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TITLE: SURFACE FINISHING AND SURFACE CONDITION PRIOR TO COATING

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SURFACE FINISHING AND SURFACE CONDITION

PRIOR TO COATING

The surface of any parts that are to be coated or finished to a certain specification has need for several processes. These processes control the cleanliness and the anchor pattern which controls the adhesion as well as the surface finish after coating.

The methods for producing the various finishes required are performed by various machines and media. Other variables such as time, intensity and proper tooling also effect the finish of the parts involved.

There are certain criteria involving the selection of the finish as it applies to the specific coating for various parts.

INTRODUCTION

The finishing process is the controlling factor.

-- Variables available to produce the desired result

-- Manufacturer's specifications are a consideration

-- Type of equipment available to perform the job

We need to consider the proper surface as it relates to the product, whether it is a protective coating or a cosmetic effect.

Mass finishing versus automated equipment for individual parts.

1. Cost per piece part is a consideration, however, when the quality and integrity of the coating is considered along with the cost of the coating, quality is the main consideration.

2. Attention to the entire operation from the raw part, machining, surface conditioning, coating materials, the coating operation, to the finished product. We also need to consider the percentage of scrap and/or rejects as well as rework to produce acceptable parts.

Surface finishing and surface conditioning on many products, specifically those in the aircraft engine manufacturing and overhaul field, cover many facets. Since I have been most closely associated with aircraft engine manufacturing and overhaul I will confine my paper to this area.

Unlike most other fields, cosmetic finishes are not of a prime consideration, but the performance of the coating and the surface after coating very definitely are considerations. These are some of the areas we will pursue.

Several things should be considered in the selection and use of finishing equipment for surface conditioning and surface preparation of parts. Let's cover them as a group and then discuss them on an individual basis. They are as follows:

1. Manufacturer's specifications
2. Type of coating or finish on the final product
3. Type of coating dictates the type of finishing equipment
4. Types of equipment and media available to produce the desired results
5. The end result is a combination of techniques and various special processes.

Let's continue and discuss briefly:

Item 1 - Manufacturer's Specifications

In the application of an organic or inorganic coating, plasma spray plating or diffused coatings, the manufacturer of the component involved has certain specifications that are required which affect the final finish and performance of the end product. Because of the critical nature of the component part, the integrity of the coating, the finish, and the performance demanded, all manufacturers give us specific instructions on the type of finish prior to and after coating.

Item 2 - Type of Coating or Finish on the Final Product, the Various Coatings and the Requirements for Each

Coating #1 that requires special consideration is Sermetel W, a registered trademark of Sermetel Incorporated of Limerick, PA. This coating, because of the final surface finish, requires a clean surface and an anchor pattern for adherence of the coating, but should still be smooth enough to give the required R.M.S. finish after coating. The coating is applied in two separate coats with a dry cycle and bake cycle between each coat. Prior to the application of the initial coat, the part requires grit blasting (automated preferred) and glove handling. This insures the proper cleanliness, an anchor pattern that will give maximum bond, and also result in an acceptable final finish.

The R.M.S. finish on the finished part is critical and is in the range of 17 to 25 R.M.S. This finish improves engine performance and conserves fuel because of improved flow through the gas path areas.

Coating #2 is plasma coating. Most recently adopted is a heat dissipating, ceramic coating marketed under the name of Magnesium-Zirconate on hot section components of jet engines. The finish prior to application is critical since this coating requires a clean surface, an anchor pattern for the base coat, and the two subsequent coats that have to be applied in a specified time frame to achieve the thickness and integrity of the heat dissipating coating.

Proper application and thickness is necessary in order to insure the proper bonding of the coating to withstand temperatures in the range of 1900° to 2000°F. Temperatures higher than this have been experienced on occasions where overtemp has occurred. Grit blasting, using aluminum 180-220 mesh, produces a 30 R.M.S. finish. Where possible the blasting is done in an automatic blast system. This will give the proper anchor pattern and coverage and does not remove an appreciable amount of parent metal. This particular treatment, with the use of the ceramic plasma coating, has increased service life of combustion area components up to three to four times the normal life of the base metal which is Hastelloy X (AMS5536) and HS188 (AMS5608).

Coating #3 - the removal and re-application of certain alumini diffusion type coatings for turbine blades in many engine types requires a grit blast and acid soak for the removal of the original coating. After inspection, repair as necessary. The re-application of new coatings provides protection against corrosion and pitting by sulfidation, as well as heat protection, which is important because of the elevated temperatures within the turbine section of the engine.

