Cost Optimization of Abrasive water jet CNC water filtration Process by Using Self proposed Technique

Mohd Nadeem Khan, Shahnawz Alam,

Abstract— Abrasive Water jet machining is a non conventional metal removal process as well as one of the best manufacturing processes suitable for machining on very hard material. The objective of experimental investigation is to practical optimization of water purification techniques, which is the main problem, by which the maintenance time increases which directly affect the productivity of the shop floor. The problem is focused on The water is used from ground water by submersible techniques, the water from ground is not in good condition it contain many impurities so here we have to purified the water by RO filtration plant which is installed in the setup. The main objective is here before supplying the purified water to the machine it is again filter by specified inbuilt filter which costs are too high and its life is too much low as 40-50 machine hours maximum and it is imported by machine manufacturer abroad most of the time due to which the productivity is affected.In this context we had used some conventional filter setup before these inbuilt filters by which the filters life will improve and which will results to increase the productivity. In this context the cost benefits are also compared.

Index Terms—Abrasive Waterjet, Filteration Technique, Cost Optimization, Cost Analysis, Conventional filter, Proposed setup

1 INTRODUCTION

In the battle to reduce costs, engineering and manufacturing departments are constantly on the lookout for an edge. The waterjet process provides many unique capabilities and advantages that can prove very effective in the cost battle. Learning more about the waterjet technology will give you an opportunity to put these cost-cutting capabilities to work.

Beyond cost cutting, the water jet process is recognized as the most versatile and fastest growing process in the world. Waterjets are use in high production applications across the globe. They compliment other technologies such as milling, laser, EDM, plasma and routers. No noxious gases or liquids are used in waterjet cutting, and waterjets do not create hazardous materials or vapors. No heat effected zones or mechanical stresses are left on a water jet cut surface. It is truly a versatile, productive, cold cutting process.

The result cutting edges are often of satisfaction and do not require additional machining. The waterjet has shown that it can do things that other technologies simply cannot. From cutting whisper thin details in stone, glass and metals; to rapid hole drilling of titanium; to cutting of food, to the killing of pathogens in beverages and dips, the waterjet has proven itself unique. Waterjets remove material without heat. In this cold cutting process, the supersonic waterjet stream performs a supersonic erosion process to "grind" away small grains of material. After this waterjet stream has been created, abrasive can be added to the stream to increase the power of the process many times.

The main tool or fuel of the machine is water, water is used as a cutting tool, this machine requires purified water for cutting operation so that RO plant is also the requirement of this setup, because if the water will not of good quality then it will damaged the various parts very soon like nozzle, orifice, various kinds of seals will wear out soon, and it also Increases the maintenance of the machine which will directly effect the over all productivity.

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2 LITERATURE REVIEW

A.A. Khan and M.M. Hague [1] analyses the performance of different abrasive particles in abrasive water jet machining of glass. They compare the effect of different abrasives on taper of cut by varying the stand-off distance, work feed rate, pressure. Garnet abrasive produce the largest taper of cut, followed by aluminum oxide, and silicon carbide. The study also describe that the taper of cut increases with increase in the standoff distances because water jet get widen with increase in standoff distance. The taper of cut decreases with increase in jet pressure, with increase in pressure the cutting energy of jet increases. The depth of penetration of jet increases with increases in hardness of abrasives.M.A. Azmir, A.K. Ahsan [2] conducted a practical study for analyzing the surface roughness and kerfs taper ratio of glass/epoxy composite laminate machined using abrasive water jet machine. The various process parameters considered are abrasive types (2-level), hydraulic pressure (3-level), standoff distance (3-level), abrasive flow rate (3-level), traverse rate (3-level), cutting orientation (3-level). The optimization of AWJM was done with the use of Taguchi method and ANOVA (analysis of variance). The ratio of top kerfs width to bottom kerfs width is called Kerf taper ratio. Types of abrasives and traverse speed are insignificant parameter for surface roughness while hydraulic pressure is most significant factor that influences surface roughness in AWJM. Standoff distance (SOD), cutting orientation and abrasive mass flow rate are equally significant

Factors that influence surface roughness, but the kerfs taper ratios are influenced by hydraulic pressure, abrasive mass flow rate and cutting orientation. Abrasives type, standoff distance and traverse speed are most significant factors that had significant influences on kerf taper ratio. The quality of cutting in AWJM can be

