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4. SURFACE TREATMENT AND FINISHING PROCESSES

4.1 INTRODUCTION:
1. After manufacturing parts a final coating operation is required. Coatings are applied on most of the products either for protective or for both protective & decorative purpose.
2. These coatings generally impart decoration, corrosion resistance or provision of hard surface.
3. The covering should be uniform and free from runs, checks or peelings. In some instances, coatings are applied prior to completion of fabrication. Most often, however, coatings are applied to finished components to form the final product.

Q. On which factors cleaning process is selected?
1. Type of contaminants.
2. Degree of cleanliness required.
3. Composition of metal.
5. Thickness of rust and scale.

Q. How cleaning process is classified?
- Chemical cleaning.
- Mechanical cleaning.

Q. List chemical cleaning processes and explain any one of them.
   a) Alkaline cleaning
   b) Acid cleaning (Pickling)
   c) Electrolytic cleaning

Alkaline cleaning:
The most common type of cleaning is with alkali. It is efficient and economical in removing oil and grease by saponification or emulsification or both.

Process: A bath is prepared from cleaning agents, such as caustic soda or sodium metasilicate. These materials are added to some type of soap to aid in emulsification. The mixture produces an alkali which serves as the cleaning
agents. This process is used on all metals except zinc, lead, tin, brass, and aluminium.

**Acid pickling:**

The most common method of removing unwanted pigmented compounds which are mostly oxides of metal is by acid pickling.

**Process:**

Either diluted sulphuric, hydrochloric or phosphoric acid is sprayed on the part, or the part; is dipped into a tank, agitated, and then washed and rinsed thoroughly.

Acid pickling is also used in the removal of oil and grease. In some applications, acid pickling is used to remove light rust.

Acid cleaning of steel parts creates hydrogen, which is absorbed by the steel and causes "hydrogen embrittlement". The hydrogen in the steel, of course, can be reduced by heating the parts after pickling.

**Electrolytic cleaning:**

This is effective as a final cleaning process for removing oil and grease from machined surfaces when extreme cleanliness is required. It is almost always used for final cleaning of steel parts prior to electro-plating.

**Process:**

In electrolytic cleaning, an alkaline cleaning solution is used with electric current passing through the bath in which the part to be cleaned is one electrode. This causes the emission of oxygen at the positive pole and hydrogen at the negative pole. The materials from which the part is made and the cleaning action desired determine whether the part should be made the anode or cathode. Parts from soft metals, such as lead, zinc, and tin must necessarily be cleaned cathodically because they would be badly etched if cleaned anodically. Steel may be cleaned either anodically or cathodically. The electrolytic action, however, breaks up the oil film adhering to the metal surface and results in chemically clean surface suitable for plating.
Q. List Mechanical cleaning processes and explain any one of them.

   a) Abrasive blast cleaning
   b) Tumbling
   c) Barrel rolling
   d) Power brushing

**Abrasive blast cleaning:**
This method is widely used for removing all classes of scale and rust from forgings, castings, weldments, and heat treated parts. Depending on the finish requirements, blasting may be the sole means of scale removal or it may be used to remove the major portion of scale, with pickling employed to remove the remainder.

**Process:** The parts are generally cleaned by the use of abrasive particles such as sand, steel grit, or shot, impelled against the surfaces to be cleaned.

Some cleaning is performed by means of a high-velocity air blast, with the blast directed by hand. The abrasive is fed from an overhead storage hopper to the centre of a radially rotating wheel, whereupon the metallic shot or grit is hurled in a controlled stream upon the work to be cleaned. All traces of sand, scale, oxides, and other material are removed right down to the virgin metal, providing an excellent surface for bonding final finishes.

**Applications:** engine blocks, crankshafts, railroad cars, car wheels, oil and gas pipes, steel strip, and many other purposes.
Tumbling:

Tumbling, often, is the least expensive process for removing rust and scale from metal parts.

**Process:** The operation is accomplished by placing workpieces in a drum or barrel, together with stars, jacks, slugs, or abrasive materials. The abrasive materials can be sand, granite chips, slag, or aluminium oxide pellets. In operation, the barrel is rotated, and the movement of the workpieces and the accompanying slugs or abrasive material against each other produces by friction a fine cutting action which remove the fins; flashes, and scale from the products.

Q. Which are the surface coating processes? Explain any one of them.

- Electroplating
- Galvanizing
- Metal spraying
- Painting

**Electroplating process:**

a) Electroplating is carried out in an electroplating tank where the cathode and anode are hung on the bars, and are connected to a rectifier. (For d.c. supply)

b) The anode is either the coating metal itself or an inert material of good electrical conductivity like graphite.

c) The base metal to be plated is hung on the cathode.
Theory of Electroplating:

a) If a solution of metallic salt is used as an electrolyte, it ionizes when a potential difference is applied to this through two electrodes. On ionization the metal ions migrate to the cathode and get deposited there. If the electrolyte is the salt of the anodic metal itself the salt is reformed by the anode metal, which gets ionized and goes into the solution. In this way, there is a continuous supply of metal ions, which are deposited over the cathode.

