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Machine Profiling—A Guide

UNTIL A DECADE or so ago, the term "profile" was commonly used in reference to angles, channels and other formed sections. That's changed now! My know-it-all friend Google now informs me that the average internet user has created at least five "profiles" on social media. A profile presents a detailed and sometimes vivid description of oneself! What if we take this concept and apply it to our ever-evolving machines in the blast cleaning and shot peening world? Why, you may ask? Your machine was purchased for a specific application, but this will likely change over its life. Creating a machine profile will help us better understand its capabilities and, more importantly, its limitations. If your curious mind is questioning the legitimacy of this term in our industry, you're probably justified. It doesn't exist in a formal capacity, though one does come across highly organized users of equipment making attempts at creating a profile.

This discussion is an endeavor to do just that!

Defining the Machine Profile

Let's discuss some basics of the application, process and machine design in order to define a machine's profile. To keep our discussion in general terms, we will include blast cleaning and shot peening equipment, both with air- and wheel-type media propulsion systems.

The Application: The broad processes we commonly encounter in surface treatment (and pre-treatment) are blast cleaning and shot peening. In addition, processes such as descaling, grit blasting, etching and de-burring form minor variants of the main two processes. Therefore, the first classification could be in terms of its primary application from the above list.

Media Propulsion System: A vast majority of machines for the above applications utilize air- or wheel-type media propulsion systems. Wet blast systems need to be acknowledged, but since they aren't as widely used, we won't go into their specifics. Let's conclude that your system is either dry, in which case it's either a (centrifugal) wheelblast or airblast system, or it's a wet blast system.

Why is this important? Wheel or airblast systems are initially chosen based on the application they were meant to handle. Therefore, it's not always possible for a machine, wheel or air, to be adapted to a new application.

Pressure blast nozzles mounted on a robotic arm provide travel path flexibility

Airblast systems could further be segmented into suction- or pressure-style propulsion systems. Wheelblast systems, on the other hand, are almost always centrifugal systems driven by an electric motor. One could drill down further into wheel size, motor horsepower (HP), etc. (More on HP later.)

Why is this important? Suction systems are commonly used for applications that don't involve tenacious cleaning or high-intensity peening. Suction systems are also restricted in the size of steel abrasive they can propel. Therefore, the interchange between suction and pressure blast is not straightforward.

Machine Design: The main aspects when developing your machine profile include the type of media reclaim, work handling, blast delivery system (including robots, nozzle manipulators, etc.) and controls. Several other aspects of a machine could be used to enhance our profile, such as cabinet material, lining, and sound insulation. However, let us focus only on those that will help us analyze the machine's ability to adapt for a change in its application in the future.

Type of Media Reclaim

The two main types of media reclaim are Vacuum and Mechanical. The choice depends on the type and quantity of media being conveyed and reclaimed. Wheel blast machines flow a significantly greater volume (as high as 10 times per wheel, depending on the wheel HP) of abrasive than airblast nozzles. Moreover, wheels almost always only propel ferrous abrasive. Therefore, given the higher flow rate and specific weight (steel shot = 280 lb./cu. ft. and glass bead/aluminum oxide between 100-125 lb./cu. ft.), mechanical style reclaim systems are more effective to convey blast media in wheelblast machines. Further, the size (capacity) of such reclaim systems are based on the total amount of abrasive propelled, since wheelblast machines could have a single or multiple wheels blasting simultaneously based on the work being processed and speed of operation. All wheelblast manufacturers designate different capacities of a mechanical reclaim system with their specific nomenclature. For example, a wheelblast machine with four (4) 16" diameter wheels driven by 40 HP motors might generate a total abrasive flow of over 2,500 lb. per minute. In order to convey this amount of abrasive, you might need a 12" diameter lower reclaim screw and a bucket elevator with a specific bucket capacity and casing size to elevate the abrasive. The profile of a machine with such a reclaim system will incorporate all these values.

Why is this important? If this machine, built with a reclaim system, is now tasked with a different part style that requires additional wheels, it may not work. If faced with a higher media flow, it will overload the system and likely trip the drive motors. On the other hand, if the media flow is significantly lower than the design value, it creates issues with the efficiency of the airwash separator when cleaning dust and fines from the abrasive stream. This is because the airwash separator relies on a full curtain of abrasive for efficient cleaning.

If your machine is now going to be used for a shot peening application, your media reclaim system may need to incorporate a vibratory size classifier in the mix.

Vacuum reclaim systems are in most airblast systems. They convey non-ferrous abrasives including glass bead, ceramic, aluminum oxide, and ferrous abrasives (typically small sizes and low flow rates). Vacuum reclaim systems are rated on their total volumetric conveying capacity (determined by the type and amount of abrasive). The main elements of a vacuum reclaim system are the media reclaim hose (different diameters and material), reclaimer or cyclone, and the exhaust fan that provides the suction power to move the abrasive through. Please note that an increase in volumetric capacity could affect the ability of the dust collector and exhaust fan to handle the new air volume.

