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KEY PARAMETERS IN LOOSE ABRASIVE MACHINING

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ABSTRACT

Loose abrasive machining is discussed in this paper. Key parameters of loose abrasive machining such as lapping and polishing are reviewed under systematic view of manufacturing system. Currently, such parameters considered as tacit knowledge. Different loose abrasive processes required diverse treatment for expected results. The obtained key parameters will be used to produce basic data and information structure to achieve a knowledge warehouse system in finishing processes.

Keywords loose abrasive machining; system; knowledge structure; key parameter

1 INTRODUCTION

Characteristic of manufacturing processes are dynamic, where states are constantly changing and decisions have to be made within a short time. It is often preferable to make a decision at the right moment rather than to seek the optimum decision without time limit. The better manufacturing companies have the available relevant data at the right time, the better decision they can reach. Computers are tools that can be employed to minimize the gap between the demands of time and decision. Computer systems can store and manipulate large quantity of data in a short period of time, hence the acceptance of computers by industries as data processing equipment.

Manufacturing deals with the conversion of raw materials into finished materials or products. A manufacturing operation can be viewed as a manufacturing system with inputs equal to the raw materials and with outputs equal to the finished materials or products. The types of processes that arise in manufacturing include casting, machining such as drilling, cutting, and grinding, materials handling using conveyors and robotic loaders/unloaders, casting, painting or plating, parts assembly, molding, brewing or cooking, blending or mixing, and waste management. Figure 1 illustrates the manufacturing system in general.

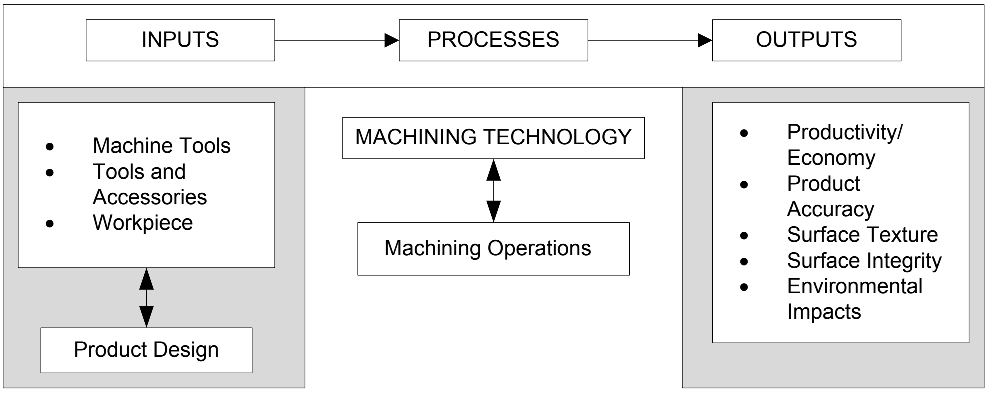

Figure 1: Input/output representation of a manufacturing system

A manufacturing system is specified in terms of a collection of stations (machines, processes, or work centres) that are required to produce the product. The equipment needed to manufacture the product comprises the machine or process level of manufacturing hierarchy.

2 OVERVIEW OF ABRASIVE MACHINING

Abrasive machining works by forcing abrasive particles, or grains, into the surface of workpieces so that each particle cuts away a small bit of material. Abrasive machining is similar to conventional machining, such as milling or turning, because each of the abrasive particles acts like a miniature cutting tool. Unlike conventional machining, the grains are much smaller than a cutting tool, and the geometry and orientation of individual grains are not well defined. Most abrasive cutting edges of abrasive machining are less power efficient and generates more heat.

Figure 2 classifies abrasive machining processes as a part of manufacturing processes and technology which include grinding, superfinishing, honing, lapping, polishing, etc. The common characteristic of these processes is that its main stock removal mechanism is the abrasive process. The processes are manufacturing techniques which employ very hard granular particles in machining, abrading, or polishing to modify the shape and surface texture of manufactured parts. While accuracy and surface texture requirements are common reasons for selecting abrasive processes, there is another common reason. Abrasive processes are the natural choice for machining and finishing hard materials and hardened surfaces. Abrasive processes are usually expensive, but capable of tighter tolerances and better surface finish than other manufacturing processes.