b) Consider copper plating where the electrolyte is copper sulphate solution. The article is conned to cathode and a copper plate is connected to anode.

c) When D.C. supply is given between anode & cathode the copper sulphate dissociates as

\[ \text{CuSO}_4 \rightarrow \text{Cu}^{++} + \text{SO}_4^{-2} \]

The positive Cu\(^{++}\) ions are attracted to cathode and get deposited over cathode surface (i.e. article) and the negative SO\(^4^{-2}\) ions move towards the anode. Now as anode is made of copper only, it ionizes as

\[ \text{Cu} \rightarrow \text{Cu}^{++} + 2e^- \]

These Cu ions from anode plate combine with attracted SO\(^4^{-2}\) ion in the electrolyte as

\[ \text{Cu}^{++} + \text{SO}_4^{-2} \rightarrow \text{CuSO}_4 \]
Thus the depleted electrolyte of Cu\(^{++}\) ions (as lost to deposit on cathode) is replenished with Cu\(^{++}\) ions from anode & the process run continuously as long as the supply is ON. Therefore finally in effect the material of anode gets deposited on cathode in electroplating.

**Electroplating Application:**
1. Nickel plating
2. Chromium plating

This is used for corrosion resistance and decorative purpose.

**Galvanizing process:**
It consists of the coating of zinc over the iron or steel articles by hot dipping process.

1. Steps in galvanizing process are as follows:
   a. The metal sheet is cleaned by alkali wash to remove oil and greases.
   b. The metal then pickled for 15-20 minutes at 60-90°C in dilute sulphuric acid to remove rust and scale.
   c. After this the surface is prepared by treating with 5% hydrochloric acid to dissolve any grains of sands etc. and then stored under water to prevent oxidation. The metal is then passed through 5 to 20% zinc ammonium chloride solution to remove the superficial oxide if any.
   d. Now it is then passed through a bath of molten zinc at about 450°C for zinc metal coating. Further it is passed through a pair of hot rollers to make the coating uniform. Finally it is annealed and then slowly cooled.

**Application:**
Galvanizing is widely used for protecting iron exposed to the atmosphere, e.g. roofs, wire fences, pipes.

**Metal spraying:**
1. This process consists of spraying the coating metal in a molten state, on the cold surface of the base metal. The process is carried out with the help of special spraying gun. The spraying metal is melted by using
oxy-hydrogen flame or an electric arc. Then the molten metal is sprayed by using a jet of compressed air. Some part of metal gets oxidized, so the final spray contains a mixture of metal & its oxide.

2. In most guns the metal in the form of wire is fed by powered rollers to the flame, but some guns use powder or granulated metal.

3. The process uses compressed air to atomize fully the molten metal or oxides and project them against a prepared surface where they are embedded assuring good mechanical adhesion. This is illustrated in figure.

4. The surface must be roughened first and be free of dirt, oil and greases.

5. The compressed air helps cool the work parts, so that the coatings may be asbestos and certain plastics.

6. A metal spray gun may be directed by hand or mounted on a machine.

7. Metals like Al, Cu etc are coated by spraying. Wood, plastic, worn-out parts of machine and structure are coated by spraying and protected.

Advantages:

a) The coating can be applied to the finished articles.

b) As coating can be done on parts after assembly, there is no possibility of its getting damaged during the assembly of parts.

c) Large and irregularly shaped articles can also be coated.

d) Greater speed of working.
Disadvantages:

a) The coating is not consistent and is somewhat porous.

b) Adhesive strength of coating is comparatively low (as compared with hot-dipping or electroplated).

Applications:

a) Sprayed coatings can be applied even to non-metallic surface such as wood, plastic etc.

b) Metal spraying is used for reclaiming the worn out machine parts.

Q. List the surface finishing processes & explain any one of them.

- Lapping
- Honing
- Buffing
- Burnishing
- Super finishing

**Lapping**

Lapping is a surface finishing process used on flat or cylindrical surfaces (mainly external). Lapping is the abrading of a surface by means of a lap (which is made of a material softer than the material to be lapped), which has been charged with the fine abrasive particles. When the lap and the work surface are rubbed together with the fine abrasive particles between them, these particles become embedded in the softer lap. It then becomes a holder for the hard abrasive. As a charged lap is rubbed against a hard surface, the hard particles in the surface of the lap remove small amounts of materials from the harder surface. Thus it is the abrasive which does the cutting and the soft lap is not worn away, because the abrasive particles become embedded in its surface, instead of moving across it.

In lapping, the abrasive is usually carried between the lap and the work in some sort of a vehicle. The vehicle or lubricant controls to some extent the cutting action and prevents scoring the work and caking of the abrasive. Some of the vehicles used include: kerosene plus a small amount of...
machine oil, and greases for fine job, olive oil, lard oil, spindle oil, and soapy water. Naphtha is used to clean the laps.

Thus, lapping is done:

1) To produce geometrically true surface.
2) To correct minor imperfections in shape.
3) To obtain fine dimensional accuracy to provide a very close fit between the contact surfaces.
4) To secure a fine surface finish.

Lapping Methods: Lapping may be done by hand or mechanically with the help of special lapping machines.