Your airblast machine profile will need to specify these details in order to paint the complete picture.

Why is this important? Just like in our earlier discussion, if the total media flow rate or type changes due to the arrival of a new application, this may impact the reclaim system design thereby rendering the existing system ineffective. Your new application may require a larger size reclaimer and possibly a new dust collector with an increased capacity exhaust fan and motor. If, on the other hand, your machine is required to tackle a peening application from an earlier cleaning job, you'll need to introduce media classification as part of the reclaim system.

In our exercise to develop our machine profile, we have defined the broad classification of wheel or air, the type of media reclaim system, mechanical and vacuum, and recognized the specifics of both. Let's continue our exercise to another important classification—work handling.

Work Handling

From an equipment manufacturer's perspective, work handling arrangements are part and process dependent. A long part will necessitate a roller or belt conveyor whereas a rotary part will require a turntable. It's process dependent because a customer's plant layout might make it more practical to interface with a blast machine conveyor than, for example, an overhead monorail standard to a blast machine manufacturer. Customers operating at a smaller scale might adapt their layout to standard work handling arrangements offered by the equipment manufacturers.

The classic example is the ubiquitous tumblast- and table-style wheelblast machines. These "workhorses" in the blast cleaning and shot peening machine world are always purchased in their standard format and customer parts are "brought" to these machines rather than adapting them to existing plant layouts.

To enhance our developing profile, work handling arrangements could be segmented into rotary tables, roller and belt conveyors, overhead conveyors and derivatives of the same. The tables could be further segmented into a single rotary table turning continuously, with indexing motion or even interpolating, to present specific areas of the part to the nozzles or blast wheels. Main tables are classified simply by their diameter, and if available, by the number of satellite stations on top. Rotary tables could be fixed inside the blast cabinet, mounted on a swing arm or travel in and out of the cabinet on a work car, adding to further classification in your profile.

Inline conveyor systems are either roller- or belt-style with the former being more popular than the latter. Roller-style systems offer the benefit of processing the parts from the top and bottom surfaces simultaneously, accessing the lower portion of the part through the gap between consecutive rollers. The roller drives could move the part continuously (at variable speeds) or in an intermittent motion.

Several other custom handling arrangements are also possible. However, it is impractical to incorporate all of them in our discussion here.

Why is this important? Since part styles dictate the handling arrangement, any change in that will directly affect the process. Consider this example. Your roller-style system is now required to handle new work, still along its length but with a shorter part length. The new length may not satisfy the requirement of resting on a minimum of three rollers for stability. Tables are usually very flexible, and as long as the work physically fits within the cabinet walls, the existing table could be adapted to different part styles.

Blast Delivery Systems

Blast delivery systems in a wheel machine are dependent on one component—the blast wheel. Most wheel blast machines incorporate a fixed wheel with the exception of an oscillating wheel pod or panel in special cases. The blast wheel is categorized by its size, connected drive motor HP, rotational speed in RPM and quantity in the machine. Wheels could also be direct or belt driven. For example, a 25EZ155 would denote a Wheelabrator 15.5" diameter wheel with 2.5" wide blades and belong to the popular EZEFIT family. In broad terms, it's common for users in the wheelblast world to refer to their machines by the number of wheels.

Why is this important? This definition is important because it determines the part style and size that can be processed in this machine. Further, the wheel power (HP) determines the abrasive flow rate and the speed at which a part can be cleaned or peened. In case of peening applications, the wheel speed and diameter determine the abrasive velocity and thereby the intensity. The former can be varied using an inverter, but the latter is usually fixed. Abrasive velocity has a direct impact on the intensity value, and is important to assess before committing the machine for a specific peening project.

The blast delivery system in an airblast system is a bit more involved. It's comprised of the blast nozzles and hoses—size, material and type, blast tank (pressure blast systems) capacity, quantity of outlets, nozzle holding arrangements, including nozzle manipulators, robots, or even manual systems. The blast nozzle is addressed by the size of its bore. As a common practice, the blast hose is about three times the length of the nozzle bore. Nozzle types could be straight bore or venturi- style. Some machines utilize nozzle lances when accessing bores, holes and slots, providing another differentiation to the family of nozzles.

Blast tanks are categorized on tank volumetric capacity (cubic feet), quantity of outlets (single or as many as 8 or 12) and intermittent duty (single chamber), or continuous duty (twin chamber). Some manufacturers have alternate blast tank designs that allow for one tank per nozzle in an attempt to maintain a higher degree of media delivery precision. This results in an airblast system carrying a description such as four (4) nozzle system with a 6.5 CFT single chamber blast tank with four (4) outlets.

