Performance of Mos_2 based cutting fluid Lubricants during Maching of AISI 316Ti Austenitic Stainless Steel

Mr. Devesh Kumar Singh[1], Mr. Manish Kumar Singh [2], Prof. Dharmendra Dubey[3]

[1]*PG Scholar, Department of Mechanical Engineering, Bhagwant University, Ajmer, Raj., India*
[2] *Asst. Prof., Department of Mechanical Engineering, Bhagwant University, Ajmer, Raj., India*
[3] *Associate Prof.,Department of Mechanical Engineering, Bhagwant University, Ajmer, Raj., India*

ABSTRACT

Machining is one of the most critical processes in the manufacturing industries which involve a controlled removal of material from the substrate by using a cutting tool. While these materials solve a great deal of technol ogical issue, they also pose considerable challenge in machining due to poor machinability characteristics. However, environmental friendly machining techniques have been given major emphasis and minimum quantity lubrication (MQL) technique is one of them. During the current research work, the effect of addition of MoS2 powder, with average size of around 1.5 µm, in two different base fluids namely conventional water soluble oil and paraffin oil (a mineral oil) has been investigated during turning of AISI 316Ti grade austenitic stainless steel. Although molybdenum disulfide (MoS2) is widely regarded as solid lubricant material, its potential as an effective medium in MQL particularly in turning operation is yet to be explored.
The results clearly indicated the beneficial aspects of MoS2 in reducing the cutting temperature by virtue of enhanced heat transfer characteristics of micro-particle of MoS2.The same powder also helped in bringing down cutting force and chip thickness while improving surface finish. It was observed that MoS2- mixed conventional cutting fluid demonstrated superior machining characteristics. The study, therefore, clearly established promising potential of MoS2 powder to be mixed with suitable base fluid under MQL environment during machining AISI 316Ti grade austenitic stainless steel.

Keyword: - *Minimum quantity lubrication, molybdenum disulfide, conventional water soluble cutting oil, paraffin oil, machining, AISI 316Ti stainless steel.*

1. INTRODUCTION

Industrial development and application of new methods for improving production processes require extensive studies in various fields, especially in the machining. Manufacturers always look for higher yields and incomes. In fact, the main goal in manufacturing is to minimize production time, cost, energy and resources along with improving the function [1]. In metalworking operations, the frictional resistance can be reduced by adding a lubricant between the surfaces. Lubricants separate the sliding surfaces by forming a film, and thereby reduce the frictional resistance and wearing [2]. In this way cutting fluids play an important role. For this purpose, metalworking fluids, prevent from metal to metal contact and decrease internal friction [3]. Cutting fluids can also be used to prevent re-welding, corrosion protection, reducing the energy consumption of the machine, and increasing tool life [4]. Cooling ability of a fluid helps to control undesirable temperature of tool, workpiece and chip. Furthermore, during the process, cutting fluids can wash and remove generated chip [5]. For many years, coolants, popularly known as metal working fluids (MWF) continued to be successfully employed for the heat removal until it was realized that these fluids are a serious damage to the environment and to the health of the operator working with it. The researches of Klocke and Eisenblatter (1997b) showed that they create a waste disposal problem and add to the cost of the manufacturing. These negative consequences of the flood cooling promoted the researchers to switch to those technologies which involve least usage of the cutting fluids [6].

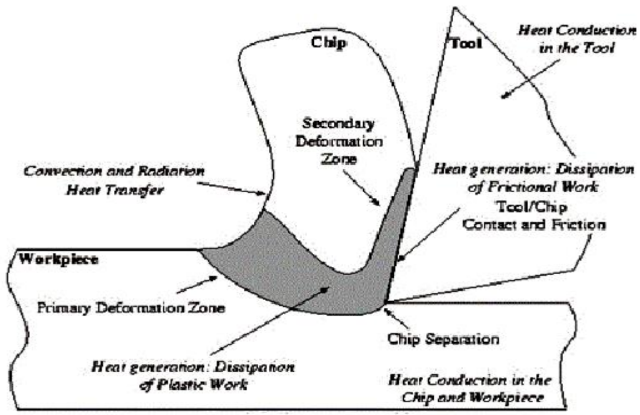

Fig. 1.1: Generation and distribution of heat during machining [1]

Many alternatives were developed to minimize the quantity of cutting fluid used. Some such techniques that came into focus were:

- Dry machining
- Cryogenic cooling
- Coated tools
- Minimum quantity lubrication

In order understand the influence of addition of solid lubricant powder on MQL, molybdenum disulfide has been selected for the current study. To study the effect of base fluid on powder- mixed MQL, two different base fluids have been used conventional water soluble cutting fluid and light paraffin oil. It is also essential to recommend optimal cutting condition for machining under powder-mixed MQL condition. Since, machining of austenitic stainless steel is considered difficult primarily due to low thermal conductivity and tendency of strain hardening, AISI 316Ti grade stainless steel has been considered as workpiece material for turning operation during the current research work. Therefore, the study has been planned and undertaken with the following broad objectives:

- To study the effect of MoS2 powder-mixed cutting fluids under MQL mode on various machinability characteristics such as cutting force, cutting temperature, surface roughness, chip thickness and macro morphology of chips and compare the results with that of cutting fluid without the use of MoS2 powder during turning of AISI 316Ti austenitic stainless steel.
- To undertake a comparative study of the effect of paraffin oil and conventional water soluble cutting oil as base fluids on the performance of powder-mixed MQL during machining austenitic stainless steel.
- To optimize the various output responses during turning under powder-mixed MQL using grey relational analysis and thus to determine the most optimal parametric combination which can yield the best possible performance characteristics.

