

TECHNICALLY speaking

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Exploring Options and Alternatives for Material Removal and Surface Finishing

A useful method to aid finishers in evaluating the advantages and disadvantages of various systems.

Some time ago, I wrote an article for this publication called, “How to choose Mass Finishing Equipment for Surface Profile Improvement” (*MF*, Volume 101, No. 4, April 2003, pp 22–26). This can be considered Part II. The first article covered everything readers wanted and needed to know about how to select mass finishing equipment. However, it did not offer any alternative options, and there are no organizations that recognize or recommend systems for material removal or surface modifications. That option is left up the end user.

Now, even though I am an advocate of mass finishing systems, I think readers should be aware of alternatives, because time is money; equipment is money; and knowledge is money. So how much time and money do you want to save? Again, unless you know what you are looking for, how do you investigate your options and alternatives?

Also, before we proceed with alternatives, let us discuss options. Basically, anyone interested in surface finishing applications may be considering one of three types or options. Type 1 is to prepare a rough surface finish to accept a heavy thickness coating, such as paint. Type 2 is to prepare a relatively smooth and uniform surface finish to accept a thin coating, such as a plating of some kind. Type 3 is to produce the smoothest finish possible or a reflective finish with or without a protective coating. The option one chooses depends mostly on how the part is to

be used, or the environment in which it will be utilized. Once the surface finish requirement is determined, the method to achieve that surface preparation needs to be selected.

In mechanical finishing, the concept of energy and force uniformly applied to abrasive particles is an important factor both in surface finishing quality and the speed or rate of the material removal process. In addition to speed, one has to consider the factors of consistency and repeatability, and the economics that can be achieved using these forces. Other factors to consider are the limitations of the part size, shape, and quantity of parts, as well as the abrasive used and the finishing characteristics in relation to the equipment.

In all material removal systems, there is the factor of energy and resistance, and in the case of material removal, resistance of the part. How much material removal occurs—and what kind of surface profile is achieved—depends on how that energy or force is applied. In my book, *Understanding Deburring Polishing and Mass Finishing Systems*, I proposed a classification system based on a series of four digit sequences for all material removal systems. This is an unofficial system, similar to the old library Dewey Decimal system.

In mechanical systems, there are at least two elements or forms of energy that are used for material removal. As mentioned, energy is related to movement, speed, or velocity. Resistance is related to pressure, friction, compression, or contact. In

simple terms, you need to use one force to overcome another force. The greater the amount of energy or force directed to the part, the greater the material removal up to the point where resistance overcomes energy.

How energy or processing equipment uses energy is critical to a finishing system, and each system has its own unique characteristics. I have proposed a classification system based on six groups determined by the energy system application, of which five are processing or equipment systems.¹ The reason for the five vs. six classifications is that I have purposely called the first system a Type 0, also shown as 00, to indicate that this is designated for manual, hand-working tools where the energy or system is not of a consistent or constant force. Types 1, 2, and 3 are mechanical systems that use abrasives in the process. Type 4 systems are used primarily in the plating industry, and Type 5 systems use temperature to achieve material removal.

To make this presentation as short and simple as possible, a lot of technical data have been left out. The proposed numbering system is composed of two digits for the type of processing equipment, followed immediately by one digit for the amount of material removal and one digit to indicate how these systems work either the outside, inside dimensions, or both. Some equipment systems use more than one energy system, and that is the reason for the first two digits. The first number is the dominate characteristic of the energy system, followed by a second number or 0 for no other energy force. These groups are noted in Table 1.

<i>Equipment Classification (first two numerical digits)</i>	
Type 0	This system is for manual hand working of parts only. Energy is directed downward in a back and forward or circular pattern with an abrasive medium. The greater the force downward, the greater the abrasion.
Type 1	This system is used on relatively flat materials where the energy forces are directed down and parallel to the material being worked, via a wheel, disc, or belt. The results of action create a horizontal wiping action and the smoothing of surface features.
Type 2	This system is used primarily for surface preparation for heavy thickness coatings. This uses the abrasive blast method where the energy force is transmitted to a solid particle, which is directed perpendicular or downward at a slight angle to the work piece. The results of the action are a rough textured surface finish.
Type 3	This system is used in mass finishing—type equipment. This uses abrasive particles or preform shapes in a random combination or mixed-energy forces or patterns that occur in all directions relative to the part. The results produced are modified blended surfaces and uniformly worked parts.
Type 4	This system, used in the plating industry, is primarily an electrical current directed through a liquid medium-type energy force system. The results produced are both surface and sub-surface molecular changes to parts.
Type 5	This system is an air-based, high-temperature heat method. This is a very selective material removal system that works primarily on surface irregularities or burrs. The results of this process vaporize and melt thin surface protrusions.
<i>Burr Classification (third digit)</i>	
Class 0	Burrs or material irregularities do not exist, but surface modification is required.
Class 1	Burrs are sharp edges that can cut one's finger or cut wire or tubing over a period of time and/or vibration.
Class 2	Burrs are thin irregularities that can be removed from part with one's fingernail. Material thickness approximately 0 to 0.010.
Class 3	Burrs or material irregularities require greater pressure to remove than by the unaided hand alone. Material thickness approximately 0.010 to 0.020.
Class 4	Burrs or material irregularities require a lot of pressure and force on media and part. Material thickness over 0.020.
<i>Burr Location (fourth digit)</i>	
0 Location	For surface modification only.
1 Location	For easy-to-reach outside dimensions.
2 Location	For difficult-to-reach inside or internal dimensions.
3 Location	For all burrs, inside and out, and surface modifications.

