Electro Chemical grinding

Introduction :-

→ Conventional grinding produces components with good surface finish and dimensional tolerances but such components are also associated with burrs, comparitively large heat affected zones, and thermal residual stresses.

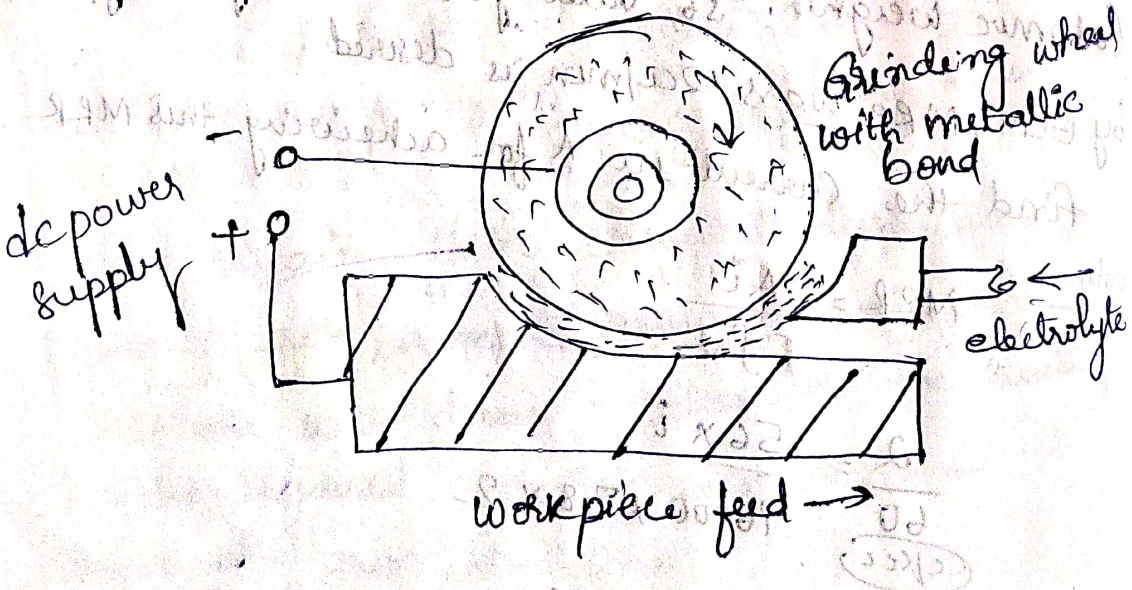
→ These defects are not found in electro Chemically grind w/p's (anodes)

→ During ECG, material is removed by mechanical abrasive action (about 10%) and by electro Chemical dissolution (about 90%) of anodic w/p.

→ Electrolyte is recirculated in ECG, hence an effective and efficient electrolyte supply and filteration system is needed.

