Development of Part Washing System for Clean Factory

Su-Jin Kim*, Jeong-Hwan Jang and Soo-Yong Cho

Abstract

The washing process is a technology which removes cutting oil, metal chip and soil dust on the surface of mechanical part. It is typically an environmentally hazardous activity because of solvent vapor spread into air. Today, a great deal of effort has been devoted to developing alternative metal cleaning technologies in advanced countries and some processes are being commercialized among them. Therefore we developed alternative part washing process that use water solvable cleaners replacing organic chlorinated solvents. The equipment transfers metal parts at a given rate through the cleaning, rinse, rust preventing and dry tunnel. It was applied to a factory and it is shown that part washing process became cleaner, faster and more comfortable compared to the previous process.

Key Words: Part washer, Metal cleaning, Water solvable cleaner, Water jet, Cleaner recycling, Clean factory

1. Introduction

The washing process is a technology which removes cutting oil, metal chip and soil dust on the surface of mechanical part. It is typically an environmentally hazardous activity because of solvent vapor spread into air. Today, a great deal of effort has been devoted to developing alternative metal cleaning technologies in advanced countries and some processes are being commercialized among them.

There have been many studies about the use of water jet for cleaning of hard-to-remove materials. Experimental results have been the main source of knowledge on cleaning by water jet droplets [1]. With a useful knowledge obtained from the various experimental studies, there exist analytical investigations [2]. The dynamic modeling and simulation of cleaning and rinsing process of electroplating shop are studied [3].

In this paper, we are going to develop alternative part washing process using water solvable cleaners replacing organic chlorinated solvents. The equipment will transfer metal parts at a given rate through the cleaning, rinse, rust preventing and dry tunnel. It will be applied to a factory and it will be shown that part washing process became cleaner, faster and more comfortable compared to the previous process.

2. Design Washing Process

In a part washing process, metal parts pass through 4 types of process units like as cleaning tunnel, rinsing tunnel, rust preventing tunnel, and drying tunnel as shown in Fig. 1. There are loading and unloading system at the entrance and exit of washing tunnel, and conveyer passing through washing tunnels with metal pats.

Cleaning and rinsing are two key unit operations in achieving high plating quality in an electroplating shop. These two operational steps, however, are identified as major sources of waste, such as wastewater, spent solutions and sludge.

The rust preventing and drying are steps that should be added because water solvable cleaner is week at rust of metal.

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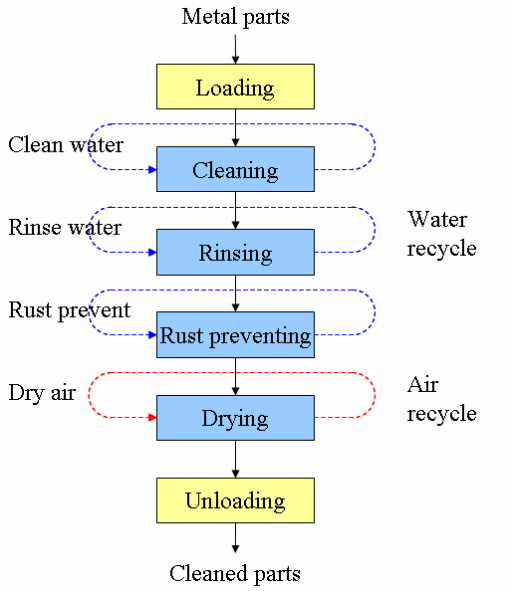

Fig. 1 Part washing process

2.1 Cleaning and Rinsing

In a cleaning tunnel, metal parts are cleaned, and the cutting oil, metal chip and soil dust on the surface is removed by applying to it certain type of energy, such as mechanical, chemical and thermal energy. A certain amount of the loose dirt on parts sinks to the bottom of the tanks as sludge.

The amount of dirt on parts is negatively proportional to a dirt removal rate with time variable. This rate is determined by the mechanical power like as the flow rate and the velocity of cleaning water, and the type of chemicals used and their concentration, and the type and amount of the dirt on parts. The process can be described by the fallowing first-order differential equation.

$$A_p \frac{dw_p(t)}{dt} = -r_p(t) \tag{1}$$

where,

A_p : total surface area of the part (m^2)

w_p : amount of dirt on part (g/m^2)

r_p : dirt removal rate in the cleaning tunnel (g/s)

After cleaning, the loose and remained dirt on part should be washed out in the rinsing step. The efficiency of the dirt removal is largely dependent on the cleanness of the rinse water, and the flow rate and velocity of rinse water, and the dirt of parts.

2.2 Rust preventing and Drying

The rust preventing step should be added because water solvable cleaner is week at rust of metal. The rust preventing mist is spread on the surface of metal parts.

The natural drying process results in water-dot on the surface of metal part which makes part look like dirty though it is not. The hot dry air blow system will increase drying speed and remove water-dot on the part surface.

2.3 Cleaner recycling

The used cleaning water drop down to water tank and recycled through paper filer, fiber filet and pump. The used cleaning water contains various pollutions, such as, cutting oil, metal chip and soil dust. The quantity of pollutants is related to the washing efficiency, water flow rate, the initial dirtiness of parts, and the cleanness of the cleaning water.

The metal chip and soil dust are removed by paper filter and fiber filer before they recycled. The cutting oil that can't be removed by filter is removed by oil collector witch used the density difference between oil and water.

2.4 Atomization

The temperature, flow rate and press of water that affects the dirt removal rate should be controlled. The temperature and flow rate of hot dry air also should be controlled. The moving speed of loading and unloading conveyer that affects the dirt removal rate also should be controlled. There need many kinds of sensor for effective washing and safety of equipment and worker. So, the temperature, pressure, water level, conveyer speed are automatically controlled by programmable lock circuit and micro computer. The atomized loading and unloading system will help worker free from heavy metal loading unloading process.

