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AN OPTIMIZE SYSTEM OF USING CUTTING FLUID IN MACHINING OPERATION FOR LIGHT WORK MACHINE SHOP

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Abstract

Cutting fluid is essential for the better performance in any machining operation; it is desirable for the cutting tool life and degree of accuracy of the operation to supply proper cutting fluid. The quality of the finish product largely depends on it. But in light machine shop the aspect of cutting fluid are ignored. Though there is high energy consumption, huge maintenance works, and complicated system used by machine shop but there is little use of any lubrication system. In such situation a work force need to develop an optimize system for the proper supply of cutting fluid during operation. In this research the system is used mainly mechanical energy of air pressure through foot pumper use to supply the adequate amount of cutting fluid in to the cutting area. The system developed in this research is handy and portable so it is useable for any machine in the machine shop and provides the flexibility of use with low maintenance and also very much cost effective.

Keyword: Cutting fluid, Machining operation, Foot pumper, Maintenance.

1.0 Introduction:

In this modern competitive world it is very difficult to attain market share for a product. To sustain in this competition, it is important to ensure best of quality besides the price of the product. Sustaining market of a product highly depends on its quality. To ensure the required quality scale it is essential to monitor and inspect the quality of the product. Besides this it is also needed to ensure that the quality inspection is neither time consuming nor expensive. In general, quality control procedures should be as simple as possible and only give the required information. Too little information means the test has not done its job; too much information and management decisions may be delayed or confused; just required information is desired.

The aim of the quality control in industrial application is to analyze and monitor the quality of industrial manufacturing activities. Signal processing systems and automatic visual inspection systems, which are automatic systems that perform visual inspection by means of machine vision, can play a fundamental role in quality assessment since they can guarantee a high and constant non invasive quality inspection.

As consumer demands are rising for high quality products, manufacturing industries are striving hard to achieve high quality at reduced costs. Manufacturing techniques can be improved upon by a considerable extent by employing automated machine inspection. Real-time, direct and fast tests can be performed on the product to be marketed to verify if it meets production standards. Also, repetitive tasks can get monotonous for human workers hence leading to erroneous results. The probability of errors and bias caused by the human factor in inspection of products can be reduced to a bare minimum by employing automated machine inspection. Quality assessments done by employing machine detection has highly desirable features like consistency, quantization, very low error probabilities and fast analysis times.

In this work both quality of the product and the cost is taken into consideration. Because the developed system is noticeably low cost with low maintenance cost which serves a vital role in machining operation. Tool life and product quality is one of the greatest concerns for the machining industries. Using this system remote machining area can have the supply of cutting fluid which increase the tool life and enhance the quality of the cutting.

2. Literature review

2.1 Cutting Fluid

Cutting fluid is a type of coolant and lubricant designed specifically for metalworking and machining processes. There are various kinds of cutting fluids, which include oils, oil-water emulsions, pastes, gels, aerosols (mists), and air or other gases. They may be made from petroleum distillates, animal fats, plant oils, water and air, or other raw ingredients. Depending on context and on which type of cutting fluid is being considered, it may be referred to as cutting fluid, cutting oil, cutting compound, coolant, or lubricant. Cutting fluids are used in metal machining for a variety of reasons such as improving tool life, reducing work piece thermal deformation, improving surface finish and flushing away chips from the cutting zone.

The properties that are sought after in a good cutting fluid are the ability to:

- Keep the work piece at a stable temperature (critical when working to close tolerances). Very warm is OK, but extremely hot or alternating hot-and-cold are avoided.
- Maximize the life of the cutting tip by lubricating the working edge and reducing tip welding.
- Ensure safety for the people handling it (toxicity, bacteria, and fungi) and for the environment upon disposal.
- Prevent rust on machine parts and cutters.

2.2 Function of Cutting Fluid

Cooling:

Metal cutting operations generate heat due to tool friction and energy lost deforming the material. The surrounding air is a poor coolant for the cutting tool because it conducts heat poorly and has low thermal mass. Ambient-air cooling is adequate for light cuts and low duty cycles typical of maintenance, repair and operations (MRO) or hobbyist work. However, production work requires heavy cutting over long time periods and typically produces more heat than air cooling can remove. Rather than pausing production while the tool cools, using liquid coolant removes significantly more heat more rapidly, and can also speed cutting and reduce friction and tool wear.

Lubrication**:**

Besides cooling, cutting fluids also aid the cutting process by lubricating the interface between the tool's cutting edge and the chip. By preventing friction at this interface, some of the heat generation is prevented. This lubrication also helps prevent the chip from being welded onto the tool, which interferes with subsequent cutting.