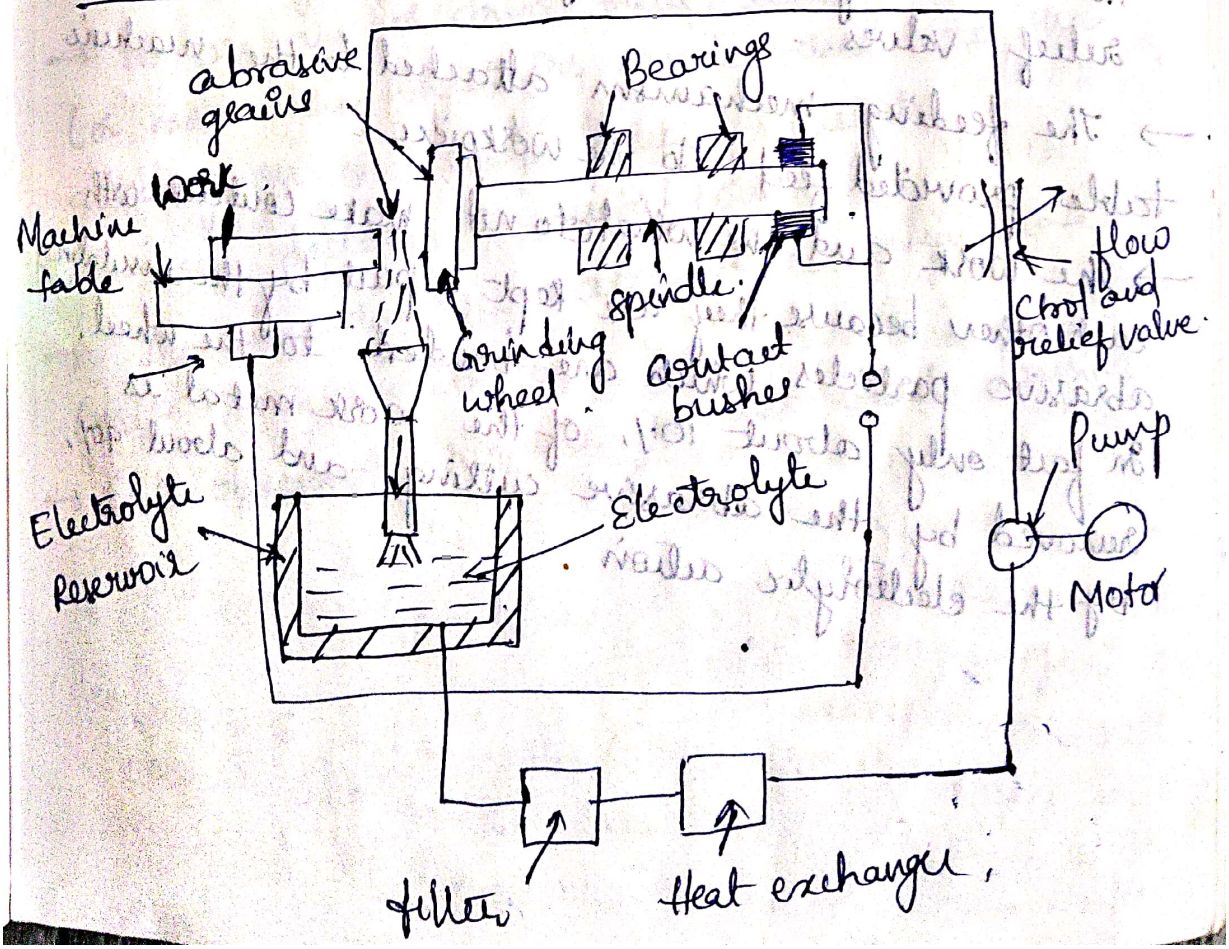
→ The commonly used electrolytes are sodium Chloride (NaCl) and sodium nitrate ($NaNO_3$)

Principle of Electrochemical grinding :-

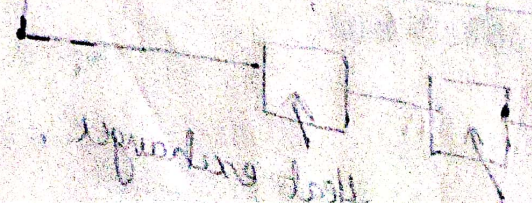


→ In this process, the rotating wheel is made the cathode and the w/p functions as the anode of an electrolytic cell.
→ The electrolyte is passed through the machining zone in order to complete the electrical bridge between the anode and cathode.
→ Effective gap b/w the anode and cathode is about 0.0025 mm.
→ The abrasive in the grinding wheel are insulating in nature and are held by conductive bonds in the wheel.
→ When a low voltage of 4 to 9 V dc, is applied across the device, a high current density of upto 100 amps/cm² will be set up at the machining zone and this electrochemical cell b/w the conductive bonds and the workpiece will be completed by the electrolyte.
→ With the rotation of the grinding wheel metal will be removed from the w/p surface by the simultaneous electrolytic and abrasive action.