The nozzle handling arrangements for an airblast machine create additional differentiation in our machine profile. Nozzle carriages are used for applications with relatively defined travel paths. Such carriages or manipulators are defined by their degrees of motion such as single axis, up to five axis of motion. Further, their definition is strengthened by the travel range of the individual axes, such as 18" stroke, 300-degree swing, etc. Robots have brought increased flexibility to our industry. With a standard six-axis robot, the machine capability is only limited by the programmer's imagination (and, of course, the physical size). Machines incorporate multiple robots to not only manipulate nozzles but also to position and present parts to fixed nozzles.

The profile of a shot peening machine, in addition to the basic features above, may also include closed-loop flow control valves and PID loops for blast tank pressure.

The final link in your machine profile is its control system. Most machines now have programmable features and their basic functions are coordinated through a PLC with a graphic HMI for operator control. Shot peening systems carry a more sophisticated version of controls with CNC for motion control of nozzles and computer controls for other features. These elements define the controls, with emphasis on the make of the PLC, CNC and servo drives.

Your machine profile is now complete to a degree that will help define its capabilities to a person familiar with this type of equipment.

Machine Profiles and Conversions

We started this discussion not only to define the machine profile, but also to understand its limitations when handling a part or application it wasn't originally designed for. However, our technical minds don't like to be limited by anything, and the innate response is to find a way to work around it. Let's find out if that is possible.

We have spent time discussing some of the possible issues in the "why is this important" sections. Let us now review the costs associated with a blast machine. Costs in a new machine are broken down into the following: Engineering (12-15%), material (25-30%), labor (25-30%) and the remainder in overheads, profits, etc. A simple modification requiring no new materials or structural modification does seem probable and even practical. Given the investment in labor and material, changes requiring either may not be that practical. You might even agree that learning the machine's limitation is as important as understanding its features! So, what are some of those conversions/modifications that might make sense. Below is a partial list:

- Addition of a new nozzle (if an extra outlet is available in the blast tank) and maintaining the total media flow by reducing media flow rate from the individual nozzles. Adding more suction guns is relatively easier since there is no blast tank in a suction system.
- Addition of a classifier in the media reclaim system and flow control valves at the blast tank outlet.
- Adding a nozzle carriage to an existing machine with fixed nozzles (as long as sufficient space is available inside the cabinet). Inclusion of a robot may not be as simple since cabinets are seldom designed with additional room to accommodate a robot as an afterthought and if located outside the cabinet, it will require extensive cabinet modifications for it to be able to reach inside the cabinet.
- Wheelblast machines can be adapted to different part styles as long as the physical size and orientation permit the same. Needless to mention, media type and size must be the same in order for this to be a successful conversion.

Theoretically, conversions do look good on paper. However, most customers considering conversions in our industry almost always find the cost of a new system to be not much more and opt for the latter.

OEMs can take advantage of a fully developed machine profile when deciding how to best add a new feature to a successful machine design. The following profile of an Empire machine demonstrates this.

Machine Profile of the Empire TT36-S

The TT-36 is an Indexing Turntable Machine with multiple satellites on top. This original design allows for fixed nozzles or those mounted on manipulators. Let's start developing the profile for this machine in a format discussed earlier.

Machine Model: TT36-S (S for Suction)
(The standard Empire TT-36P would denote Pressure blast)

Media Propulsion: Suction

Blast Delivery: Number of nozzles: Six (3/8" diameter with 3/16" diameter airjet)

Work Handling: Main table diameter: 36"

Satellite stations: 5/8" diameter x ¾" long keyed shaft, quantity: six (6), upgradable to twelve (12)

Nozzle manipulator (in a standard TT-36): single axis, stroke length: adjustable from 2 to 12", variable speed: 0.1 to 1.0 IPS

Maximum work envelope: 12" diameter x 18" high x 20 lb

Media reclaim system: 1200 CFM capacity, Ultrawear lined

Ventilation and dust collection: 1200 CFM cartridge

Controls: Allen Bradley Micrologix 1000 PLC with PanelView 300 HMI

The profile was used to develop an upgrade for this machine, allowing it to process more complicated profiles with added flexibility. The newly developed machine was designated TT36-SR—utilizing a robot instead of the conventional nozzle carriage.

The new machine profile matched the above with the inclusion of a Fanuc LR Mate 200i robot mounted outside and penetrating the cabinet from one of the sides. Another modification to the original design was to add a vibratory classifier to address the requirements of a peening application.

As discussed earlier, would the standard TT-36 render itself to an easy conversion to the robotic version? Given the space required to accommodate a robot, and to take advantage of its reach capabilities, the cabinet had to go through a slight expansion.

Summary

Part styles are constantly changing. The likelihood of utilizing a machine for a single part style is very low. Developing a machine profile helps you establish your baseline and define capabilities. It will help you market your services when spare machine time is available. Whether your machine functions in a job shop environment or large plant alongside other machines dedicated to specific parts, developing a profile will only help organize your cleaning or shot peening set-up.

The TT-36S with robotics has increased nozzle travel flexibility