Experimental Setup

The experiment involved turning process to be carried out on a cylindrical job of stainless steel (AISI 316Ti). The workpiece considered had the initial diameter of 70mm and length of 320mm. All the turning experiments were carried out on a heavy duty lathe machine

Preparation of cutting fluids

The experiments were carried out under minimum quantity lubrication (MQL) environment. Two cutting fluids i.e. conventional cutting oil and light paraffin oil was used as the base fluids. Molybdenum disulfide particles were added into the base fluid and mixed thoroughly to avoid any particle settlement at the base due to difference in specific gravity. Four types of MQL environment was set up.

1. Conventional cutting fluid MQL
2. Conventional cutting fluid with varying concentrations of MoS2 nanoparticles
3. Light paraffin oil

4. Light paraffin oil with varying concentrations of MoS2 nanoparticles

Working of MQL setup

The setup used for applying minimum quantity lubrication in machining operations is Fig. 1.2.

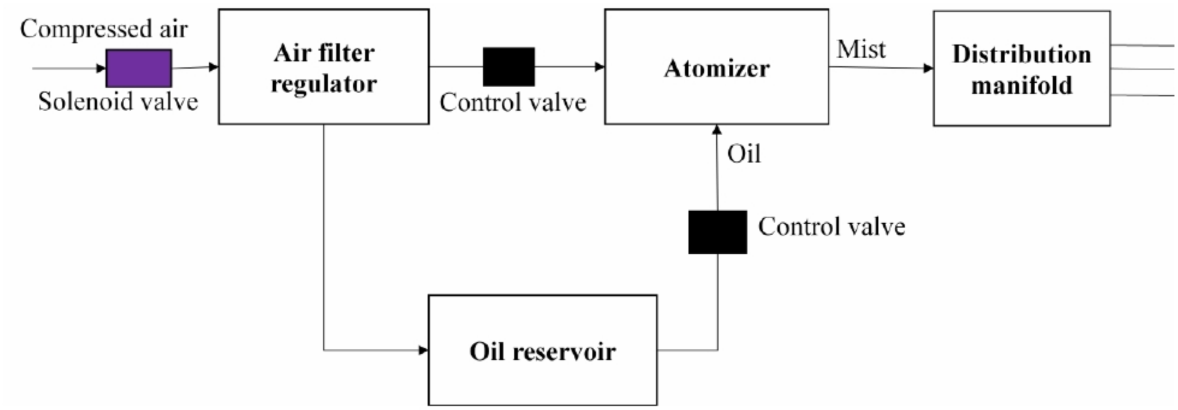

Fig. 1.2: Flowchart depicting the working of oil mist lubricator

The oil mist lubricator functions in the following manner.

- Highly compressed air with typical air pressure of 4-6 bar is supplied into the air filter via a solenoid valve.
- The air filter removes any impurity or contaminations that may have come along with the supplied air so as to keep the equipment clean and dirt free.
- In the mean time cutting fluid from the oil reservoir is supplied to the mixing chamber via an oil control valve. Oil control valve helps to control the flow rate of oil to be supplied.
- In the mixing chamber, the compressed air from the filter via air control valve and the cutting fluid get mixed to form an aerosol known as oil-mist.
- This oil mist is then supplied to the cutting zone through a very small holed (< 2 mm) nozzle.

Results and Discussion

After machining, the output responses were measured and tabulated as shown in Table 5.1, 5.2 and 5.3

Table 5.1: Output response table for machining with conventional oil as the cutting fluid

Run no	Vc (m/min)	f(mm/rev)	Fz(N)	T(^{0}C)	Ra	Avg Chip Thickness(mm)
1	100	0.15	115	41	0.6	0.2733
2	100	0.2	118	43	1.8	0.3567
3	130	0.1	127	44	1	0.17
4	130	0.1	113	43	1.2	0.18
5	60	0.2	122	45	2	0.38
6	100	0.15	114	45	1.6	0.2533
7	100	0.15	114	47	1.2	0.2533

8	130	0.2	129	54	1.8	0.3233
9	100	0.15	112	48	1.2	0.24
10	100	0.1	111	37	1.9	0.1833
11	60	0.2	119	45	1.5	0.1956
12	100	0.15	113	42	1.2	0.25
13	100	0.15	114	44.6	1.4	0.2545
14	60	0.15	107	41	1.2	0.1933
15	100	0.15	112	44.5	1.2	0.2534
16	100	0.15	113	44	1.3	0.2567
17	130	0.2	118	43	1.8	0.3567
18	60	0.1	108	43	1.8	0.1933