The coating is removed by blasting, using aluminum oxide 150-220 mesh and acid strip, which requires a minimum removal of the parent metal with no IGA (intergranular attack) of the parent metal. Once the original coating is removed and the part inspected and repaired, vibratory finishing of the part is required to improve the finish. The surface is then blasted with wet novaculite blasting media using 1200 mesh to ensure 25 to 30 R.M.S. finish so the diffusion process will ultimately result in a surface finish of 20 to 25 R.M.S. on the finished turbine blade. This is critical since the gas flow effects engine efficiency and fuel consumption in a direct relationship to the surface roughness of the part.

The diffusion coating process is one of the more critical processes because of the structure of the coating in relation to the parent metal and the extreme care required in surface preparation of the part prior to the diffusion process. It is also very important that the composition of the coating powders and the time and temperature cycles be rigidly adhered to in order to insure the quality and integrity of the finished coating. The coating deposition and thickness, as well as surface roughness, constitutes many exacting processes before the desired finish is obtained.

The aircraft engine field has many peculiar requirements and the surface finish and protective coating are of prime importance for protecting the integrity of the part from extreme stress and heat levels, adding extra life to component parts. Decorative finishes are not of prime importance.

Item 3 - Type of Coating Dictates the Type of Finishing Equipment

We have seen the need for blasting equipment, both automated equipment properly tooled, and also vibratory equipment which is necessary to produce the required finish. By using the specified media and compounds, we can obtain the correct finish prior to coating. Numerous variations of abrasive media and equipment are necessary to obtain the proper finish for many parts of various requirements. The proper solution and combination of machines and media can return the surface of the part to the original specifications. It also insures the proper bonding as well as giving us the proper R.M.S. surface after coating.

Item 4 - Types of Equipment and Media Available to Produce the Desired Result

There are various sizes and types of vibratory equipment and media for mass finishing, fixturing of work pieces and flow through types of machines to meet every need. Blast cleaning and finishing, utilizing both suction and pressure types along with various size blast media, can produce a wide variety of surfaces. These machines are available on the market in automated and manual types, which can be adapted with proper tooling to cover almost any type of finish requirement. In order to select the best system for the finishing problems let us review the systems available and the advantages and disadvantages.

Let us consider vibratory finishing equipment and the media. Vibratory finishing is a versatile process that is widely used for deburring, radiusing, descaling, burnishing, cleaning, brightening, and fine finishing. It is the most common of four major mass finishing techniques, the others being barrel, spindle and centrifugal finishing.

A. The Basic Principle

In vibratory finishing, energy in the form of vibratory forces is transferred by the machine's drive system into a mass of loose media and then into the parts. The entire load is in motion at the same time so that the media acts against the parts throughout the complete mass.

B. Tub-Type Vibrators

A tub-type machine has a rectangular tub with a U-shaped cross section and flat parallel ends. Vibratory motion is created either by a vibratory motor attached to the tub bottom, or by one or two shafts mounted eccentrically and driven by a motor. The tub-type vibrator generally provides a more aggressive scrubbing action than its round-bowl counterpart.

C. Round-Bowl Machines

Round-bowl, or toroidal, machines have a doughnut shaped chamber positioned horizontally. The chamber has either a flat bottom or a spiral bottom similar to that of a lock washer. Action in the finishing chamber is controlled with an eccentric weight system mounted vertically in a center tube. The amount of weight placed on the top and bottom eccentrics, the angular displacement between the two, and the rotational speed are the variables controlling the action. Parts and media flow in a toroidal pattern around the bowl.

D. Media and Compounds

Finishing media performs the work on the surface of parts being processed. Abrasive and non-abrasive types are included in both natural and synthetic forms. Natural media has a crystalline structure which limits cutting rate. Thus, synthetic media is manufactured to control the cutting rate in a given finishing operation.

The size and shape of the media are important considerations and many variations are available. The shapes include cones, angle-cut cylinders, and random nuggets. Others available include triangles, stars, spheres, diamonds, pyramids and arrowheads.

Media must be of proper type and size to reach all surfaces to be finished without wedging into the parts. Random shapes are sometimes recommended for parts where there is no chance of wedging or lodging. Media should either be small enough to flow through holes and slots, or big enough to remain outside these areas.