Construction :-



→ The above figure shows the complete set up for ECG process.
→ The w/p is held on to the machine table which is fitted with a feed device.
→ The grinding wheel is supported between bearing
→ The w/p (through the m/c table) is connected to the positive terminal.
→ The grinding wheel and its spindle are insulated from the rest of the m/c and are connected to the negative terminal of a d.c supply source.
→ The electrolyte supply system consists of pump, filter relief valve etc.
→ The electrolyte is pumped in the gap b/w the work and the grinding wheel. The used electrolyte containing precipitates sludge etc. is collected in the reservoir from which it passes through the filter and is pumped to the machining zone through the flow control and relief valves.
→ The feeding mechanism attached to the machine table provided feed to the workpiece.
→ The work and the wheel do not make contact with each other because they are kept apart by the insulating abrasive particles which are bonded to the wheel. In fact only about 10% of the work metal is removed by the abrasive cutting and about 90% by the electrolytic action



ECG Machine tool :-

→ It is very similar to conventional grinders
→ In ECG system, machining area is made up of non corrosive materials
→ power is supply through spindle either with the help of brushes or mercury coupling.
→ The probabity of short circuiting during ECG is very low because of the presence of protruding abrasives which create a positive IEG
→ Hence in this system, there is less need of having short circuit cut off devices.
→ Metal bonding grinding wheels have many advantages over resinoid bonded wheels
→ In ECG wheel, the commonly used bonding materials are copper, brass, nickel etc.
→ Such metal bonded wheels are effectively dressed using electrochemical process
→ To prepare (or dress) them, reverse the current (or make the wheel as anode) and do the grinding on the scrap piece of metal.
→ It will deplate the metal bond.
→ The commonly used abrasive is alumina (grit mesh size 60-80).
→ ECG doesnot require frequent wheel dressing.

Process characteristics:

Performance of ECG process depends on various process parameters such as wheel speed, workpiece feed, electrolyte type, concentration and delivery method, current density, wheel pressure etc.

1) Current density :- It is one of the most important parameters that influences the process performance.

→ MRR in ECG is also governed by current density.

→ With higher current density, both MRR and surface finish improve.

→ If the applied voltage is very high (usual range is 4-15V), it may deteriorate surface finish of the machined w/p as well as damage the tool (grinding wheel).

Feed rate :-

→ Selection of an appropriate feed rate to the tool is important.

→ If it is higher than the required one, the abrasive particles will prematurely detach from the wheel leading to excessive wheel wear.

→ If it is lower than the required one, a large overcut (or poor tolerances) and poor surface finish will result.

→ Surface speed of the wheel is in the range of 1200-1800 m/min.

→ The depth of cut is usually below 2.5 mm and it is limited by the wheel contact arc length, which should never exceed 19mm.

→ otherwise electrolyte becomes ineffective because of higher concentration of H_2 gas bubbles and sludge.

3) MRR:-

→ MRR achieved during ECG may be high as 10 times compared to conventional grinding on hard materials (hardness >, 65 HRC)

→ But tolerances obtained in ECG are poorer (± 0.0025 mm)

→ Min. inside corner radius of 0.25 mm and outside corner radius of 0.025 mm can be produced by this process.

→ Abrasive particles maintain electrical insulation b/w cathode and anode, and determine the effective gap b/w them (may be as low as 0.025 mm).

→ Surface finish obtained by ECG ranges from 0.12 and 0.8 μm.

→ The surface produced by ECG is free of grinding scratches & burrs.

→ Surface finish produced on non homogeneous materials during ECG is better than that produced during conventional grinding.

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Types of ECG operations:-

There are five different kinds of ECG operations can be performed.

1) Electrochemical cylindrical grinding
2) Electrochemical form grinding
3) EC surface grinding
4) EC face grinding
5) EC internal grinding

→ EC cylindrical grinding is the slowest process because of the limited area of contact b/w the wheel and the w/p.

→ EC face grinding is the fastest process because of maximum area of contact b/w the anode and the cathode.

→ Uneven wheel wear can be controlled by providing oscillating motion to the workpiece.

→ In EC surface grinding, the w/p reciprocates.

→ EC internal grinding and EC form grinding are the same as conventional internal and form grinding operations except that the ECG wheel is electrically conducting and the electrolyte is present in the ECG.

Advantages :-

1. The fixtures used for holding the components are simple in construction.
2. Hard metal parts can be easily machined without cracks and burns in a fraction of the time taken by conventional grinding.
3. No overheating occurs, hence no surface cracks are produced on the parts machined by ECG, hence less rejections
4. A surface finish upto 0.25 micron is possible.
5. closer tolerances can be obtained in this process
6. Cost of grinding is reduced by 25-40%.
7. Higher amount of metal removed per carat

of diamond consumed thus saving in diamond wheel consumption.

