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ANOCOAT 6004 AND ANOCOAT 6005 INSULATION COATINGS

Supplier

Anocut Engineering Co. 2315 Estes Avenue, Elk Grove Village, Ill. The following technical information is provided for Anocut customers to aid in the use of Anocut equipment. The submission of this information is not under any circumstances to be taken to imply a license under any patent rights pertaining to this subject matter except only in the use in operation of Anocut equipment.

General

Anocoat 6004 and Anocoat 6005 are epoxy type adhesive plastics especially well suited to the coating of copper, beryllium-bronze, and stainless steel electrodes to provide insulation. Anocoat 6004 is in putty form, meant to be applied by knife coating for thick coatings and filling. Anocoat 6005 is a flowable syrup used for thin coatings. Both materials are resistant to most saline, acid, and alkali type electrolytes and have good resistance to peeling, chipping, and mechanical and thermal shock.

Caution

Anocoat 6004 and Anocoat 6005 are toxic. The usual precautions in dealing with epoxy type plastics should be observed. Avoid contact with the skin and avoid breathing of vapors. Anyone working regularly with these materials should be protected by suitable exhaust arrangements. If skin contact occurs, remove with rubbing alcohol followed by washing with soap and water. Remove contaminated clothing and wash before

Appendix

reuse. Avoid breathing of dust during grinding operations. Wash hands thoroughly before eating or smoking.

Dilution

The shelf life of Anocoat 6004 and Anocoat 6005 is limited.

- The material should be stored at 40°F.
- Shelf life—3 to 6 months if stored in a refrigerator at 40°F.
- Shelf life—4 to 6 weeks if not stored in a refrigerator.

Before using, it should be allowed to warm thoroughly to room temperature before opening in order to prevent moisture condensation on the surface.

Application

1. Roughen electrode where coating is desired. See Anocut Engineering Company Technical Bulletin 2-C for more information on this point.
2. Wash electrode in detergent. Rinse thoroughly.
3. Etch electrode, and then wash thoroughly in running hot water. For copper and beryllium-bronze electrodes, use Anocut Engineering Company Anoetch 5001 as prescribed in their Technical Bulletin 2-C. For stainless steel electrodes, use Anoetch 5002 as prescribed in their Technical Bulletin 8-C.
4. Rinse thoroughly and dry at 180°F. Let cool. After etching, it is essential to avoid handling the electrode with the fingers or in any way so that dirt, grease, skin oils, and so on can adhere to the surface which is to be coated. Contamination will destroy the adhesion of the coating to the electrode. Rinse in Toluol just prior to coating and let dry.
5. With Anocoat 6005, dip electrode in the coating and let drain for 15 to 20 min. With Anocoat 6004, apply the coating where desired with a knife.
6. Preheat at 170 to 180°F for minimum of 30 min. This applies to 6005 only. Anocoat 6004 does not require a preheat period.
7. To cure, heat at 335 to 390°F for 60 min (longer at the lower temperatures). For an electrode that has been soldered, the curing temperature must be below the melting point of the solder (335°F is adequate for this). However, the higher curing temperatures (380 to 390°F) can produce a more heat-resistant coating.
8. Clean and polish face. Any coating material left on the cutting lip will cause sparking.

ANOCOAT 6006 INSULATION COATING

Supplier

Anocut Engineering Co., 2375 Estes Avenue, Elk Grove Village, Ill. The following technical information is provided for the assistance of Anocut customers in the use of Anocut equipment. The submission of this information is not under any circumstances to be taken to imply a license under any patent rights pertaining to this subject matter except only in the use in operation of Anocut equipment.

General

This Anocoat material is very useful for coating intricately shaped electrodes, for coating parts of tooling, and for use as a masking material to protect areas adjacent to areas being machined by ECM. It is necessary to heat the part being coated to above the melting point of the powdered resin. The coating may be applied by spraying or by dipping the part into an aerated bed of the coating material. The coating may be machined to a smooth surface after curing.

Application—Cleaning

The coating adheres only to clean parts. The surface to be coated should be sandblasted or similarly prepared to remove dirt and oxidation. The surface should then be cleansed with a solvent such as trichloroethylene. Brass and copper parts must be cleaned with steel wool and

trichloroethylene after they have been heated since the heating produces an oxide coating on these materials. It is important that this cleaning does not cool the part below 375°F.

