Usage of Nanocutting Fluids in MQL Turning of Alloy Steel - A Review

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Abstract: ***Today any type of pollution is our great concern for the environment. In machining a huge quantity of cutting fluid is used and it causes pollution when it disposed of environment after usage. So,Machining with MQL (minimum quantity lubrication) is very much important for the betterment of ecosystem. Recent study shows that metal cutting fluid with Nano inclusion has great advantage to save power and get better product. And hybrid Nano fluid has more advantage than single Nano cutting fluid.***

Keywords: Nano particle inclusions, MQL, machining of stainless steel

1. Introduction

In metallurgy, stainless steel, also known as inox steel or inox from French inoxydable (inoxidizable), is a steel alloy with a minimum of 10.5% chromium content by mass [1].However stainless steels have very high corrosion resistance, it is more difficult to machine.

These materials because of their low heat conductivity, built – up edge tendency and high work. Hardening properties than carbon and low alloy steels. Poor surface finish and high tool wear are the common problems for machining of stainless steel [2].Cutting fluids lubricate and cool the interfaces and improve the tribo-logical conditions there and it plays an important role to increase the productivity in industries. But their properties degrade over a period of time during usage. So, maintenance of cutting fluid is a must to keep its properties within range and to increase its life time. When it becomes uneconomical to maintain the fluids, it has to be disposed of. This causes environmental concern due to hazardous metal carry-off, hazardous chemical composition, depletion of oxygen and excessive nutrient loading leading to imbalance of ecosystem in water bodies [3]. So an effective way is very much needed to get rid of these problems which is MQL (minimum quantity lubrication) method and the performance of cutting fluid is increased when we add Nano particles and hybrid Nano particles have greater advantage over single Nanoparticles [4].

2. Properties of Nano Materials

1) Thermal conductivity:

Choi et al. (1995)established that due to high surface-area-to-volume ratio the thermal, mechanical, magnetic, and electrical properties of Nano phase materials are superior to those of conventional materials with coarse grain structures [5]. Again Choi et al. (2001) noticed that Nanotubes show greater thermal conductivity below 0.3 vol.% and thermal conductivity ratio exceeding 2.5 at at 1 vol.% Nanotubes when compared with other Nanostructured materials including copper Nanoparticles[6]

2) Lubricating properties

ALLAM (1991) reported that Graphite has more lubricating capability (up to 450^{0}c) compared to molybdenum disulphide (up to 300^{0}c) and tungsten disulphide, boron nitride, and lead oxide, are useful lubricants [7].Tao et al. (1996**)** invented the ball-bearing effect of diamond Nanoparticles dispersed in paraffin oil in tribological test where wear is less below 1% diamond Nanoparticles (Purity 95%) concentration and after that it is more [8].Choi et al. (2001) noticed that Nanotubes show greater thermal conductivity below 0.3 vol.% and thermal conductivity ratio exceeding 2.5 at at 1 vol.% Nanotubes when compared with other Nanostructured materials including copper Nanoparticles[5].

3) Friction and wear properties

Liu et al. (1997) studied friction and wear properties of a surface-modified TiO_2Nanoparticle as an additive in liquid paraffin and found Nanoparticles possess excellent load-carrying capacity, good anti-wear and friction-reduction properties [9]. Sunqing et al. (1999) shown CeF_3Nanoparticles possess excellent extreme pressure and friction reducing properties [10]. Chang-GunLee et al. (2009) established that graphite Nano lubricants friction coefficient and roughness is lowest at 0.5 vo. % npi in tribological test [11].

4) Application of Nano fluids in turning of stainless steel:

Khandekar et al. (2012) performed turning ofAISI 4340 by Al_2O_3 npiMWF (Servo Cut ''S''+ Additives + Water**)** and found that adding 1% Al2O3 Nanoparticles (volume) to the conventional cutting fluid greatly enhances its wettability characteristics and reduction of 50% and 30% cutting force and 54.5% and 28.5% in the Ra while machining with Nano-cutting fluids compare to dry cutting, conventional cutting fluid respectively [12].

Amrita et al. (2013) performed turning of AISI 1040 stainless steel by MQCL method which showed better machining performance compared to MQCL application with conventional cutting fluid, flood lubrication, and dry machining with respect to cutting forces, tool wear, cutting temperature, surface roughness, and chip shape and color [1].