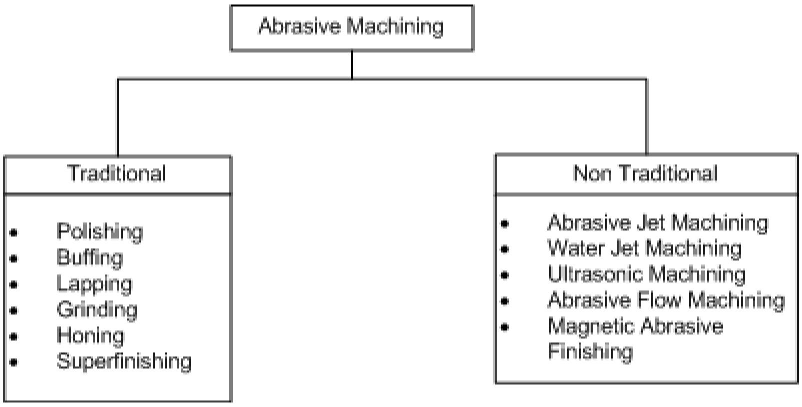

Figure 1: Classification of abrasive machining processes

Traditionally, manufacturing processes are conducted by operators in workshops or shop-floors. These operators worked based on their experiences after several years using particular machines. They are considered as experts in their jobs. The knowledge belong to these operators will be hard to be replaced even they transferred their knowledge to 'younger' operators. The operators that succeeded former operators will need to get acquainted with the process and the machine to gain better understanding and follow the best practices as demonstrated by their 'seniors'.

Best practices to produce expected final result from finishing processes will rely on deep understanding of the process itself. Several factors such as workpiece properties, tools properties, abrasives machining operation conditions are only a few of related variables that need to be concerned. Lapping and polishing have different stock removal mechanism from grinding or any other processes. Both of the processes are free abrasive processes. (Marinescu, Hitchiner, Uhlmann, Rowe, & Inasaki, 2007). Furthermore, most of the knowledge used in the study of lapping and polishing has been carried out from tribology. Currently, tribology is a means in studying wear, friction and lubrication of grinding process that is widely used in manufacturing.

Lapping and polishing are similar processes. Both processes generate very fine surface finishes, created high dimensional accuracy and flatness, and minimum subsurface damage. The techniques have been around for many years. Modern industries employ lapping and polishing to achieve high precision surfaces, such as semiconductor manufacturing, read or write heads, and hard disk preparation. In ceramic industries, lapping is a very important finishing technique. The processes mentioned have common intention in removing the material from workpieces and producing the desired part form and finish on brittle and ductile materials by randomly oriented abrasive and superabrasive particles.

Abrasive machining processes can be divided into two categories based on how the grains are applied to the workpiece (Kalpakjian & Schmid, 2003);

1. In bonded abrasive processes, the particles are held together within a matrix, and their combined shape determines the geometry of the finished workpiece. For example, in grinding the particles are bonded together in a wheel. As the grinding wheel is fed into the part, its shape is transferred

onto the workpiece. Common processes in bonded abrasive are; Grinding, Honing, Tape finishing, Buffing, and Abrasive sawing

2. In loose abrasive processes, there is no structure connecting the grains. They may be applied without lubrication as dry powder, or they may be mixed with a lubricant to form a slurry. Since the grains can move independently, they must be forced into the workpiece with another object like a polishing cloth or a lapping plate. Common processes in this category are; Polishing, Lapping, Abrasive Flow Machining (AFM), Water-jet cutting, and Abrasive blasting.