Heating

The surface to be coated must be heated to a temperature of 375 to 450°F. A part which dissipates heat rapidly should be heated to the higher temperature. Also, the thickness of the coating parts which are dipped is regulated by the temperature of the part. Higher temperatures produce thicker coatings.

Application

Dipping

An aerated bed of resin is required for dipping applications. Parts to be coated should be dipped, while hot, into the aerated bed for 1 to 3 sec. Heavy coatings should be produced by multiple dippings rather than prolonged exposure.

Spraying

The coating can be applied by spraying with a flocking gun. Air pressure should be at least 40 psi and the air must be dry. Recommended spray guns are

- Binks model 171
- DeVilbiss model GB
- Paasche model FF $\frac{3}{4}$ in.

Curing

Residual heat in the part is usually enough to cure the coating. If not sufficient, the part may be oven cured for 2 min at 375°F or 30 sec at 450°F.

Precautions

Keep away from fire. The fine particles can be ignited by open flames or sparks. Avoid excessive air pressure, use adequate ventilation, and do not inhale dust. If an aerated bed is used, it must be grounded. If sprayed, a spray booth should be used. (It is possible to reclaim the unused resin.) Epoxy materials are toxic. Avoid inhalation. Use rubber gloves to avoid prolonged contact with the skin.

SYNTHETIC RUBBER INSULATION COATING*

This type of insulation may be applied in thicknesses of 0.010 to 0.250 in. It is tough and flexible, and securely bonds to copper that has been specially oxidized and treated with a primer coating. The finished coating may be readily machined using sharp tools, that is, milled, turned, or wet ground.

Materials Required

- Ebonol C Special. Crystalline material, which is made into a water-based solution of strength 1.5 lb/gal, used to oxidize copper. *Supplier:* Enthone Inc., Box 1900, New Haven, Conn.
- C-1445 primer. Liquid prime coat for insulation.
- C-1445 reducer. Liquid used for thinning or removing uncured primer.
- Microsol E-1003 Plastisol. Liquid insulation.
- Microstrip B. Liquid used for stripping insulation. *Supplier:* Michigan Chrome & Chemical Co., Detroit, Mich.
- Ensign 803 Encostrip Paint Stripper. Liquid used for stripping C-1445 primer. *Supplier:* Ensign Products Co., Cleveland, Ohio.
- Acetone may be used for cleaning up both primer and insulation.
- Binks model 171
- DeVilbiss model GB
- Paasche model FF $\frac{3}{4}$ in.

Insulation Procedure

1. Immerse the tool to be insulated in Turco Vitro-Klene for 20 min. at 180 to 208°F or use a similar degreasing process.
2. Water rinse.
3. Dip for 20 sec, or until no more color changes occur, in 20 to 30% hydrochloric acid to remove surface oxides.
4. Water rinse but do not allow to dry and immediately proceed to next operation.
5. Totally immerse in solution of Ebonol C Special (1.5 lb/gal) at 210 to 215°F. Maneuver to eliminate trapped air in reentrant part of tool. Allow to soak until uniform "velvet" black oxide is formed over surfaces to carry insulation. This takes about 20 min.

* For application to copper only.

6. Thoroughly water rinse tool to flush all Ebonol from fibers of black oxide film and reentrant features of tool. Soaking in an overflowing water tank for 10 min is usually sufficient. *Note.* Do not touch or allow anything to touch areas to be coated.
7. Blow dry.
8. Inspect for deep black velvet appearance of oxide in areas to be coated. If not perfect, repeat steps three through seven.
9. Brush or spray C-1445 primer on surfaces that are to be insulated.
10. Air dry the primer for 15 min.
11. Suspend the tool in oven at 360 to 375°F for 50 to 60 min to cure primer.
12. Allow the tool to air cool to below 150°F.
13. Using masking tape, cover openings, holes, and slots that must be kept free from Miccosol insulation.
14. Heat to 250 to 260°F for 10 min.
15. While hot, dip the tool slowly into Miccosol allowing coverage without trapping air. Allow to remain in solution until a sufficient thickness of Miccosol has jelled onto the surface of the tool.
16. Remove the tool from Miccosol and allow excess to drain off.
17. Suspend in oven at 220 to 240°F for 25 min for insulation to set firm. If more insulation thickness is required repeat operations 15, 16, and 17.
18. Using a thin blade, trim Miccosol from surfaces not requiring insulation.
19. Suspend in oven at 350 to 375°F for 50 to 60 min to cure insulation.
20. Air-cool. *Note.* Do not allow any solvents to contaminate the Miccosol E-1003. Miccosol is very viscous. When using allow time for it to flow slowly and smoothly without flopping and trapping air bubbles. Use care at all times to avoid creating bubbles in the Miccosol. Pour or dip the tools slowly.