ISSN 2229-5518

increased by increasing the kinetic energy of the water jet. Ahmet Hascalilk, Ulas Aydas, Hakan Gurun [3] has carried out the study of effect of traverse speed on AWJM of Titanium alloy. The width of cutting, changes with changes in traverse speed. The study also reveals that the kerf taper ratio and surface roughness increases with increases in traverse speed. The increase in traverse speed reduces the interaction of abrasives particles and the work piece thus narrow kerfs widths with a greater kerf taper ratio can be cut with AWJM. J. John Rozario Jegaraj, N. Ramesh Babu [4] worked on 6063-T6 aluminum alloy to find efficient strategy and quality cutting of materials with abrasive water jets considering the variation in orifice and focusing nozzle diameter in cutting. The study found that the effect of orifice size and focusing nozzle diameter on depth of cut, material removal rate, cutting efficiency, kerf geometry and surface roughness. The study suggested that a ratio of 3:1 between focusing nozzle diameter to orifice size was best suited combination to achieve the maximum depth of cut out of several combinations of focusing nozzle to orifice size. They suggest that the ratio of 5:1 and beyond cause ineffective entrainment of abrasives in cutting head. The investigation also analyze that the increase in hydraulic pressure for different combinations of orifice and focusing nozzle size the depth of cut increases. The material removal rate also increases with an increase in the size of focusing nozzle up to 1.2 mm diameter and further increase tends to decrease the material removal rate. The abrasive flow rate has less significant on kerf width. This study suggests that taper of kerf can be minimized by maintaining the orifice size and focusing nozzle size within certain limits raging from 0.25–0.3 mm and 1.2 mm, respectively. The surface quality does not depend on the increase in the size of orifice and focusing nozzle but larger size of orifice produces a better surface finish on cut surface. J. Wang, W.C.K. Wong [5] conducted a statistically designed experiment to study the effect of abrasive water jet cutting of metallic coated sheet steels. The relationship between kerf characteristics and process parameters are also investigated in this experiment. An empirical model was developed for kerf geometry and quality of cut for the prediction and optimization of AWJ cutting performance. A three-level four-factor full factorial designed experiment performed for analyzing the AWJM process. The various process parameters used are water jet pressure, traverse speed, abrasive flow rate and standoff distance (SOD). The study found that the top and bottom kerf widths increase with increase in hydraulic pressure, standoff distance but the rate of increase for the bottom kerf width is smaller. The traverse speed produces a inverse effect on the top kerf width and bottom kerf widths but at same time the kerf taper increase as the traverse speed increase. The surface roughness of the cut surface decreases with an increase in the abrasive flow rate. Mohemed Hashish [6] observed that as the pressure increases the power required for cutting get reduced drastically. This suggests that cutting at higher pressure is more efficient than at low pressure for the same power consumption. Plain waterjets are capable of cutting thn sheet metals at pressure of 600 Mpa. Elevated pressure promise cost reduction due to reduction in abrasive usage or increased cutting speed. The study shows that the depth of cut increases with increases in water pressure.

3 Experimental Setup

The objective of the present work is to optimize practically the use of conventional type filters before the machine inbuilt filters by which the inbuilt filters life will improve and water quality will also improve which will results to reduce the maintenance of filters plant and also increase the productivity

Fig.1 CNC Abrasive water jet Machine Setup

The fig 1 is the CNC Abrasive Water jet machine setup which is located in Reetu Marble Pvt. Ltd Industrial area Unnao, the practical optimization of the cost of the filters is done on this setup. Fig2 is the inbuilt filter setup which cannot be removed from the machine and these filters choked very earlier which was the main problem.

Fig 2 Inbuilt filters attached with the machine

Fig.3 RO Plant use to purified the ground water for machine

Reverse osmosis (RO) is a water purification technology that uses a semi permeable membrane to remove larger particles from drinking water. The fig.3 is the Ro plant which installed in this setup which provides the purified water to machine.

4. Filter Selection

The filter is used for the removal of all the sediment like sand, silt rust and other particles bigger than the micron of the filters. The filters are changed regularly or when the pressure differentiation occurs.

4.1Imported (0.45) micron filter cartridge

Fig.4 (0.45 micron cartridge) used in inbuilt filter

4.2 Imported (1) micron filter cartridge

Fig 5 (1 micron cartridge) used in inbuilt setup

(Fig.4 and fig.5) is the filters cartridge which is inbuilt with machine as shown in (fig.6). These filters are directly imported from machine manufacturer abroad, which costs high to the company and most of the time it take time to import here which directly affects the productivity and also increases the maintenance time.

4.3 Machine inbuilt filter setup

Fig.6 Machine inbuilt filter setup

So due to this problem we used the conventional filters cartridge before these filters which costs are affordable and easily available in local market. So we had prepared the setup of some conventional filters before the machine inbuilt filters, as shown in (fig.7).