Srikanth et al. (2014) performed turning of AISI 316L with MQL method by CNT inclusions cutting fluids and It is found that adding CNT to the conventional cutting fluid greatly enhances its wettability characteristics compared to pure water compared to conventional cutting fluid. It also reduce crater and flank wear [13].

Rajmohan et al. performed turning operation on AISI 316L in Nano cutting environment where CNT as a Nano materials and concluded that wt % of MWCNT and feed rate are the dominant variable on cutting force and the addition of MWCNT improved the lubrication and cooling effects with their enhanced penetration and entrapment at the turning interface[14].

Padmini et al.((2015)performed turning AISI 1040 steel with vegetable oil (CC+SS+CAN) based Nanofluids and found reduction of cutting forces, cutting temperatures, tool wear and surface roughness compared to all other lubricating conditions with 0.5% CC+nMoS2 npi[15].

Khalil et al.(2015) investigated Effect of Al_2O_3Nanolubricant(0.1%wt) with SDBS on tool wear during turning process of AISI 1050 with MQL(20 ml/h) and reported that Flank wear is lowest for pure Nanofluidsand it is largest for in dry conditions[16].

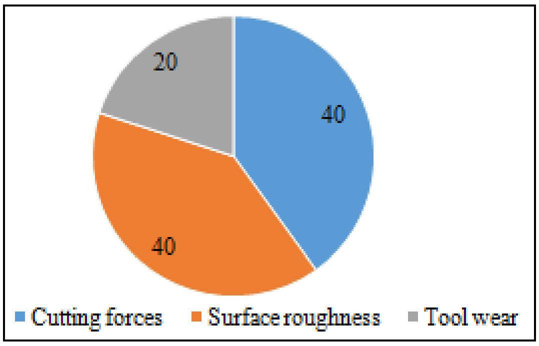
Sharma et al.(2015) have done experimental investigation of Al_2O_3Nanoparticle based cutting fluid in turning of AISI 1040 steel under minimum quantity lubrication (MQL) with 1%(vol.) Al_2O_3 (flow rate 50 ml/min and lubricating pressure 4 bar) and found reduction of cutting forces(Fx, Fy, Fz) 59.1%, 29.2%, 28.6% comparedto dry machining, less tool wear up to ~ 63.9%, ~44.9% and~5.27% w.r.t. dry and ~ 47.8%, ~29.1% and ~25.5% in case of average surface roughness[17].

Singh et al.(2017) evaluated performance of Alumina-graphene Hybrid Nano-cutting Fluid in Hard Turning using MQL conditions of AISI 304 steel where Al_2O_3:GNP 90:10 inclusions and noticed Al-GnP hybrid Nanofluid shows a significant reduction of 9.94%, 17.38%, 7.25%, in Fz, Fy, Fx, and 20.28% Ra[18].

3. Summary of Literature Review

Sl No.	Author	Work piece	Nano particle	Percentage of addition
1	Khandekar et al.(2012)	AISI 4340	Al_2O_3	1%
2	Amrita et al (2013)	AISI 1040	Graphaite	
3	Srikanth et al(2014)	AISI 316L	Cu	1%
4	Padmini et al ((2015)	AISI 1040	CC+nMoS2, SS+nMoS2, CAN +nMoS2	0.5%
5	Rajmohan et al. (2015)	AISI316L	MWCNT	0.1 %
6	Khalil et al. (2015)	AISI 1050	Al_2O_3	0.1%
7	Sharma et al.(2015)	AISI 1040	Al_2O_3	1%
8	Singh et al(2017)	AISI 304	Al-GnP(9:1)	-
9	Prasad et al.(2017)	AISI 304	Al2O3 + ZnO, TiO2	0.01 %

Average contribution of Nano fluids in percentage for reduction of Cutting forces, Tool wear and Surface roughness



4. Conclusion

1) Turning of stainless steel is a difficult machining because its high wear resistance and toughness. Cutting fluid has a great role to get good surface finish.
2) Nano cutting fluid shows greater advantage than conventional cutting fluid for machining of stainless steel in terms of cutting forces, surface finish and tool wear.
3) Also it has a great role in green manufacturing means less environmental pollution.

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