Recommendations for Further Reading

Electrochemical Machining, by A. E. DeBarr and D. A. Oliver. London: Macmillan and Company (Publishers) Ltd., 1968.

Nine experienced users of the process (the writer was one) from different locations contributed to this book. It deals with the theoretical and some of the practical aspects of ECM.

Non-Traditional Machining Processes, by R. K. Springborn. Dearborn, Michigan: American Society of Tool and Manufacturing Engineers, 1967. A book with many expert contributors, which provides a concise account of some eleven new manufacturing processes, including ECM.

Electrochemical Machining, by Graduate Students at Harvard Business School. Boston, Massachusetts: The Nimrod Press, Inc., 1966. Business survey and recommendations on ECM.

Glossary of Terms

The glossary of terms was prepared by the Cincinnati Milacron Company. The ECM terms and their definitions are generally accepted and used in Europe and the United States.

ACCUMULATOR A surge chamber to smooth out the pressure pulsations generated by a high pressure pump.

AMMETER A low-resistance meter connected in series with the circuit, used to measure the machining current (in amperes).

ANODE The work piece in electrochemical machining that is positive in polarity.

ANODIC METAL Metals vary in resistance to corrosion, oxidation, and dissolution in the presence of an electrolyte. A list showing the order of corrosion resistance is called the Galvanic series, and a metal near the bottom of the list will be more anodic in comparison to one at the top of the list and will dissolve, corrode, or oxidize quicker than a metal near the top of the list if the two metals are connected electrically in the presence of an electrolyte.

ARC An electrical flash, bluish in color, which is the result of a short circuit when the cathode physically contacts the work piece while current is flowing. Modern EC machines have anticipator circuitry to eliminate damage to the cathode or the work piece.

ARC ANTICIPATOR An electronic device to monitor the DIDT and the DVDT derivatives to protect the tooling by stopping the machining operation.

ATMOSPHERIC CORROSION Normal deterioration of a metal exposed to the weather. When used in contaminated atmospheres, or at raised temperatures, most metals will show increased breakdown.

AUTOMATIC CYCLE A machine feature that results in the machine automatically completing a machining operation on one work piece.

BACK PRESSURE Pressure above atmospheric which is purposely built up in the machining zone either by a valve or by another set restriction

placed in the discharge side of the electrolyte flow. Back pressure produces the best side wall surface and increases the overcut.

BACKUP A piece of metal, usually the same as or similar to the work piece (anode), or any other device, attached to the back surface of a workpiece and used to overcome breakthrough difficulties.

BERYLLIUM COPPER Copper-base alloys containing varying percentages of beryllium copper and nickel, having high tensile strength, high fatigue limit, and hardness, and a relatively high electrical and thermal conductivity, depending upon heat treatment. This material is primarily used to construct cathodes and holding fixtures.

BREAKTHROUGH That point in machining a through hole when the cathode machines through the back surface of the work piece.

BRIGHT DIP FINISH The finish obtained by immersing copper or copper alloy tooling, after brazing, in a suitable oxidizing acid solution. This process removes most scale and oxides. Some solutions contain detergents, and a thorough rinsing of the tool is necessary to prevent electrolyte foaming.

BUS BAR A large copper bar used to carry the machining current.

CATHODE The electrode or tool in electrochemical machining, which is negative in polarity.

CATHODE BODY That section of the cathode that supports the tip—the main or middle section.

CATHODIC METAL (see ANODIC METAL). The metal that better resists corrosion, dissolution, or oxidation in preference to another metal, when the metals are connected electrically in the presence of an electrolyte.

CAVITATION The rapid formation and collapse of vapor pockets in a flowing liquid, accompanied with pressure variations. This is a potential source of serious damage to impellers in pumps, valve parts, and so on.

