufacturing, green machining

1 Introduction

1.1 Introduction to MQL

Green manufacturing tends to all the issues identified with assembling without upsetting the environment. Natural inviting machining is a need of great importance for the manageable turn of events, which consolidates social and affordable perspectives notwithstanding ecological concerns [1]. Minimum Quantity Lubrication (MQL) operates precisely as its name suggests. It employs a minimal quantity of fluid to diminish friction between a cutting tool and the workpiece. MQL is most effective in cutting applications like turning, milling, sawing, and drilling. However, its effectiveness diminishes in abrasive operations such as grinding, honing, and lapping, where the presence of fluids is crucial for clearing away the resulting swarf to prevent gumming. Lubrication and heat dissipation are fundamental to controlling tool wear. During flood cooling, there are numerous advantages to reducing the amount of fluid used. From an economic standpoint, Minimum Quantity Lubrication proves to be a more cost-effective option. Many are surprised to discover that the cost savings extend beyond the purchase of a smaller volume of fluid. Although MQL fluids may have a higher per-gallon cost, the actual quantity used is

significantly less, often less than 1/10,000 of the amount used in traditional methods. This results in a much lower charge per machined volume. MQL is categorized as a near-dry process, with less than 2 percent of the fluid following the chips. While it differs from dry machining, which involves no fluid, both methods share the characteristic of not requiring reclamation equipment. This eliminates the need for investments in sumps, recyclers, containers, pumps, or filtration devices. In addition, we do not pay any fees for washing and drying the chips before they are sold. Figure 1 shows Cost Analysis of Machining operations which cost some 8 to 16% from the metalworking fluid-(MWF) related activities.[2]. Minimum Quantity Lubrication (MQL) is a technique that involves applying a small quantity of lubricant directly at the interface between the tool and the workpiece. This method replaces the conventional flood coolant, which relies on fluid for removing metal chips. In MQL machining, a restricted amount of cutting fluid (typically 10-100 ml/h, in contrast to the 30,000-60,000 ml/h used in flood machining) is focused against the tool and workpiece interface, aided by an appropriate ratio of compressed air [3]. While flood cooling proves highly effective at lower cutting speeds, it becomes less efficient at higher speeds due to increased heat generation, preventing adequate coolant reach to critical areas