4.4 Proposed filter setup

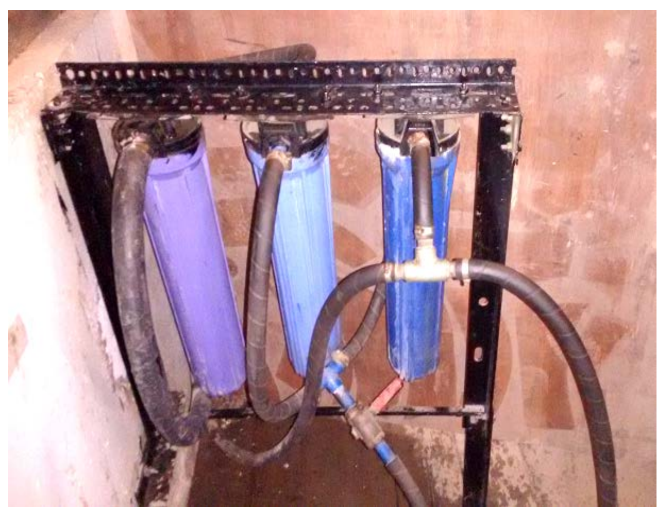

Fig.7 The proposed setup

Here we had made the conventional filter setup of (5 micron filters). It is installed before the machine inbuilt filter setup. In this setup we used conventional 5 micron filter (Fig 8) these filters are easily available in the local market, by using these filters the machine inbuilt filters life is increases about triple life as earlier.

Fig.8 Proposed 5 micron filter cartridge

5. Line Diagram For The Final Setup

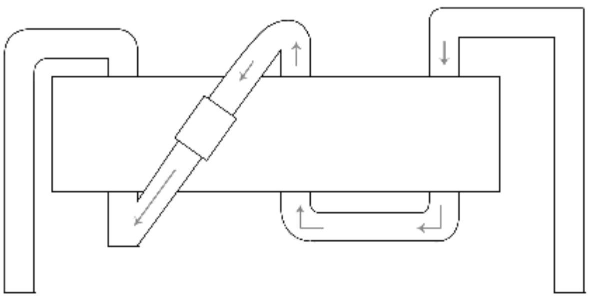

Fig 9 Line diagram for the proposed setup

The line diagram of the proposed filter setup is presented, it is very much clear from this line diagram that before supplying the water to machine inbuilt filter setup it will passed through the proposed filter by which the inbuilt filter's life will increase which is the main problem. The design of this setup is very simple and conventional type, very easy to install and easy to maintenance. The size of the filter we used in this setup is 22 inches.

6. Cost Analysis

Compared cost of the inbuilt setup to proposed setup.

6.1 Cost analysis of inbuilt setup

Filter number	Filter Cost	Overall life
0.45 micron imported filter	*3120/- + shipping Charges*	*35-40 hours*
1 micron imported filter	*1870/- + Shipping charges*	*35-40 hours*

The table shows the cost and an average life of the imported filters for the inbuilt setup of water filter.

6.2 Cost Analysis of proposed filter Setup

Filter number	Filter cost	Overall life
5 micron Indian filter	*800/-*	*140-150 hours*
5 micron Indian filter	*800/-*	*140-150 hours*
5 micron Indian filter	*800/-*	*140-150 hours*

The table shows the cost and an average life of the proposed filters for the proposed setup of water filter.

7. Comparative Analysis

In this context the comparison of the price and average life of the imported filter to the conventional or proposed filters.

This analysis is done by two methods, Analytical Method and Graphical Method

7.1 Analytical Method

The calculation is done between the cost and average life of the filters for about 400 machining hours and finds the benefits of proposed filter over the inbuilt filters.

Let A and B are the imported filters
And C, D and E are the proposed conventional filters

Cost of A+B = 5040/- +shipping cost
Cost of C+D+E = 2400/- from local market

Life Of A+B = 40 hrs approx
Life of C+D+E = 140hrs approx

If a machine works 24 hrs in a day 3 shifts, the pump of machine will used about 20 hrs in a day , that's means for inbuilt setup the filters (A and B) will change every second day i.e. about 40 hrs.

Now on adding 03 conventional filters (C, D, E), the replacement of the filters occurs after 140 hrs approx that is about 7th day.