CAVITY MACHINING Three-dimensional machining such as forging dies, molds, and so on. Also known as forming, shaping, or die sinking.

CENTER SLUG (CONE) The projection extending up from the machined surface toward or into the electrolyte passageway, caused by the current distribution in the electrolyte passageway.

CENTRIFUGE A clarifying device using centrifugal force to remove the metal hydroxides (precipitate or sludge) from the electrolyte.

CONDUCTO-LUBE A registered trademark of the Conducto-Lube Company for a conductive silver-base paste, recommended for use in high current connections.

CONTACT AREA The surface area of an electrical conductor that contacts another conductor for the passage of machining current.

COOL-AMP A registered trademark of the Cool-Amp Company for their silver plating powder; used to silver plate the contact area of high current connections.

COPPER TUNGSTEN A sintered copper metal containing 50 to 70% tungsten.

CORROSION PITTING Corrosion with some depth in small individual areas on the surface of a metal. Also known as pitting.

CREVICE CORROSION Associated most often with recesses and crevices such as a lapped joint, the space between two loosely joined plates, or other areas where corrosives may stagnate. It often occurs under the head of a bolt or washer.

CURRENT DENSITY The ratio of the machining current to the machining area, expressed in amperes per square inch (ASI); depends on type of material, but is proportional to the feed rate for a given material and is affected by the type of electrolyte.

DIDT DERIVATIVES The rate of change of voltage with respect to time.

DWELL Stopping feed for a predetermined time, with machining current and electrolyte flow remaining on, to produce greater overcut in the vicinity of the cathode lip.

ELECTRICAL CONDUCTIVITY A relative conductivity rating of metals based on the conductivity of technically pure copper which is rated as 100% on the International Annealed Copper Standard scale.

ELECTROCHEMICAL MACHINING (ECM) The controlled removal of metal by electrolytic action, without mechanical aid.

ELECTRODE The cathode or tool made of electrically conductive metal and having the desired contour or shape, size, and so on. It is always connected to the negative terminal of the power supply in electrochemical machining.

ELECTROLYSIS The process of chemical decomposition of metals, encouraged by the passage of current through an electrolyte.

ELECTROLYTE The electrically conductive fluid composed of concentrations of chemicals dissolved in water. Sodium chloride is used to machine a majority of metals, but other salts and various salt combinations have been used for cutting other metals. Dilute acid solutions are also used as electrolytes.

ELECTROLYTE CONCENTRATION The amount of a dissolved substance in solution per unit of volume of the electrolyte. Electrolyte concentration is measured with a hydrometer, and the reading can be converted to the usually expressed pounds per gallon (lb/gal).

ELECTROLYTE CONDUCTIVITY The electrical conductance measured between opposite faces of a 1-cm cube of an electrolyte at the point being measured; opposite of resistivity.

ELECTROLYTE RESISTIVITY The electrical resistance measured between opposite faces of a 1-cm cube of an electrolyte; opposite of conductivity.

ELECTROLYTIC CELL A general term for an area producing electrolysis, consisting essentially of the electrolyte, its container, and the electrodes.

ENTRY RADIUS The radius on the corner between the side wall of the machined cavity and the tool entry surface of the workpiece.

EQUILIBRIUM GAP A condition where the metal removal rate is equal to the feed rate. The machining current and the electrolyte flow have leveled out and are steady.

EXIT RADIUS The radius on the corner between the side wall of the machined cavity or hole and the tool exit surface of the workpiece.

FARADAY'S LAWS OF ELECTROLYSIS A theoretical basis for computing the amount of material set free, or deposited, by the ECM process. The amount removed is directly proportional to the current that passes through the electrolyte from the anode to the cathode in a given time. In practice, a number of factors tend to reduce the actual rate of metal removal per ampere.

FEED IN Moving the tool towards or into the work piece.

FEED OUT Retracting the tool from a cavity already machined in the work piece, with machining current and electrolyte flow remaining on to produce additional overcut or to obtain better surface finish.

FEED RATE The selected rate at which the cathode advances into or retracts from the work piece, usually expressed in thousandths of an inch per minute.

FEED RATE METER The instrument that indicates the rate at which the platen advances or retracts, usually expressed in thousandths of an inch per minute.