One of the main factors relative to media is the media-to-parts ratio, by volume. High ratios reduce the chance for impingement. The media must surround the parts and keep them well mixed in the mass. Media that is too large increases the chances for impingement.

Average media-to-parts ratios are in the 3:1 to 4:1 area. This gives good coverage of the parts with minimum impingement. Greater ratios are generally used for decorative finishes or extremely heavy parts. Media-to-parts ratios for typical vibratory finishing operations are listed in the accompanying table.

Let's consider the variables. In blast cleaning and finishing equipment several combinations are available.

A. Wet (slurry) Versus Dry Systems

The wet system was developed primarily for use with very fine cleaning media. It was used on precision parts, where minimum metal removal or no metal removal was required. The media was mixed with water and this mixture was conveyed by air to a nozzle and blasted against the work piece to be cleaned or peened. The water was intended for use as a conveying agent only, but it acted as a cushion, thereby reducing the abrasive velocity and minimizing any eroding action by the fine abrasive.

There are several inherent problems with wet honer:

1. From a work piece standpoint, the introduction of water will set up almost immediate oxidation. This can cause serious problems in subsequent finish operations, i.e. plating, coatings, etc.

2. Should the work piece have cavities or holes, the wet media has a tendency to pack into these crevices causing a removal problem. In some instances it is virtually impossible to clean work pieces with deep cavities.

3. Due to the cushioning effect of the water, cleaning rates are slow. Additional rinsing operations, drying to eliminate water spotting, additives or wetting agents, anti-bacteria, and corrosive inhibitors are also problems.

From the operator's standpoint there are many problems:

1. Poor vision due to a constant stream of water over the viewing window contributes to operator fatigue. This also dilutes the slurry mixture and increases production cost.

2. The operator's clothes and feet are always wet causing health problems ranging from colds to athlete's foot.

3. Breathing wet air constantly can have an affect on the operator's lungs.

Maintenance on a slurry system is an added problem:

1. Installation is costly due to having to plumb water to and from the machine.

2. Arrangements must also be made to flush the residue out of the machine for disposal and to meet EPA requirements.

3. Corrosion is a constant problem as internal piping, valves, filters, pumps are high replacement and maintenance items. Also seals must be replaced with regularity.

Media consumption is high due to the inability of the system to salvage good material from debris. As contaminants from the work pieces being cleaned fall into the slurry, along with the broken media, the mixture becomes diluted and new media material must be added several times daily in order to maintain a high percentage of usable media.

A dry suction or pressure system has the same advantages as a wet system in that we are able to use fine media to clean delicate precision parts without dimensional changes. This is done by controlling the blast pressure. With the same systems we can clean small, delicate parts at low pressures or clean hard mill scale using a higher pressure. The advantages of a dry system are as follows. All parts are cleaned with none of the problems caused by water residue. Deep holes and cavities can be cleaned without compacting the media. Visibility within the cabinet is excellent. The operator has less fatigue and his clothes remain clean and dry. Maintenance is kept to a minimum. Corrosion is non-existent. Installation cost is kept to a minimum since there is no need for water connections, plumbing or drains. Only electricity and an air supply is required. The cyclone air wash dispersing tube type separator removes fine, broken down and undersize media so as to retain a constant anchor pattern, faster cleaning rate and more economical operation.

In short, the dry blast system has greater versatility than the wet slurry with reduced operating, maintenance and installation costs. Better visibility and control of R.M.S. Micro-Inch can be met.

Wet slurry equipment is usually specified because the specifications were written many years ago before dry systems were developed which were capable of metering media under controlled blast pressures to perform the functions mentioned.

Air consumption for wet (slurry) systems is about the same as suction systems with somewhat less efficiency than that of a suction system.

Air consumption of dry pressure and dry suction systems will be discussed in the next section along with the differences and advantages.

B. Direct Pressure Versus Suction Dry Honing

As a starting place for comparison, let us assume that several variables will remain the same. For this purpose, let us assume that the in-plant air supply is maintained at 90 PSI and that all "blast" pressures refer to actual nozzle pressure. Glass beads, size 100 mesh, is the comparison abrasive. We will go through the key mechanism of each system one point at a time.