8. Due to negligible wear, electrolytic machining increases the life of the grinding wheels.

Disadvantages:-

1) Initial investment for the equipment needed for ECG is greater than that required for conventional grinding.

2) Applications of electrolytic grinding are limited. eg: non conducting hard work materials such as ceramics cannot be machined by ECG process.

3) Most of the electrolytic solutions are corrosive in nature and therefore are detrimental to machines, fixtures and piping systems, if they are not properly protected.

4) The machining of cast iron by electrochemical grinding presents certain difficulties.

Applications:-

1) ECG is used for applications such as
   (i) grinding of cutting tools
   (ii) grinding of chilled iron castings
   (iii) grinding of magnet alloys
   (iv) Contour milling of honey comb structures.

2) They can also be used for the machining of the following materials, with out any burr.
   1) Cemented carbides
   2) Stellite
   3) Refractory materials
   4) Stainless steels & high alloy steels

3) Chromium plated materials, flame hardened materials & temp's sentive alloys can be machined without forming thermal cracks and without distortion

4) Cutting tools such as drills and reamers can be finished with one pass of the grinding wheel.

5) Chip breakers on tungsten carbide tools bits can be ground without spoiling the cutting tool edges.

6) A depth of cut of 0.5 mm can be ground in one pass.

Electro Chemical Honing :-

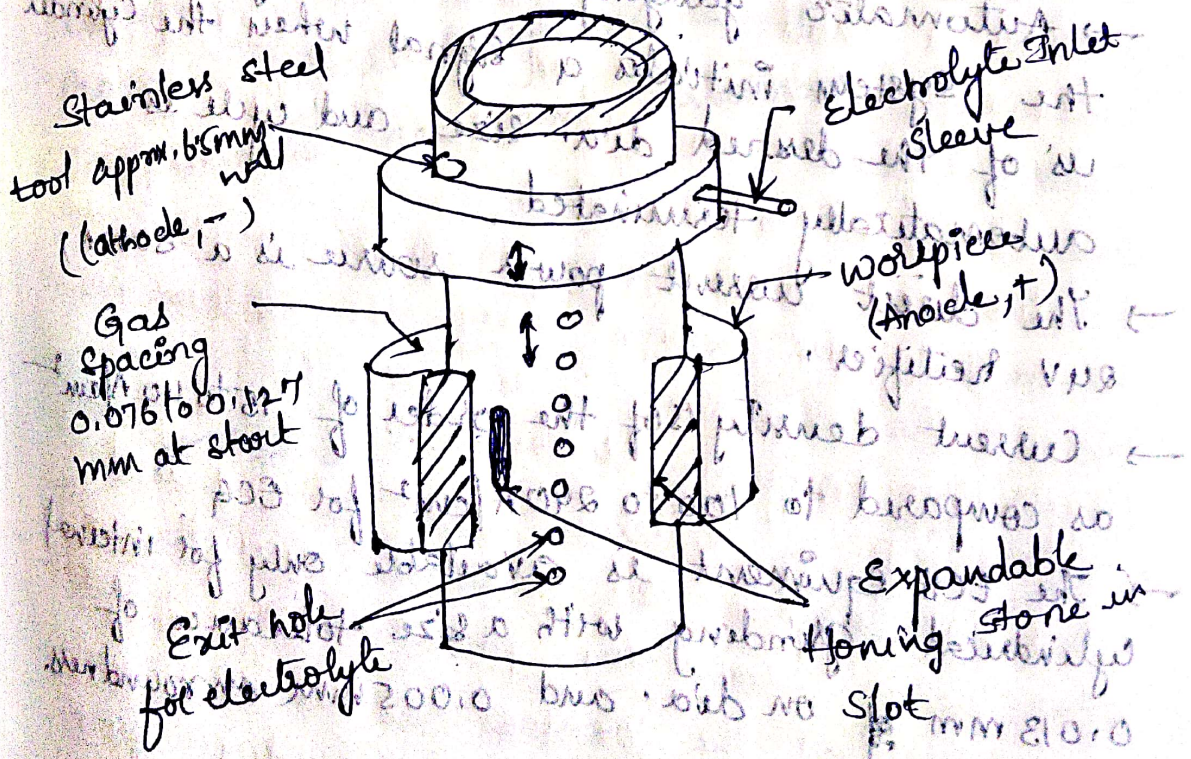
→ ECH is similar to ECG in that it combines the anodic dissolution of material with abrasive cutting action