FILTER (IN-LINE) A high pressure filter that prevents foreign particles from reaching the machining gap. It is placed as close as possible to the machining gap.

FIXED WORKTABLE A work table fastened to the machine frame; one that cannot be moved to position the work piece.

FLOW LINES Narrow grooves or fine lines on the electrochemically machined surface of a workpiece caused by turbulent, inadequate, or nonuniform electrolyte flow through the machining gap, at conditions promoting unstable anodic oxide films on the workpiece surface.

FLOW RATE The volume of electrolyte passing through the machine gap, expressed in gallons per minute (gal/min).

FLUIDIZED BED A device built like an open tank, of almost any size, using air currents or vibration, or both, to keep dry powders in suspension or agitation. A heated object held in the agitated powder for a period of time will attract some particles and will become coated with the powder. Cured under heat, the powder becomes a usable insulation.

GALVANIC CORROSION The result of two dissimilar metals in contact with each other in an electrolyte, one tending to corrode faster than the other.

GAP, MACHINING The distance between the front face of the tool and the surface being machined.

HEAT EXCHANGER A unit used to cool a liquid by a refrigerant gas, evaporation, or water cooling.

HYDRODYNAMICS The science that deals with the motion of fluids and the forces acting on solid bodies immersed in fluids.

HYDROMETER A sealed glass cylinder with a weighted bulb and graduated stem, used to determine the specific gravity of a liquid by reading the figures on the portion of the graduated stem that emerges from the liquid being tested. Specific gravity, or degrees of Baume, Salimeter, and so on, can be converted to concentration in pounds per gallon if the temperature is also considered.

HYDROSTATIC FORCE The force applied by a liquid under pressure, or water, as from overflow or leakage.

INCLUSION A particle of foreign matter, such as oxide, sulphide, or silicate, in the work piece material. Inclusions are most frequent in castings and forgings and are particularly troublesome for electrochemical machining.

INSULATION An electrically nonconductive material, either organic (epoxy) or inorganic (porcelain enamel), applied to the tool and fixture to restrict the flow of machining current to the desired areas.

INTERGRANULAR ATTACK A type of electrochemical corrosion that progresses along the grain boundaries of an alloy, usually because the grain boundary regions contain anodic material as compared to the central regions of the grain.

LAMINAR FLOW A smooth flow pattern of a fluid, as contrasted to turbulent flow.

LIP CLEARANCE The small area of the machining face of a cathode that extends beyond the body or shank of the cathode. This lip supplies protection for the insulation. Also known as tool land.

MACHINING CURRENT The electrical current which is used to remove metal from desired location on the part. It is the total current flowing between tool and work piece.

MACHINING ENCLOSURE The barrier that surrounds the machining operation to contain the electrolyte spray; usually made of stainless steel and/or plastic.

MACHINING VOLTAGE The voltage applied across the machining gap.

MACHINING ZONE The space between the active face of the tool and the machined surface of the work during machining.

METAL REMOVAL RATE The volume of metal removed in a unit of time, usually expressed in cubic inches per minute. This will vary from one metal to another, depending on its chemical analysis, as well as the chemistry and temperature of the electrolyte.

MICRON One millionth of a meter or 0.00003937 in. Twenty-five microns are about 0.001 in. and 50 μ are about 0.002 in.