Table 5.2: Output responses for machining with conventional oil and MoS_2 particles

Run no	Vc (m/min)	f(mm/rev)	Concentration of MoS_2	Fz(N)	T (^{0}C)	Ra	Chip Thickness(mm)
1	100	0.15	6	99	39	1.4	0.1933
2	100	0.15	6	109	36	1.4	0.2667
3	100	0.15	6	105	40	1.2	0.3433
4	100	0.15	6	109	36	0.8	0.18
5	130	0.2	3	100	35	1	0.27
6	100	0.15	6	96	40	1.8	0.3733
7	100	0.2	6	98	38	1.4	0.2773
8	60	0.2	3	96	35	1.3	0.3667
9	100	0.1	6	104	36	1.8	0.2033
10	100	0.15	9	93	34	0.5	0.1967
11	130	0.1	3	99	42	0.6	0.2786
12	60	0.2	9	97	38	0.4	0.2981
13	100	0.15	6	103	40	1.6	0.3933
14	100	0.15	3	105	44	1.4	0.2453
15	130	0.1	9	147	31	0.2	0.2775
16	60	0.1	3	101	43	1.4	0.1833
17	60	0.1	9	94	36	0.4	0.243
18	60	0.15	6	100	38	1	0.3633
19	130	0.15	6	102	41	1.8	0.1767

Table 5.3: Output response table for machining with paraffin oil and MoS_2 as the cutting fluid

Run no	Vc (m/min)	f(mm/rev)	Concentration of (wt%)	Fz(N)	T(^{0}C)	Ra	Chip Thickness(mm)
1	100	0.15	6	120	42	1.4	0.2733
2	130	0.1	3	115	51	2.8	0.18
3	100	0.15	6	118	43	1.4	0.2533
4	100	0.1	6	118	43	1.2	0.19
5	100	0.15	6	117	45	1.2	0.26
6	100	0.15	6	112	42	1	0.25
7	130	0.2	9	110	45	3.2	0.4733
8	60	0.1	9	118	45	0.8	0.1833
9	100	0.15	3	124	49	1.2	0.2667
10	130	0.1	9	114	42	1.4	0.1867
11	100	0.15	6	119	42	1.2	0.26
12	130	0.2	3	113	47	1.8	0.3433
13	100	0.15	9	117	41	1.4	0.2667
14	100	0.2	6	120	44	1.8	0.3633
15	130	0.15	6	113	43	1.4	0.2567
16	60	0.1	3	121	50	1.6	0.21
17	100	0.15	6	118	43	1.8	0.2633
18	60	0.2	9	120	42	2	0.383
19	60	0.15	5	120	42	1.2	0.27

CONCLUSIONS

Based on the observations and analysis, following conclusions can be drawn:

- The parametric effect on the output responses showed that cutting forces decreased with increase in cutting velocity and increased with feed. Addition of MoS2 particles helped in reducing the cutting forces.
- Increase in cutting velocity and feed rate resulted in an increase in cutting temperature, while mixing of MoS2 powder in both the cutting oils contributed in reduction in cutting temperature. Increase in concentration of MoS2 particles also led to reduction in cutting temperature.
- Surface roughness increased with increase in cutting velocity and feed rate while increasing the concentration of MoS2 particles assisted in improving the surface finish.
- The cutting environment of conventional fluid mixed with MoS2 particles helped in considerable reductio n in the cutting force. Increase in concentration of MoS2 also resulted in reduction in cutting force.
- Higher cutting temperature was observed for paraffin oil as compared to conventional water soluble cutting oil. Addition of MoS2 powder restricted the increase in temperature for both the base fluids. However, the study established conventional cutting fluid as a better coolant than paraffin oil.

REFERENCES

[1] R. Neugebauer, W. Drossel, R. Wertheim, C. Hochmuth, M. Dix, Resource and energy efficiency in machining using high-performance and hybrid processes, Procedia CIRP 1 (2012) 3-16.

[2] W.J. Bartz, Ecological and environmental aspects of cutting fluids, Lubrication Eng. Illinois 57 (2001) 13-16.

[3] Y. Shokoohi, E. Khosrojerdi, B.H. Rassolian Shiadhi, Machining and ecological effects of a new developed cutting fluid in combination with different cooling techniques on turning operation, J. of Cleaner Prod. 94 (2015) 330-339.

[4] J.P. Byers, Metalworking fluids, CRC Press, USA, 2012.
[5] K. Weinert, I. Inasaki, J. Sutherland, T. Wakabayashi, Dry machining and minimum quantity lubrication, CIRP Annals-Manuf. Tech. 53 (2004) 511-537.
[6.] Klocke, F. and Eisenblatter, G. Dry cutting. Annals of the CIRP 1997, 46(2), 519-526.

BIOGRAPHIES

	Mr. Devesh Kumar Singh PG Scholar. Department of Mechanical Engineering Bhagwant University, Ajmer, Raj., India
	Mr. Manish Kumar Singh Asst. Professor Bhagwant University, Ajmer, Raj., India
	Prof. Dharmendra Dubey Associate Professor Department of Mechanical Engineering Bhagwant University, Ajmer, Raj., India