Abrasive processes also categorized into: (i) grinding, (ii) honing, (iii) lapping, (iv) polishing. Grinding and honing are processes which employ bonded or fixed abrasives within the abrasive tool, whereas lapping and polishing employ free abrasive particles, often suspended in a liquid or wax medium.
In abrasive machining, the main objectives are usually to minimize friction and wear of the abrasive while maximizing abrasive wear of the workpiece. Other objectives are concerned with the quality of the workpiece, including the achievement of a specified surface texture and avoidance of thermal damage.

3 KEY PARAMETERS IN LAPPING

Lapping is defined as a cutting process with loose abrasive grains dispersed in a paste, which is guided on the lapping tool with nondirectional paths. It is also known as a cutting process with geometrically undefined cutting edges.

According to the classification of surface to be generated, type of surface, kinematics of the cutting process, and tool shape (profile), lapping process can be divided into;

1. Surface lapping
2. Cylindrical lapping
3. Thread lapping
4. Roll lapping
5. Profile lapping
6. Ultrasonic-assisted lapping
7. Lapping-in
8. Vapor lapping
9. Dip lapping

With certain force and speed, abrasive particles, which are harder and crystalline tougher than workpiece materials, remove small chips from the workpiece. The pressure applied during operation may cause abrasive particles to crack. If the resistance of particle against breakage is too high, sharp

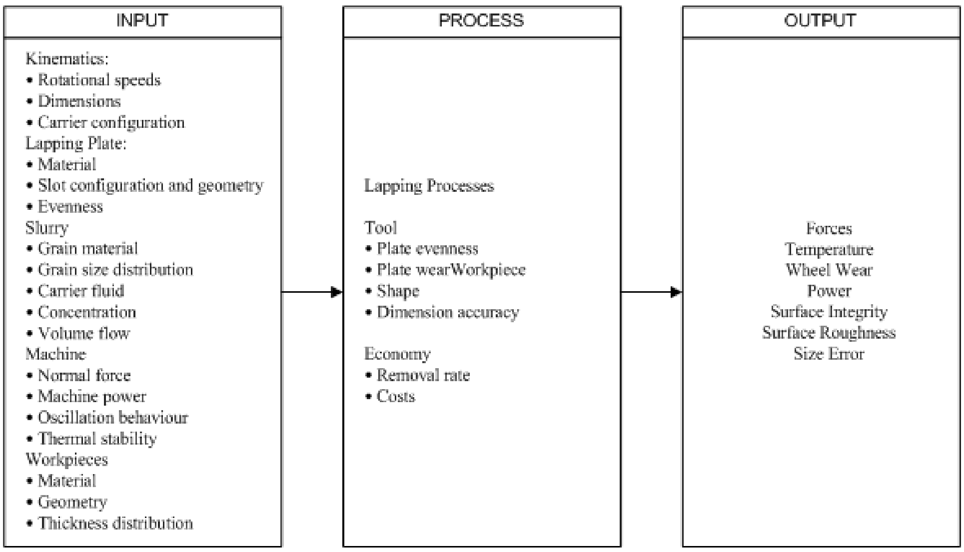

Figure 3: Key Parameter in Lapping

edges of the particle become dull and cutting operation becomes difficult. The strength of particles against breakage should be at a certain value so that the dull edge breaks and a new cutting edge can appear.

Abrasive size has also influence on surface roughness. The more abrasive particles accumulate in a unit volume, the better surface roughness can be obtained in lapping. Therefore, the number of abrasive particles is very important for better surface quality. The basic key parameter of lapping presented in figure 3 in the form of inputs, lapping processes and outputs produced.

4 KEY PARAMETERS IN POLISHING

Polishing is a lapping like process. It also uses free abrasives. Very fine surface finishes, high dimensional accuracy and flatness, and minimal subsurface damage are major results of a polishing process. The technique has been used for many years and, in a crude form, since the origin of humans. Many different industries achieve high precision surfaces with this technique. For example, polishing are very critical processes in semiconductor manufacturing, read or write heads, and hard disk preparation. The above-mentioned micromachining process is used for a common purpose: to remove material and obtain the desired part form and finish on brittle and ductile materials by randomly oriented abrasive and superabrasive particles. Polishing is free abrasive process that is categorically different from other micromachining processes such as honing, fine grinding, and superfinishing (Marinescu, et.al, 2007).