→ It uses rotating and reciprocating, non conducting bounded honing stones instead of conducting grinding wheel

→ ECH is a modification of conventional honing and it combines the metal removal capabilities of ECM with the accuracy capabilities of honing

→ Electrolyte is introduced into the gap between the cathodic honing tool and the anodic workpiece, while D.C is passed across the gap and the rotating tool is reciprocated through the workbore.

→ The gap b/w the tool and the workpiece is usually about 0.075 to 0.125 mm at the start of the cycle.
→ The gap can increase upto 0.50 mm or more.
→ Because the honing stones keep the w/p surface clean, the electrolyte does not have to be as corrosive as is necessary for ECM.
→ On many metals, sodium nitrate can be used instead of more corrosive sodium chloride.
→ Several rows of small holes in the tool body enable electrolyte to be introduced directly b/w the tool and the work surface.
→ Supply of the electrolyte can be up to 112.5 lit/min under a pressure of upto 1.05 N/mm², depending upon the w/p size.



→ Bonded abrative honing stones are inserted in slots in the tool.
→ These stones are forced out radially by the wedging action of the cone in the tool.
→ The expansion is controlled by an adjusting screw.
→ The stones, which must be non conducting, assist in the metal removal action and generate a round, straight cylinder.
→ They are fed out with equal pressure in all directions so that their cutting faces are in constant with the cylinder's surface.
→ If the cylinder is tapered, out of round or wavy, the stones cut more aggressively on the high or tight areas and remove that geometric ~~error~~ error
→ Automatic gauging devices designed to the system initiates a signal when the cylinder is of the desired dia. size and cycle is automatically terminated.
→ The direct current power source is a 3000A, 24V rectifier.
→ Current density is of the order of 15 to 40 A/cm² as compared to 100 to 240 A/cm² for ECG
→ The ECH equipment is available only for internal cylindrical grinding with a size tolerance of 0.013 mm on dia. and 0.005 mm on roundness and straightness.
→ The size of the cylinder that can be processed by ECH is limited only by the current and electrolyte that can be supplied and properly

distributed in the circuit.
→ Hard materials can be finished more quickly than soft materials.

Advantages of ECH:

1) faster and higher metal removal rate with reduced hone wear.
2) It removes sharp or burred edges.
3) Increased life of bonded abrasive.
4) The finished surfaces are virtually free from stress or heat damage.
5) less pressure is required between stones and work.
6) Reduced noise and distortion, when honing thin walled tubes.
7) cooling action of the electrolyte leads to increased accuracy with less material damage, so the process is particularly suitable for parts susceptible to heat and distortion.

Electro chemical deburring :-

→ When a component is processed by a conventional machining method, usually it is left with burrs specifically along the two intersecting surfaces.

→ Such burrs are undesirable from the view pts of performance of a component as well as safety of an operator.

→ Such burrs can be removed by one of the deburring processes

→ Deburring is an important phase for manufacturing quality products, especially in large scale industries

Principle of working :-

→ When a voltage is applied b/w two metal electrodes immersed in an electrolyte, current flows through the electrolyte from one electrode to the other.