2.3 Types of Cutting fluid

❖ Practically all cutting fluids presently in use fall into one of four categories:

- Straight oils
- Soluble oils
- Semi synthetic fluids
- Synthetic fluids

Straight oils are non-emulsifiable and are used in machining operations in an undiluted form. They are composed of a base mineral or petroleum oil and often contain polar lubricants such as fats, vegetable oils and esters as well as extreme pressure additives such as Chlorine, Sulphur and Phosphorus. Straight oils provide the best lubrication and the poorest cooling characteristics among cutting fluids.

Synthetic Fluids contain no petroleum or mineral oil base and instead are formulated from alkaline inorganic and organic compounds along with additives for corrosion inhibition. They are generally used in a diluted form (usual

concentration ration = 3 to 10%). Synthetic fluids often provide the best Collin performance among the cutting fluid.
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Soluble Oil Fluids form an emulsion when mixed with water. The concentrate consists of a base mineral oil and emulsifiers to help produce a stable emulsion. They are used in a diluted form (usual concentration = 3 to 10%) and provide good lubrication and heat transfer performance. They are widely used in industry and are the least expensive among all cutting fluids.

Semi-synthetic fluids are essentially combination of synthetic and soluble oil fluids and have characteristics common to both types. The cost and heat transfer performance of semi-synthetic fluids lie between those of synthetic and soluble oil fluid.

❖ Cutting fluid can be also classified in following categories;

Liquids
There are generally three types of liquids: mineral, semi-synthetic, and synthetic. Water is a great conductor of heat but has drawbacks as a cutting fluid. It boils easily, promotes rusting of machine parts, and does not lubricate well. Therefore, other ingredients are necessary to create an optimal cutting fluid. Mineral oils, which are petroleum-based, first saw use in cutting applications in the late 19th century. These vary from the thick, dark, sulfur-rich cutting oils used in heavy industry to light, clear oils.

Pastes or gels
Cutting fluid may also take the form of a paste or gel when used for some applications, in particular hand operations such as drilling and tapping. In sawing metal with a bandsaw, it is common to periodically run a stick of paste against the blade. This product is similar in form factor to lipstick or beeswax. It comes in a cardboard tube, which gets slowly consumed with each application.

Aerosols (mists)
Some cutting fluids are used in aerosol (mist) form (air with tiny droplets of liquid scattered throughout). The main problems with mists have been that they are rather bad for the workers, who have to breathe the surrounding mist-tainted air, and that they often don't even work very well. Both of those problems come from the imprecise delivery that often puts the mist everywhere and all the time except at the cutting interface, during the cut—the one place and time where it's wanted. However, a newer form of aerosol delivery, MQL (minimum quantity of lubricant), avoids both of those problems.

Air or other gases (e.g., nitrogen)
Ambient air, of course, was the original machining coolant. Compressed air, supplied through pipes and hoses from an air compressor and discharged from a nozzle aimed at the tool, is sometimes a useful coolant. The force of the decompressing air stream blows chips away, and the decompression itself has a slight degree of cooling action ($pV=nRT$); lowering the pressure lowers the temperature).

2.4 Importance of Cutting Fluid

The primary needs of cutting fluids are (In Machining):
- Lubricating the cutting process primarily at low cutting speeds
- Cooling the work piece primarily at high cutting speeds
- Flushing chips away from the cutting zone

Secondary importance includes:
- Corrosion protection of the machined surface
- enabling part handling by cooling the hot surface

Process effects of using cutting fluids in machining include:
- Longer Tool Life.
- Reduced Thermal Deformation of Work piece.

- Better Surface Finish (in some applications).
- Ease of Chip and Swarf handling.

2.5 Conventional System

- ❖ Coupling of a pump with the machine; which process high electric energy a fluid tank, and high maintenance.
- ❖ Most commonly in machine shop they used a bottle of fluid for spray with hand when needed, which need to stop working for spray.
- ❖ Using a large pot of water for submerge work piece, which also need remove work piece frequently during operation.

3. Design of the New System

3.1 Component description and functions

The main components used in this system are;

- ❖ Foot-pumper.
- ❖ Air passing pipe.
- ❖ Air inlet valve.
- ❖ Fluid inlet point.
- ❖ Cutting fluid tank.
- ❖ Fluid passing pipe
- ❖ Magnetic disk post
- ❖ Flexible coil pipe.

The descriptions of these components are given bellow-

Foot pumper: It is a pumper with a foot paddle, which generally used for pumping motorbike tiers. When we make paddle on it the air passing forward with a help of hollow cylinder. The air is then passing through a pressure gage, which indicates the air pressure of passing air. A spring is connected with the foot paddle so after the paddle it moved it previous position.