- MIL A length of measurement equal to 0.001 in.
- MIST COLLECTOR A unit that separates electrolyte mist from hydrogen and air ducted from the machining enclosure.
- MOUNTING PLATE A metal plate fastened to the machine platen that supports the tool (cathode) body.
- MOVABLE WORK TABLE Not fixed; can be positioned in the longitudinal, cross, and vertical axes, and is sometimes rotational.
- OPEN HEIGHT Distance between the work table and the platen, with the quill fully retracted.
- OVERCUT The distance between a side of the cathode lip and the side wall of a machined hole or cavity. This distance is measured at right angles to the feed axis and is usually expressed in thousandths of an inch per side.
- PASSIVE PROTECTIVE FILM A thin, transparent oxide film, formed naturally in air or by immersion in an acid solution, which enables some metals to resist corrosion.
- PENETRATION RATE The variable rate at which the cathode advances into or retracts from the work piece, usually expressed in thousandths of an inch per minute.
- PLANING The finishing of a surface, or the sizing of a bar or a rod, with tool travel parallel to the surface being machined. This method usually produces low microinch surface finishes.
- RAPID TRAVERSE RATE The fixed rapid rate at which the platen retracts from or approaches the work piece, as compared to the adjustable feed rate, for the machining part of the cycle.
- SACRIFICIAL ANODE A length of expendable metal, usually rod or wire, used to protect a permanent part from stray machining effects. Copper becomes anodic to stainless steel when attached to a positive polarity work table or fixture.
- SEPARATING FORCE The force resulting from the high pressure electrolyte tending to separate the electrode and the work piece.
- SHORT Short circuit resulting from the cathode physically contacting the work piece with current flowing, causing arcing, sparking, and possible tool damage.
- SIDE GAP (OVERCUT) The distance between a side of the cathode lip and the side wall of a machined hole or cavity. This distance is measured at right angles to the feed axis and is usually expressed in thousandths of an inch per side.
- SLUDGE Mudlike metal hydroxides, oxides, and so on removed from the electrolyte by a centrifuge or filters.
- SMUT A coating (black when machining steel) that appears on the cathode during electrochemical machining.
- SPARK The result of a minute short circuit from small metal particles in the machining gap—yellow or orange in color.

- SPECIFIC GRAVITY (OF THE ELECTROLYTE) The weight ratio of a given volume of the electrolyte to that of an equal volume of pure water.
- STRAY CURRENT Any electrical current which removes metal from areas of the work piece, fixture, or machine, other than where desired.
- STRAY MACHINING Very low current density electrochemical machining which takes place in areas other than at the machining gap.
- THERMAL CONDUCTIVITY The relative ability of a material to absorb or to transfer heat.
- THROWING POWER (OF THE ELECTROLYTE) The "wild" cutting or "stray" machining of an electrolyte adjacent to the actual machining area. Throwing power is increased by higher operating voltages and by increased conductivity of the electrolyte.
- TREPANNING Machining the perimeter of a desired shape, from a piece of greater area.
- TRI-SODIUM PHOSPHATE Inexpensive cleaner that can be used to clean out the electrolyte system, or in general clean up around electrochemical machines.
- TURBULENT FLOW Electrolyte flow that is extremely agitated. It is a "mixed up" flow and the resulting eddies cause an increase in resistance to flow.
- UNIFORM FLOW Electrolyte flow through the machining gap which is smooth and uniform in the entire machining area. Good machine design must be augmented by good tooling design to accomplish this end. (It is usually also turbulent flow.)
- VALENCE The degree of combining power of a chemical element. The higher the valence at which the metal goes into solution, the lower the metal removal rate.
- VISCOSITY The internal resistance of a substance to becoming a fluid, caused by molecular attraction.
- VOLTMETER A measuring instrument consisting of a galvanometer plus a series resistor to establish the range and connected across a piece of electrical equipment to measure the voltage (electrical pressure) applied.
- VOLUME, PERIPHERAL The combined outside linear dimensions of the machining face multiplied by the machining gap dimension.
- WORK TABLE A flat metal surface, usually made of copper or stainless steel, that supports and holds the work piece or fixture while the part is machined.

Index

- Accounting practice, 41
Accumulator, 235
Accuracy, 4
actions for thin components, 190
concentricity, 147
effect of current concentrations, 191
improvement, 67
lack of, 187-192
sacrificial work surfaces, 191
Accuracy of machining, 218
effect of throwing power, 219, 220
Accuracy of turning, 151, 154
Acid pickling of component, 184
Aeroengine, 3
industry, 3, 4, 8, 202
Air, screening from electrolyte, 212
Air bubbles, migration of, 207, 208
Airfoil, 66
machining, 104, 106
with static tools, 87
Alloys, ferrous-based, 162, 163
heat-resistant, 3
nickel-based, 162-163
titanium, 163
Ammeter, 235
Amperage capacity of machines, 66
Anion, 203
concentration, 218
Anocut Engineering Company, 2
Anode, 11, 235
acidity, 208, 218
passivity, 220
polarization, 212, 216
potential, 51, 212, 213
effect, of flow velocity, 187
of temperature, 199
Bus bar, 236
- on surface finish, 188
sacrificial, 240
shape, 14, 15
Anodic, corrosion, 56, 60
dissolution, 27, 212
films, 212, 215, 218
metal, 235
reactions, 206, 207
Arc, 235
anticipator, 235
see also Spark, detection
Area, selection for ECM, 52
Atmospheric corrosion, 235
Atomic weights of metals, 209, 210
Automatic, cycling, 28, 235
operation of tools, 181, 182
- Back, machining, 56
pressure, 113, 115, 147, 235
dams, 114
value of, 187
Backup, 236
Barreling, 46, 171
Batch sizes of components, 200
Benches, 49
Benzotriazole, 220
Beryllium copper, 236
Boss machining, 103, 106
Braid, 59
corrosion of, 59
Breakthrough of tool, 82, 236
Bright dip finish, 236
Burgess, C. F., 2
Burrs on component, 45, 184