Like lapping, polishing employs free abrasive. In this case, pressure is applied on the abrasive through a conformable pad or soft cloth. This allows the abrasive to follow the contours of the workpiece surface and limits the penetration of individual grains into the surface. Polishing with a fine abrasive is a very gentle abrasive action between the grains and the workpiece, thus ensuring a very small scratch depth.

The main purpose of polishing is to modify the surface texture rather than the shape. Highly reflective mirror surfaces can be produced by polishing. Material is removed at a very low rate. Consequently, the geometry of the surface needs to be very close to the correct shape before polishing is commenced. Polishing is carried out without letting fine abrasive particles generate brittle fractures on the work surfaces, while removing these materials little by little only by means of plastic deformation, to finally produce a smooth mirror surface. For such polishing, fine abrasives of below 1 μm and pads of pitch, wax, synthetic resin, or artificial leather are used to realize smooth mirror finishing. Fine abrasive particles are retained on the pad surface resiliently and plastically, and the work surfaces are scratched microscopically. Polishing actions are by far smaller if compared with lapping, contributing to the successful applications to the brittle materials.

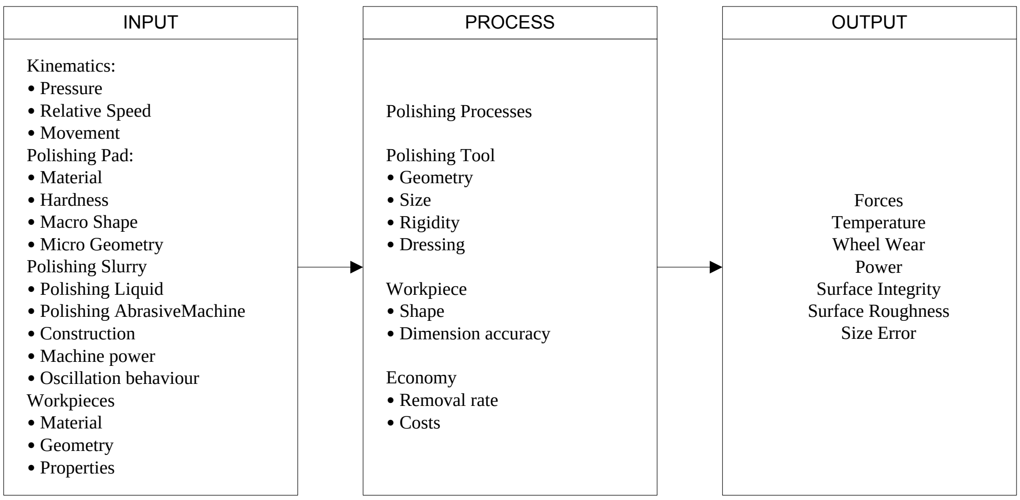

Figure 4: Key Parameters in Polishing

Aluminum oxide abrasives are widely used for polishing high-tensile-strength metals such as carbon and alloy steels, tough iron, and nonferrous alloys. Silicon carbide abrasives are recommended for hard, brittle substances such as grey iron, cemented carbide tools, and materials of low tensile strength such as brass, aluminum, and copper.
Because polishing is almost like lapping, figure 3 is adjusted to achieve basic Key Parameter of lapping as shown in figure 4.

5 CONCLUSIONS

Loose abrasive processes were discussed in this paper. It can be concluded that common inputs in abrasive machining are; kinematics, abrasive tools, slurry and coolant, machine properties, and workpiece properties. The process will be the designated abrasive processes namely lapping and polishing. Outputs of the system are forces, temperature, vibrations, surface properties, and size errors. Key parameters were suggested. The suggested parameters were separated into input – process – output schematic in order to follow the basic manufacturing systematic view. The mentioned parameters can also be addressed as key parameters in the knowledge management of loose abrasive machining.

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