A review on recent developments in nano particle based cutting fluids in machining processes

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Abstract: . Cutting fluids or cutting oils are engineering materials that optimize the machining operation. They are used for lubrication, heat dissipation, corrosion prevention, chip disposal etc. This paper demonstrates a literature survey on the development of nano particle based cutting fluids and demonstrated their effectiveness in improving various factors like surface roughness, tool wear rate etc.

***Keywords*— Cutting fluid, Machining, Surface roughness . nano particles.**

I.INTRODUCTION

Cutting fluids or oils are those fluids which are used in machining processes for the primary purpose of heat dissipation, lubrication and corrosion prevention. The revolution in cutting fluids came when mineral oils were discovered to have cooling properties. The different types of cutting fluids are straight oils, soluble oils or semi synthetic oils and synthetic oils. With increase of cutting speeds in machining, abrupt use of cutting fluids began. A study by few American institutes states that 60% companies are spending 20% more amount on their coolants/lubricants in a cutting operation than on cutting tool being used for machining [6]. Thermal conductivity and heat transfer coefficient and lubricating properties of the cutting fluid is increased as a case of induction of nano particles which leads to reduction in tool wear and surface roughness.

II. LITERATURE REVIEW

V. Vasu, K. Manoj Kumar [2011] – This paper dealt with an investigation on using TRIM E709 emulsifier with Al2O3 nano particles to reduce the heat generated at grinding zone. A detailed comparison was done with dry, TRIM E709 emulsifier and TRIM E709 emulsifier with Al2O3 nano particles in grinding EN-31 steel in terms of temperature distribution and surface finish. It was found that Surface finish significantly improved by the application of TRIM E709 emulsifier with Al2O3 nano particles. By using TRIM E709 emulsifier with Al2O3 nano particles the wheel-work piece temperatures are reduced by 20 to 30% compared to dry and plain emulsifier.

S. Khandekar et. al. [2012]- In the present study, nano-cutting fluid was made by adding 1% Al2O3 nanoparticles to conventional cutting fluid. The wettability characteristic of this nano-cutting fluid on a carbide tool tip were measured using the macroscopic contact angle method. Comparative study of tool wear, cutting force, workpiece surface roughness, and chip thickness among dry machining, machining with conventional cutting fluid as well as nano-cutting fluid was made. This study clearly revealed that the cutting force, workpiece surface roughness, tool wear, and chip thickness were reduced by the using nano-cutting fluid compared to dry machining and machining with conventional cutting fluid.

Chan et. al. [2013]- This paper presented an experimental study on the enhancement effect of the low viscosity cutting fluid enriched with nano-droplets (NDCF) in ultra-precision turning. Unlike the conventional method in which the enhancement is done by adding nano-metric particles, no suspension particles are mixed to produce the NDCF. It was discovered that the ultra-precision cylindrical turning experiments reveal that the droplet size of the NDCF is a more important factor than viscosity on affecting the surface finish in ultra-precision machining.

M M S Prasad, R.R.Srikant [2013] –This experimental work studies the use of nano cutting fluids in MQL which is a minimal cutting fluid technique, for turning operation using HSS and cemented carbide tools. Development of nano materials by nanotechnology technique, dispersing them in the cutting fluid improve the effectiveness of the cutting fluid and hence nano graphite powder of particle size 80 nm in varying proportions i.e. 0.0%, 0.1%, 0.3% and 0.5% by weight are mixed in water soluble oil and applied drop by drop. Experimentation is carried out at different flow rates like 5 ml/min 10 ml/min and 15 ml/min with nano particle suspended fluids along with dry machining, flood coolant machining under constant cutting conditions. It was deduced that increase in percentage

inclusion of the nano graphite lead to better performance of the fluids in terms of properties and machining responses like cutting forces, temperatures, surface roughness and tool wear.