- Cables, 59
corrosion of, 59
fluid trap for, 27
Capital investment, 4
Casting alloy, 60
Castings, 67
Cathode, 11, 236
body, 236
plating, 207, 208
reactions, 207
shape, 16
Cathodic, corrosion protection, 27, 60
metal, 236
Cations, 203
Cavitation, 39, 67, 115, 186, 187, 236
corrective actions, 187
effect on current, 186
suppression, 114
Cavity machining, 236; *see also* Die sinking
Center slug, 236
Centrifugal separation of hydroxides, 208
Centrifuges, 17, 34, 163, 236
Chemical corrosion, 54, 60
Component, appraisal, 143
for turning, 151
batch sizes, 200
contour tolerance, 72–74
corrosion of, 52
design changes to, 66, 67, 144
distortion of, 60, 66, 102–104
electrical contact to, 59
fatigue strength of, 66
grouping for machining, 106
heating effects, 104
inclusions in, 192–193
incompatible with tool shape, 123
initial shape before ECM, 106, 144
inspection of, 201
post ECM treatment of, 66
ridges on, 67
selecting areas to be machined, 95
sharp features of, 67
strength of, 102–104
stresses in, 77
thin or intricate, 60, 66
voltage loss in thin sections, 190
washing tanks for, 49
Condenser, evaporative, 34, 48
Conductivity of electrolyte, 61
Conducto-lube, 236
- Contact area, 236
Cool-amp, 236
Cooling water, 33
Copper braid, 59
cables, 59
plating for tool repair, 197
tools, 56
tungsten, 237
Corrosion, anodic, 56, 60
of cables and braid, 59
cathodic protection against, 27, 60
chemical, 54, 60
effect of electrolytes on, 54
electrochemical, 54
of equipment, 199
fixtures and tools, 51
galvanic, 54
inspection for, 55
inter-granular, 55, 164
of pipes, 31
pitting, 237
prevention of, 77
stray current, 202
of tooling, 27
use of titanium, 60
of work, 52
Cost, 3
comparative, 44, 46
direct labor, 41
of electricity, 43–44
of electrolyte, 42
of fixtures, 25
future reduction of, 202
installation, 48, 49
investment, 47
labor, 4, 41
machine breakdown of, 47
machines, 7
operation, 41
standard machines, 48
turning, 148
Costing an ECM operation, 65
Cost overhead, 41
Cost reduction for tools, 67
Crystalline structure, 46
continuity measurements, 180
field concentration, 133–134
joints, 59, 60
cleanliness, 191
effect on accuracy, 191
maintenance, 199