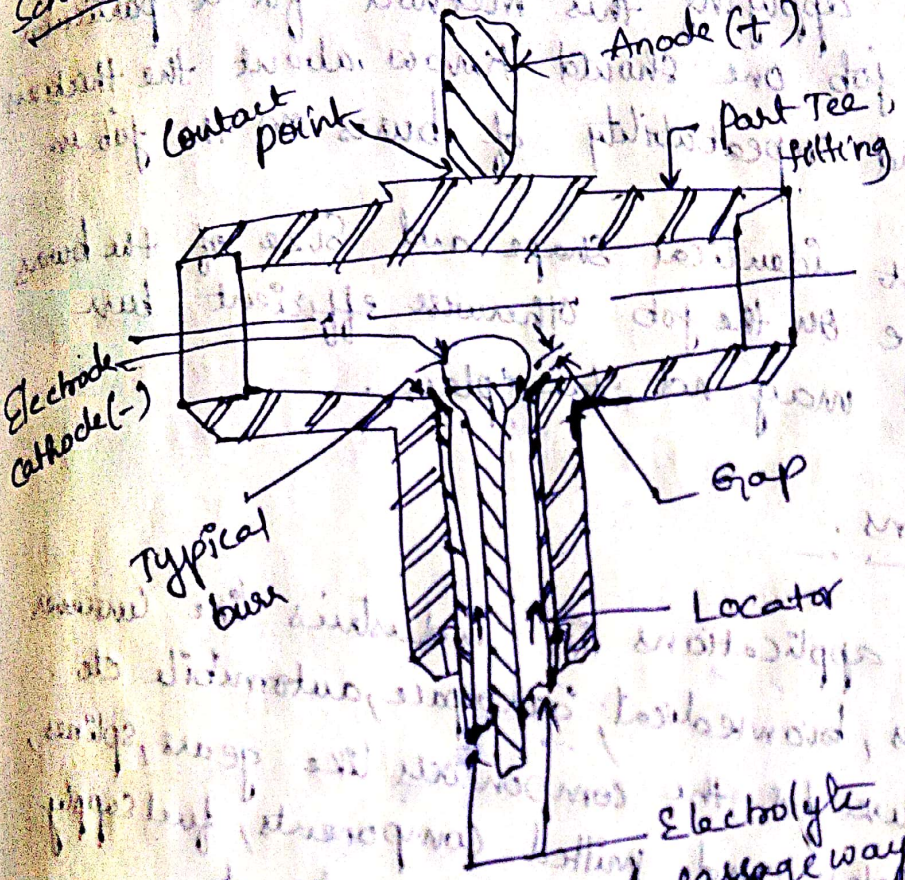
→ Unlike the conduction of electric current in the metals in which only the electrons move through the structure of the material, ions physically migrate through the electrolyte.

→ The transfer of electrons b/w the ions and electrodes complete the electrical circuit and also brings about the phenomenon of metal dissolution at the positive electrode or anode.

→ Metal detached atom by atom from the anode surface appears in the main body of the electrolyte as positive ions, or as precipitated

Semi solid of the metal hydroxide, which is more common in electrochemical deburring process.

Schematic diagram

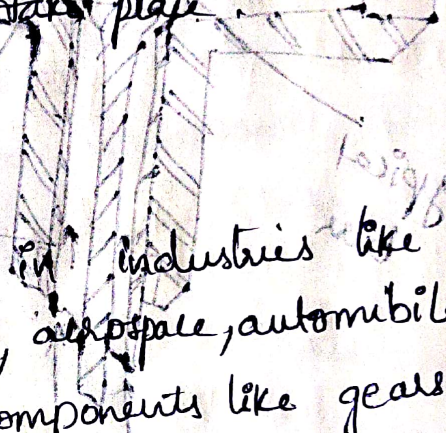


→ The tool is usually insulated on all surfaces except a part which is adjacent to the burr.
→ Instead of insulated tool, a bit type of tool can also be used.
→ The electrolyte is made to flow through inter electrode gap.
→ However Setting of dimensions of the bare part of the tool, time of machining, and other machining conditions are all decided by trail and error method.
→ The inter electrode gap is kept in the range of 01-0.3 mm.

→ It is considered as a high tech method when compared to the conventional methods of deburring.

→ Before applying this method for a particular type of job one should know about the thickness shape and repeatability of burrs on the job in hand

→ Almost identical shape and size of the burrs should be on the job otherwise efficient burr removal may not take place.



Applications :-

1) It has applications in industries like consumer appliances, biomedical, aerospace, automobile etc.
2) It is used for the components like gears, splines, drilled holes and milled components, fuel supply and hydraulic system components etc.
3) It is very successful even in the situations where two holes cross each other like crank shaft.
4) It gives higer reliability, reduced operation time and more uniformity.