Table 1: Classification System

<i>System</i>	<i>Range</i>	<i>Option</i>
Wheel and Belt Systems	1000–1051	3 - 2 - 1
Abrasive Blasting	2500–2503	1 - 2
Cryogenic Blasting	5200–5233	2
Wheel Blasting	2500–2501	1
Wet Blasting	4200–4233	2
Water Jet	4200–4211	2
Ultrasonic	4200–4211	2 - 3
Abrasive Extrusion	4200–4243	2 - 3
Thermal	5000–5303	2
Chemical	4000–4303	2 - 3 - 1
Mass Finishing Systems	3000–3501	2 - 3 - 1
Spindle/Drag Systems	3000–3501	3 - 2 - 1
Turbo-Abrasive	3000–3301	2 - 3 - 1
Orbital	3000–3301	3 - 2
Magnetic	3000–3201	3

Table 2: Most Common Material Removal Systems: Classification Chart for Surface Finishing Options

System	Equipment					Burr Class						Location			
	1	2	3	4	5	0	1	2	3	4	5	0	1	2	3
Wheel and Belt	G					VG	G	G	G	G	G	VG	G	P	
Abrasive Blasting*		G				VG	G	S	P	P		VG	G	P	S
Cryogenic Blasting		G			G	S	G	S	P			S	G	P	S
Wheel Blasting		G				VG	VG	G	S	S	S	S	G	P	
Wet Blasting		G		G		VG	G	S	S	P		G	G	S	G
Water Jet		G		G		G	G	S	S	P		G	G	P	
Ultrasonic		G		S		VG	G	S	P			G	G		
Abrasive Extrusion		P		G		S	G	G	G	G	S	S	G	VG	G
Thermal					G	S	G	G	S	S		S	G	G	G
Chemical				G		G	G	S	P	P		G	G	G	G
Mass Finishing			VG			G	VG	VG	G	S	S	G	VG	S	S
Spindle			VG			G	G	G	G	G	G	G	G	P	
Turbo-Abrasive			VG			G	G	G	G	S	S	G	G	P	
Orbital			G			G	G	G	S	S		G	G	S	S
Magnetic		G		G		G	S					G			

Explanation of letter symbols: VG = very good; G = good; S = some; P = poor; blank = not recommended for application or classification.
 * Rating based upon material removal, not surface finish.

Table 3: Equipment Classification Evaluation by Category

Classification of Part Sizes		
Letter	Measurement	Description
A	1/2" or smaller parts	Can't be seen in closed hand
B	1/2" up to 12" length	Can be held in one hand
C	weight	Need 2 hands, or over 2 lbs.
D	weight	Need material handling assistance

Equipment Classification Evaluation by Part Size				
System	A	B	C	D
Wheel and Belt	S	VG	G	
Abrasive Blasting	S	VG	G	G
Cryogenic Blasting	G	G	P	
Wheel Blasting		S	VG	VG
Wet Blasting	S	VG	S	
Water Jet	S	G	G	
Ultrasonic	S	G		
Abrasive Extrusion	S	G	G	S
Thermal	G	G	S	
Chemical	G	G	S	
Mass Finishing	VG	VG	G	G
Spindle		G	G	
Turbo-Abrasive		G	S	
Orbital	VG	G	S	
Magnetic	VG	S		

Explanation of letter symbols: VG = very good; G = good; S = some; P = poor; blank = not recommended for application.

Table 4: Equipment Classification by Part Size

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Based upon the classification system listed in Table 1, I have created a revised chart for the major material removal systems. They are listed in Table 2.

Now, based upon the information in Table 2 and overall knowledge of the systems noted therein, the chart in Table 3 has been created to give you an overall view of the advantages and disadvantages of the major machine systems in relation to material removal, the amount of material being removed, and its location. The numbers in this chart show the priority for what location is worked best. It should be also mentioned that as the surface of a part gets smoother, the more difficult it is to remove or improve the surface profile of the material/part being worked.

As previously noted here and in other numerous articles, part size plays an important factor in equip-

ment system selection and the material removal process. Therefore, the set of guidelines listed in Table 4 have been used to compose the equipment classification chart that is also shown in this table.

Energy can be transferred through solids, liquids, or air. The greater the weight or mass, the greater the amount of energy transfer and the greater the amount of surface modification that can be accomplished in the shortest period of time. The more rigid the transfer media or device, the greater the energy transfer. Liquid and air transfer systems can transfer energy into small locations and are less aggressive on material surfaces.

All mechanical abrasive systems are energy transfer devices designed to increase the speed and pressure of an abrasive media. How these energy forces are applied is also important. Linear, straight-line energy differs from rotational energy systems, and fixed rigid parts behave differently from free-floating parts.

All systems have advantages and disadvantages. That is the reason why there are so many different energy transfer systems. However, hopefully you will now have a better idea of your options and alternative methods for producing the results you are looking for.

BIO

Anthony F. Kenton is the president, owner, designer, and chief engineer for his small company, Nova Finishing Systems, Inc., Huntingdon, Pa., a company he started in 1988 with a friend. Today, at 67, he keeps busy with the day-to-day operations of the company, R & D, and developing new products. Besides his technical articles, he has written two books, has one patent, is involved with metaphysics, and maintains a curious mind. He says he likes to keep moving, because a moving target is harder to hit. He can be reached via e-mail at novafinish@earthlink.net.

NOTE

1. This system was first presented at the 2000 AESF conference in Chicago.

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