In both the suction and pressure systems the dust separator system is identical. All abrasive is returned from the cabinet hoppers by vacuum into an air wash cyclone separator. The media and contaminants flow through a gentle air stream which removes broken media and small contaminants. The dust is then carried into enclosed, sealed dust bags and the clean air is exhausted into the atmosphere. This system meets O.S.H.A. specifications. The cleaned media then falls past a permanent magnet which removes the ferrous material from the glass beads. The dust free and ferrous free beads then fall through a vibrating screen which traps all oversized debris. All cleaned media then falls into either a hopper in the suction system or a pressure vessel in the pressure system. At this point the blast media is metered into a feed stem. In the case of oversize non-ferrous material it is collected on the screen or finer particles collect on the feed stone and the stand pipe type feed system eliminates any passage through the feed stem.

The feed system is located at the bottom of the hopper on the suction system and beneath the pressure vessel on the pressure system. Each feed stem is sized depending on the size and type of media to be used. The reclaimer-duct collector in both cases will meet O.S.H.A. specifications. The wye gun assembly on the suction system consists of 3/16" (4.74mm) air jet and a 3/8" (9.52mm) nozzle. (The air jet is the controlling item.) Media is literally sucked from the hopper by air flowing from the air jet past a media hose. Until the media mixes with the air in the mixing chamber it has virtually no velocity. This period of acceleration is where the velocity to do the work is generated. In the pressure system the media has the full length of the blast hose to reach a working velocity.

In the selection of a pressure or suction dry blast system all the above should be considered. However, the quality of the surface finish requirements must be maintained and it is necessary to remove undesirable contamination and broken down particles with an efficient air wash system. The pressure system is higher in initial cost, but increases production and decreases abrasive and air costs. However, flexibility for multi-nozzle systems and selection of pressure control of individual nozzles generally requires a suction system.

C. Selection of Abrasive for Surface Preparation

Cleaning Rates - pressure and abrasive size are the variables

Abrasive Breakdown - depending on the abrasive and the pressure used

R.M.S. - depends on abrasive size and air pressure

D. Selection of Equipment

We found we have the ability to produce certain finishes using various pressures and media. It is possible to clean rapidly heavy surface contamination and/or produce certain critical R.M.S. finishes depending on the requirements by the selection of abrasive and pressure to produce desired results and by using the machine best suited to the particular requirement.

An effective cyclone and air wash (dispersion tube type) system is necessary to remove the broken down media and any surface contamination removed in the cleaning process. This will then assure the required anchor pattern or surface etch for the application of coatings and/or cleaning using glass beads, alox, etc.

We want the least amount of equipment necessary to provide versatility to perform job shop functions by the use of several abrasives at various pressures, which offers flexibility and reliability over the entire range of cleaning and surface finishing. Tooling is also an important and necessary factor for holding and masking of parts components.

The equipment to meet the specifications as we see the requirements is available and tooling, depending on the part configuration and area to be processed, can be built. This would include manual nozzles when applicable, automation and tooling and a complete concept for cleaning and finishing equipment for use in manufacturing, job shops, jet engine re-builders and airline maintenance.

Item 5 - The End Result is a Combination of Techniques and Processes

Let us cover these processes, machines and techniques briefly since they are sometimes neglected in that we only look at them for cleaning applications rather than a surface conditioning application.

A. Blasting for Surface Finishing

Grit blasting for surface preparation, glass bead peening and steel shot peening on parts that are subjected to severe cyclic stress reversals in normal use, as well as increased normal loading and continued heavy duty use, fall in this category.

A wide variety of surface finishes are obtainable by the variation of abrasive types and sizes, air pressure, nozzle distance, proper angle of the nozzles and exposure time. By the proper use of automated equipment type, pressure or suction, along with the number of nozzles and amount of automation, production time can be reduced drastically.

B. Vibratory Finishing of Media Selection

Tumbling and vibratory equipment, using cleaning and polishing media in various combinations, produces a variety of surfaces offering a wide choice of finishes prior to coating and on finishing of the final product. By control and variation of the intensity of vibrations and selection of many grades of media, cutting and polishing ceramic or plastic is available in various shapes and sizes.

One last comment we should touch upon in closing, we commonly overlook the use of burnishing of many parts for surface improvement after coating or machining. This improves surface finishes and performance on certain parts, as well as reducing stress risers produced during the grinding and machining operations. Each type of equipment, with the proper combination of media and tooling offers us a wide range of finishes for surface finishing and conditioning in the coating field as well as other manufacturing operations, such as deburring, cleaning, shot peening and appearance where coating need not be applied.

I have not been able to go into detail on as many of the processes or techniques, but I hope I have been able to convey in a small way the various methods available to meet some of the processing problems in manufacturing today.

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