- ❖ **Air passing pipe:** It is one kind of plastic hose pipe for passing air through a hollow passage. The pipe is coated with cotton fiber. Air passing pipe is connected with pressure gage in one end and other end has a tiger head.
- ❖ **Air inlet valve:** It generally used in bi-cycle or motor bike, where an inlet valve permit passing air in only one direction, so a certain amount of pressure can easily create upon the fluid.
- ❖ **Fluid inlet point:** Through this point fluid feed in tank. This must need to fit strongly so that air cannot get out from this point.
- ❖ **Cutting fluid tank:** This is a steel made tank with a cylinder or rectangular shape. The tank has three outlets, one for air inlet, one for fluid inlet and other is for fluid outlet, having a capacity of 4 to10 litter cutting fluid.
- ❖ **Fluid passing pipe:** It's a rubber made tube pipe with a small diameter (1/4" to 1/8"). The pipe has a length of 4 feet to 8 feet according to requirement. Low friction is a considerable factor for selecting pipe.
- ❖ **Magnetic disk post:** It's a steel made post which has a magnetic disk in the bottom side and a elbow pipe. The elbow pipe has a right angle shape, one end connected with fluid passing pipe and other is connected with flexible coil pipe. The elbow pipe is welded upon disk post.
- ❖ **Flexible coil pipe:** The flexible coil pipe is a stainless steel coil pipe, which can be rotate at any direction. A nozzle can be attached at the opening the pipe.

3.2 Photographs of the System Components

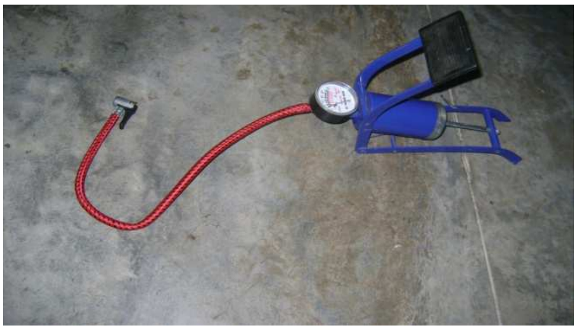

Figure: Foot pumper with pressure gage & air passing pipe.

Figure: Air inlet valve.

Figure: Fluid passing pipe.

Figure: Magnetic disk post with flexible coil pipe.

Figure: Cutting fluid tank.

Figure: Full Arrangement.

3.3 Design of the System

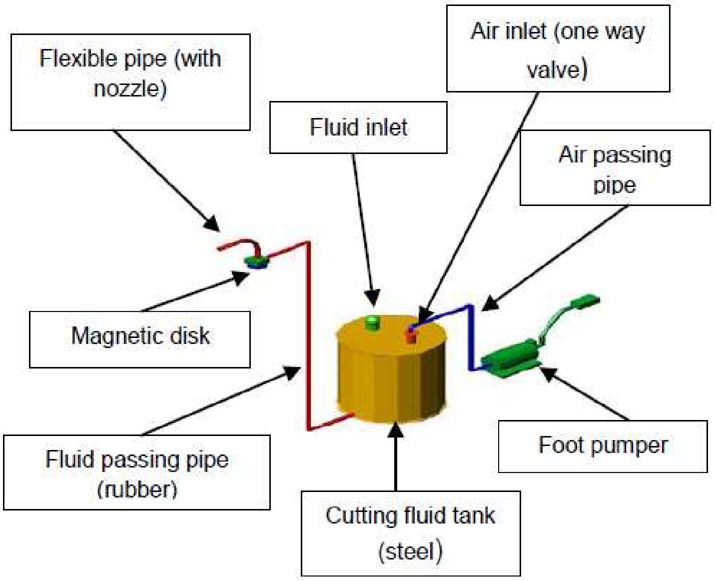

Fig: The proposed system

3.4 Operation of the system

To operate the system first it's need to set the magnetic disk post in any convent position from where the supply of the cutting fluid is convenient. Then using the foot pumper the pressure level of the fluid is increased. This pressure will aid to start to flow the fluid through the pipeline to the desired location. It is easy for the worker to make a few paddles to raise the fluid pressure during the time of working on the same machine.

This not only makes easier the operation but also clean the chip from the work zone, as well as no external sources of energy in needed. As the machining is done to a certain machine the worker can move away the foot pumper and the system is ready to use for another machine. In this way it helps to save energy, save money and increase the quality of the product by increasing the tool life.

4. Performance measurement

From the study of the system in a machine shop using an Automatic saw and Lathe machine it is found that these following performance are achieved based on flow rate:

- When the pressure level is highest then **maximum flow rate: 430 ml/ min.**
- From the fluid head rising up to **120 psi (lb/inch) gives 290 ml fluid flow.**
- For normal operating condition **3 to 4 paddles need for usual flow** of fluid.

Suitable for;

1. Lathe machine.
2. Milling machine.
3. Shaper machine.
4. Drill machine.
5. Planner machine.
6. Automatic saw.
7. Any cutting machine used in machine shop.