1. Hand lapping for flat work: Here, the lap is a fiat similar to a surface plate. Grooves are usually cut across the surface of a lap to collect the excessive abrasive and chips. For finishing of the work surface, either the lap or the workpiece is held by one hand and the irregular rotary motion of the other by the second hand, enables the abrading of the two surfaces in contact. The work is turned frequently to obtain uniform cutting action.

Applications: press work dies, dies and metallic moulds for castings etc., surface plate, engine valve and valve seat, and piston rings etc.

2. Hand lapping for external cylindrical work (Ring Lapping): An external lap for external workpieces (round) is shown in Figure. It is split by a saw cut and can be closed in by tightening one or more screws. The diameter of the hole is made the same as that of the piece to be lapped, and the hole is, of course bored before the saw cut is made. Internal laps are made to expand. The ring lap is reciprocated over the work piece surface.
Applications: stepped plug gauges or gauges made in small quantities.

3. **Machine Lapping:** Mechanical lapping machines are of vertical construction with the work holder mounted on the lower table which is given an oscillating motion. The upper lap is stationary and floating, while the lower one revolves at about 60 rev/min. Several types of lapping machines are available for lapping round surfaces. A special type of centreless lapping machine is made for lapping small parts such as piston pins, ball bearing races etc.

A general purpose machine for lapping both cylindrical and flat surfaces is shown in Figure. A number of workpieces are placed between the upper and the lower lap, whose surfaces have previously been lapped flat. The workpieces are placed in slots in a work holder so that their axes X-X are not quite radial. The shape of the slots will depend upon that of the workpieces.

Applications: aircraft piston pins, automotive wrist pins, diesel engine injector-pump parts and spray nozzles, certain dies and moulds, refrigerator-compressor parts, oil-burner parts, micro-meter spindles, roller bearings, crankshafts, camshafts, ball bearing race-ways etc.

Lapping is normally adopted for external surfaces. However, it can be used for internal surfaces also.
Honing:

Honing is a grinding or abrading process. In it, a very little material is removed. This process is used primarily to remove the grinding or tool marks left on the surface by previous operations. The cutting action is obtained from abrasive sticks (aluminium oxide or silicon carbide) mounted in a mandrel or fixture. A floating action between the work and the tool prevails so that any pressure exerted on the tool is exerted and transmitted equally on all sides. The honing tool is given a slow reciprocating motion as it rotates, having resultant honing speeds from 15 to 60 r.p.m. This action results in rapid removal of stock and at the same time, the generation of a straight and round surface. Defects such as slight eccentricity, a wavy surface, or a slight taper caused by previous operations can be corrected by this process

Applications: automobile engine cylinders, bearings, gun barrels, ring gauges, piston pins. Shafts and flange faces.
Buffing:

Buffing is a polishing operation in which the workpiece is brought in contact with a revolving cloth buffing wheel that usually has been charged with a very fine abrasive. The polishing action in buffing is very closely related to lapping in that when a polishing medium such as 'rouge' is used, the cloth buffing wheel becomes a carrying vehicle for the fine abrasives. In this action the abrasive removes amounts of metal from the workpieces, thus eliminating the scratch marks and producing a very smooth surface. When softer metals are buffed, particularly without the use of an abrasive, there is some indication that a small amount of metal flow may occur which helps to reduce the high spots and produce a high polish. Buffing wheels are made of discs of linen, cotton, broad cloth and canvass. They are made more or less firm by the amount of stitching used to fasten the layers of the cloth together.
**Applications:** Automobiles, motor-cycles, boats, bicycles, sporting items, tools, store fixtures, commercial and residential hardware and household utensils and appliances.

**SUPER-FINISHING:**

Super-finishing is a micro finishing process that produces a controlled surface condition on parts which is not obtainable by any other method. The operation which is also called 'microstoning' consists of scrubbing a stone against a surface to produce a fine quality metal finish. The process consists of removing chatter marks and fragmented or smears metal from the surface of dimensionally finished parts. The method is performed by rapidly reciprocating a fine grit stone with a soft bond and pressing it against a revolving round work-piece. The stone quickly wears to conform to the contour of the work-piece.
Applications: Computer memory drums, sewing machine parts, automotive cylinders, brake drums, bearings, pistons, piston rods and pins, axles, shafts, clutch plates, tappet bodies, guide pins etc.

Burnishing: Burnishing operation is the process of getting a smooth and shiny surface by contact and rubbing of the surface against the walls of a hard tool (punch and/or die, rollers and balls etc.). It is a finishing and strengthening process. Some other burnishing methods are discussed below:

Barrel Burnishing: It is similar to barrel rolling except that instead of using abrasive medium, medium balls, shots or round pins are added to the work in the barrel. There is no cutting action in burnishing. Burnishing will not ordinarily remove visible scratches or pits, but will produce a smooth, uniform surface and reduce the porosity in surfaces.

Roller / Ball Burnishing: Flat, cylindrical or conical surfaces (both internal and external) are burnished with hardened steel or cemented carbide rollers or with steel balls mounted in a holder.
Applications: Hydraulic system components, seals, valves, spindles and fillets on shafts.