On using this proposed filter setup the imported filters replacement is reduced by three times that is previously we were replacing the filters at about 40 hrs maximum but after installing this proposed setup we are replacing after 140 hrs means the life of the filters are increased by 100 hrs (2.5 times increased)

Cost saving by using the proposed setup

ISSN 2229-5518

Cost of one replacement of the imported setup is = 5040/-
The life increased by new setup is 2.5times
So the cost saved by using the proposed setup is = 5040 x 2.5
= 12600/-
Total cost saving = saving – proposed filters cost
i.e.
= 12600 - 2400
= 10200/-

Cost saving for every one replacement is 10200/-

Below table shows the cost saving for 50 weeks if the pump runs about 20 hours daily the cost is saved approx. 510000/-

S.No.	Days	Hours	Saving
1	1 week	140	10200/-
2	2 week	280	20400/-
3	3 week	420	30600/-
4	4 week	560	40800/-
5	10 week	1400	102000/-
6	50 weeks	7000	510000/-

7.2. Graphical method

The Fig 10 shows graphical representation of the number of filters used in 400 machining hours. It clearly shows that without the proposed filter setup these filters are changing approximately after every 40 hours. Hence during the 400 machining hours 10 filters are changed.

S.No	Filter Change	Hours
1	1	40
2	2	85
3	3	130
4	4	175
5	5	210
6	6	255
7	7	300
8	8	345
9	9	395
10	10	445

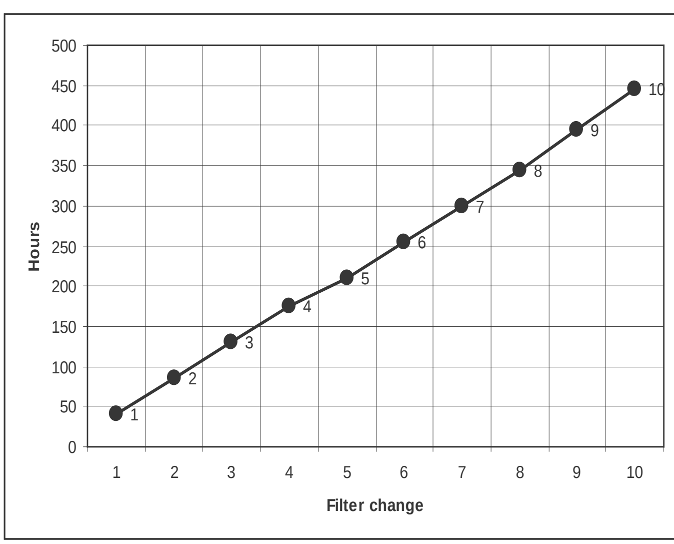

Fig 10 Graphical representation between number of filter change and No. of hours for inbuilt setup

Here by using proposed filter setup the filters are changes after 140 hrs approximately, here in Fig 11, it is graphically represented that by using the proposed filter setup about 400 machining hours the 3 filters are changed hence by using the proposed filter setup the life of the imported filters are increased.

S.No.	Filter Change	Hours
1	1	140
2	2	270
3	3	400

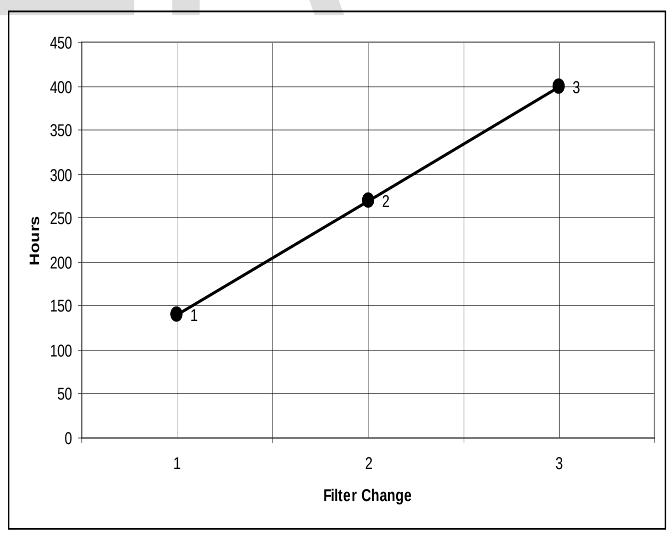

Fig 11. Graphical representation between number of filter change and No. of hours for self proposed setup.

Conclusion

The use of proposed filtration techniques to optimize the cost of filtration and life of the filters has been successfully reported in this paper.

The following conclusion can be drawn:-
Optimization of the cost and life of filters is simplified thorough this technique.The analytical and graphical representation results that there is a considerable improvement in the life of filters which directly increases the performance of inbuilt filters and also reduces the maintenance time.Implementation of this Technique also increases the productivity of Plant.Cost of the filter is also saved

ACKNOWLEDGMENT

The author is highly thankful to the management of the Reetu marble's Department of CNC Water Jet Machining for providing resources and all support.

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