5. Advantages and Limitations of the system

Advantages:

- This is a flexible system applicable for any machine.
- A cost effective system.
- This system using mechanical energy instead no electrical energy.
- Low or zero maintenance cost.
- Easy for setup and operate.
- Portable and light weight.
- Flow rate is satisfactory.
- Worker can easily operate it during operation.
- Give high surface finish.
- Increase tool life.

Limitations

- The system cannot useful for high viscous cutting fluid.
- High flow rate required high pressure, that's difficult to supply in foot pump.
- There is no recycling system of cutting fluid.
- The tank capacity 3 to 10 litter, so successive charging of fluid is a problem
- During precision work, making paddle in foot pump is difficult for worker.

6. Result and Discussion

The system is design which is compatible for any machine in a machine shop. The system can be useful for their normal operating hour. In a country like Bangladesh most of the machine shops are not fully automated to supply cutting fluid automatically. Moreover, worker remains free but watching and feeding the tool or work piece, so the worker can do the machining operation as well as supply the cutting fluid easily using this system. The worker can easily make paddle in the working time which create pressure and make flow the fluid. So, the extra cost of electric pump is totally reduced by using this system.

The system is totally environment friendly. No environmental hazards are produced by this system. This system does not make any sound pollution because there are no rotating parts here. And also the system is very user friendly. One can operate the system without any special knowledge. The setup cost is only 919 (nine hundred and nineteen taka only) or 10.9361 USD, which less enough. There is no maintenance cost related cost with the system and no electrical bill related here. Once the setup is done then this system can be used in any machine as required.

The operating principle is very easy and also the setup is very easy. So the system is accessible for the all workers to any normal operation. In other words for the light work machine shop it is very much convenient and supportive in any machining operation performs there.

7. Conclusions

In this project a system is developed to establish an optimization system for using cutting fluid in the machining operation with flexibility. For better surface finish and increasing tool life cutting fluid is essential. But most of the case it is found that in the machine shops the coolant pumps is out of work or there is no coolant system due to its cost and high maintenance cost. So this system is developed by aiming that it can be used in all machines and also cost effective with a low maintenance cost. The system is mainly design for light machine shop because the amount of fluid carrying capacity is low.

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9. References

[1]. D. P. Adler, W. W-S Hii, D. J. Michalek, and J. W. Sutherland, "*Examining the Role of Cutting Fluids in Machining and Efforts to Address Associated Environmental/Health Concerns*". Department of Mechanical Engineering – Engineering Mechanics. Sustainable Futures Institute, Michigan Technological University.

[2] O. Çakīr, A. Yardimeden, T. Ozben, E. Kilickap, "*Selection of cutting fluids in machining processes*". Department of Mechanical Engineering, Dicle University, 21280 Diyarbakir, Turkey.

[3] Wisley Falco Sales, Anselmo Eduardo Diniz, Álisson Rocha Machado, "*Application of Cutting Fluids in Machining Processes*". J. Braz. Soc. Mech. Sci. vol.23 no.2 Rio de Janeiro, 2001.

[4] *Cost-Effective Manufacturing Machining Brass, Copper and its Alloys*, Copper Development Association, Publication TN44, 1992.

[5] E. Kuram, B. Ozcelik, E. Demirbas, and E. Şık, "Effects of the Cutting Fluid Types and Cutting Parameters on Surface Roughness and Thrust Force". Proceedings of the World Congress on Engineering 2010 Vol II WCE 2010, June 30 - July 2, 2010, London, U.K.

[6] Jeffrey B. Dahmus and Timothy G. Gutowski, *"An environmental analysis of machining"*. Massachusetts Institute of Technology, Department of Mechanical Engineering, 77 Massachusetts Avenue, Room 35-234, Cambridge, Massachusetts 02139 USA.

[7] Patrick Adebisi Olusegun Adegbuyi, Ganiyu Lawal, Oluwatoyin Oluseye, Ganiyu Odunaiya, "*Analyzing the effect of cutting fluids on the mechanical properties of mild steel in a turning operation*". American journal of scientific and industrial research 2010.

[8] J. W. Sutherland, A. Gandhi, V. N. Kulur, W. K. Chan, Y. K. Siow, "*Cutting Fluids in Machining: Heat Transfer and Mist Formation Issues*". Department of Mechanical Engineering - Engineering Mechanics, Michigan Technological University, Houghton, MI 49931-1295.

[9] X.C. Tana,*, F. Liua, H.J. Caoa, H. Zhangb, "*A decision-making framework model of cutting fluid selection for green manufacturing and a case study*". Journal of Materials Processing Technology 129 (2002) 467-4706.

[10] Jain R.K. 2003, 6th edition, Production technology.

[11] Kalpakjian, 1996, Manufacturing process & technology.