3. Developed Equipment

The part washing equipment is consisted by main frame, water pipe line and nozzle, conveyer, control system, dry air blow system. Fig. 2 shows designed part washing system and Fig. 3 shows fabricated part washing equipment.

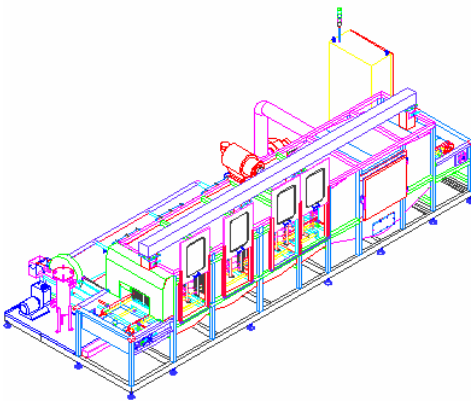

Fig. 2 Designed part washing system

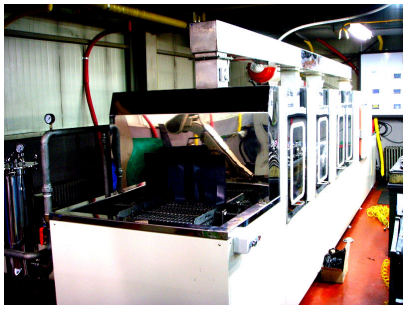

Fig. 3 Developed part washing equipment

4. Experimental Results

The developed part washing system is tested in a part machining factory. The metal parts that are fabricated by machining center and turning center include cutting oil, metal chip, and dust on the surface. During the washing process and after washing, we did three tests for to check of the equipment is developed well. The chemical mist explosion test, the noise test, and cleanness test of washed part are performed.

4.1 Chemical mist explosion

The chemical exposit test was done during washing process to check if there is chemical mist that is bad to the health of worker. This test was done for 7 hour and 15 min by the Hospital of Gyeongsang National University and it is improved that there is very small chemical mist explosion around the part washing system. The oil mist was 1.47 mg/m^3 which is smaller than allowable max value 5 mg/m^3. The other chemical elements were about 1/1000 of maximum allowable value or not detected.

Table 1 Chemical mist explosion value (mg/m^3)

Chemical mist	Measured value	Max allowance
Oil	1.47	7.5
Carbon	0.0024	1.1168
Toluene	0.1318	100
Butylacetate	0.1599	150

4.2 Noise

The sound of air gun that is used to remove cutting oil and metal chip of machined part is so larger that is bad to the hearing ability of workers. The washing system also use compressed air to remove cleaning water and rinse water before parts enter rust prevent and drying steps. To decrease the sound of compressed air, we covered the equipment by steel sheet and sound reducing texture. The sound test was done from for 7hour and 15 min by the Hospital of Gyeongsang National University. The sound at entrance was 76.5 dB and at exit was 81.7 dB which is less than allowable value 90 dB but need to be reduce more.

Table 2 Sounde measurement result (bB)

Position	Measured value	Max allowance
Entrance	76.5	90
Exit	81.7	90
Worker	80.6	100

4.3 Remained dust

The remained dust of gear part and case parts are measured at Koran Research Institute of Chemical Technology. The average remained dust of cases I is 1.3 mg and case II is 1.0 mg and

average remained dust of gears is 1.0 mg.. Fig. 4 is showing the remained dust of parts after washing.

Table 3 Remained particle after washing (mg)

Part name	Remained particle	Target
Case I	1.3	2.0
Case II	1.0	2.0
Gear	1.0	1.0

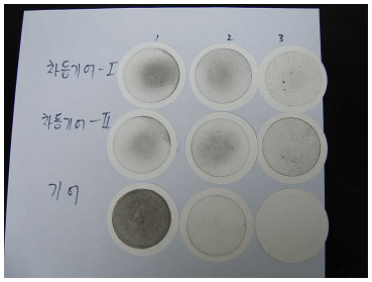

Fig. 4 Remained dust

5. Conclusions

The cleaning process is essential to remove many types of foreign elements, like oil, dirt, grease and metal chips resulted in producing machine parts. The parts washing process revealed several potential environmental, health and safety issues which it is not good for workers to perform their mission. In some manufacturing companies, the workers have been unfailingly hard-working all the time caused by the physically repetitive operations. These effort to remove the non-profitable working conditions, like hazardous fumes, high-noise, repetitive hard-working, of the workers in the plant enabled us to develop the automatic washer system.

In this paper, we developed alternative part washing process that use water solvable cleaners replacing organic chlorinated solvents. The equipment transfers metal parts at a given rate through the cleaning, rinse, rust preventing and dry tunnel. It was applied to a factory and it is shown that part washing process became cleaner, faster and more comfortable compared to the previous process. The installation of this automatic parts washer is expected to help to improving the working conditions of the employees in the plant.

The core technologies used to develop part washing system are as fallows. The control technology for the automatic cleaning enables various shaped-machine parts to be cleaned perfectly. The system minimizes the emissions of the air pollution substance, like dusts and mists produced by the operation throughout the emission control system. The recycle system enables used cleaners and rust preventive oils to be reused by using the effective refining technology.

The effects of developed part washing system are as fallows. The automatic system contributes to reduce the possible risk of working and eliminate the physical fatigue of workers. This contributes to improve the productivity of labor by non-stop washing process. The automatic washing system has a great influence on providing well-not equipped companies with the effective washing machine and designing new advanced washing machine in effort to reduce the cost of its development.

Knot ices

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