K.P. Sodavadia and A.H. Makwana [2014] - investigated the application of nano Boric acid, solid lubricants suspension in coconut oil during turning of AISI 304 austenitic stainless steel with carbide tool. Where in nano boric acid solid lubricants of 50 nm particle size were suspended in coconut oil, base lubricant and found that of all the cases,coconut oil with 0.5% Nano Boric acid suspensions showed better performance compared to other Nano fluid in terms of cutting temperatures, tool flank wear and surface roughness.

M. Amrita et. al. [2014]- experimented on the usage of nano-graphite, nano -boric acid and nano-molybdenum disulphide in emulsifier oil based cutting fluids in MQL application. cutting fluid was prepared by including 0.3 wt% of nano particles and to check its stability, as dispersion of nano particles in base fluid i. The prepared cutting fluids with nano inclusions were applied at a flow rate of 10ml per minute while performing turning operation under constant cutting conditions. Performance of cutting fluids were evaluated by measuring cutting forces, cutting temperature near chip –tool interface, tool wear and surface roughness for each turn . The results were compared with dry and MQL application with emulsifier oil without nano inclusions to reach at an inference that machining with nano emulsifier cutting fluids showed reduced tool wear compared to application of emulsifier oil. It was found that minimum quantity lubrication with inclusion of nano particles in emulsifier oil is significantly better than dry and wet machining. Nano MoS2 is preferable as surface roughness of the work piece was less when compared to that obtained with other cutting fluids.

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N. Saravanakumar et al.[2014]- In this work, silver nano particles were synthesized, characterized, dispersed in cutting fluid and experimented for a turning operation. Heat carrying capacities of the cutting fluid, cutting forces during machining process and surface finish of the work piece were assessed by suitable instruments for cutting fluids with and without silver nano particles under different machining conditions. From the experimental results, it was observed that inclusion of silver nano particles in cutting fluid showed a significant reduction in tool tip temperature, cutting force and surface roughness of the work piece. It was found that the temperature values measured during turning process for cutting fluid with nano particle additive is observed to be minimum. It was confirmed that the Cutting forces were reduced to an extent of 8.8%. Surface roughness of the work piece decreased to an extent of 7.5%.

M. Saravana Kumar, K. L. Senthil Kumar [2014] - In this work the machining of martensitic stainless steel 420 grade by the utility of multi walled carbon nano tubes dispersed with coconut oil as a metal working nano cutting fluids was investigated. Nano cutting fluid and its behavior with respect to cutting temperature, surface finish have been analyzed. - carbon nano tubes based coconut oil showed better surface finish and reduction of cutting temperature when compared to conventional cutting fluids is used as a coconut oil and dry condition.

P Subhash Chandra Bose et. al. [2014] -This paper presented the effect of MQL and Nanofluids with 1% volume of Al2O3 and 4% volume Al2O3 on the machinability characteristics of Nicrofer C263 mainly with respect to Surface Roughness, Cutting Forces and Temperature dissipation. Experimental analysis for three different conditions – dry, MQL and MQL + Al2O3 Nanoparticles were carried out. It was found that use of combination of Nano fluids and MQL gives better surface finish with good temperature dissipation in cutting zone when compared with other conditions. It is also observed that there is a decrease in cutting forces and which may lead to reduced tool wear.

Padmini R et. al. [2015] - The investigation focused on the performance of vegetable oil based nano fluids on machining performance during turning of AISI1040 steel through minimum quantity lubrication (MQL). Different samples of nanofluids were formulated using dispersions of nano molybdenum disulphide (nMoS2) in coconut (CC), sesame (SS) and canola (CAN) oils at varying nanoparticle inclusions (npi) and examined for basic properties. Machining parameters were measured during machining. 0.5% CC+nMoS2 was found to reduce cutting forces, cutting temperatures, tool wear and surface roughness compared to all other lubricating conditions.

III. CONCLUSION

The above literature suggests that the use of nano particles like Al2O3, Nano MoS2, nano Boric acid in cutting fluids showed improvement in surface roughness and reduction in cutting forces, tool wear and cutting temperatures with least environmental concerns. The future sees the scope of various varieties of recyclable and environment friendly nano particles and cutting fluids used for a numerous machining operations.

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