- minimum, 95, 99
practical upper limit, 99–100
for turning, 148, 152
distribution through component, 102–104
field concentration, 88, 190
flow distribution, 13
limiting factors, 224
machining, 239
potential curves, 213–219
effect of flow velocity, 215, 216
high values of current, 215, 216
transition points, 218
rate of change detector, 193
reversals, 207
stray damage, 104
Dams, 52
for back pressure, 114
to prevent loss of flow, 106
spring loaded, 114
Decomposition voltage, 204
Degreasing of component, 184
Design changes of component, 66–67
DIDT derivatives, 237
Die sinking, principle, 79, 83
limiting angles, 84
preference to generating, 85
tools, 129
Discharge potential, 213
Distortion of component, 60, 66
Drainage, 49
DVDT derivatives, 237
Dwell, 237
Economics, 41
Efficiency of ECM, 207, 211
Electrical anodic connection, 83
conductivity, 237
conductor, materials, 59
sections, 59
connections, 59, 191
tool platen, 27
work table, 27
contact grease, 59
continuity measurements, 180
field concentration, 133–134
joints, 59, 60
cleanliness, 191
effect on accuracy, 191
maintenance, 199
- power, 43
lines and cables, 48, 49
list of factors, 142
system, 18
unit, 37
short, 240
silvered paints, 59
substation, 48–49
transients, 39
work contact, 59–60
Electric field, 203
Electricity cost, 43–44
Electrochemical, equivalent, 209
machining, 237
accuracy, 15
advantages, 3
disadvantages, 7
flexibility, 5
fundamental principles, 11
history of, 2
introduction to, 1
learning to use, 7
manufacturing sequence, 77
operation time, 65
position in manufacturing cycle, 144
post treatment of components, 66
quality, 4
sequence with other processes, 145
stability of process, 206
successful use of, 8
team to use, 8
training, 7
reactions, 206, 207
Society (U.S.), 2
turning, 147–156
Electrochemistry, 202–225
fundamentals of, 202
research needs, 202
Electrode, 202, 237
Electroforming, 12
Electrolysis, 203, 237
laws of, 12, 208, 209, 238
of water, 12, 207
Electrolyte, acid additives, 164
aging, 221
chemical reactions, 208
circuitry servicing, 200

clarification, 37
 cleanliness, 17
 of ducts, 64
 concentration, 165, 237
 conductivity 61, 165, 225, 237
 effect on surface finish, 188
 contamination, 36
 control, 36
 corrosive effects, 54
 costs, 42
 flow, *see* Flow
 forces, 18
 heaters, 33
 material machinability, 162
 pressure, 15, 57, 61, 63
 control, 32
 forces, 64
 properties, 17
 proportion of constituents, 164
 references, 176
 requirements of, 143
 resistivity of, 237
 reverse flow, 82
 selection, 35, 162, 165, 171
 sodium chlorate, 5
 specific gravity, 241
 systems, 16, 29
 summary of, 38
 table with properties, 166–169
 temperature, 32
 control, 37, 199
 effect on polarization, 204
 testing equipment, 173
 throwing power, 219
 uniformity of properties, 189, 190
 Electrolytes, 11, 202, 237
 Electrolytic cell, 237
 Electromotive force, 203
 Electronic protection, 39
 Electrophoresis, 207
 Electroplating, 12
 Electropolishing, 12, 214
 Enclosure of machine, 239
 Entry radius, 238
 Epoxy resin, insulation, 131
 Equilibrium gap, 238
 Equipment depreciation, 199
 Etching band on component surface, 223
 Exit radius, 238

Faraday, 2, 12
 constant, 209
 laws of electrolysis, 208, 209
 Fatigue, ECM test tooling, 174
 endurance of components, 66
 Krouse specimens, 174
 strength, 4, 46, 170, 171, 174
 comparative values, 171
 testing, 170, 171
 Feed rate, effect on gap, 178
 flow, *see* Flow
 of tools, 63, 65, 140, 238
 Ferrous systems, 27
 Ferrous alloys, 65
 Filter, 17, 30, 140, 238
 cleaning and servicing, 193
 construction, 31
 corrosion, 31
 materials, 30
 mesh size, 30
 position of, 31
 Fixture, alignment, 56
 corrosion of, 51
 cost, 25
 materials, 51
 strength and stability, 51, 54, 57, 58
 thermal expansion, 32
 Flow, across tool, 113
 adjacent sources, 116, 122
 arrangement, 52, 104–122
 for turning, 152
 back pressure, 113, 115, 133
 cavitation, 39, 67, 114, 115, 140
 convergent, 186
 deflection by ridge, 103
 direction, 161
 changes in, 115
 distribution, 122, 123
 divergent, 133, 186
 duct sections for, 64
 effect of solid particles, 193
 exhaust, boundaries, 116
 from tool, 79
 forward, 112
 general guide to, 145
 general rules, 109
 high velocities, 225
 inadequate, 193, 212
 Faraday, 2, 12
 constant, 209
 kinetic energy, 58, 109
 laminar, 239
 lines, 187, 216, 238; *see also* Surface, striations
 meter, 32
 methods of supply to tool, 100, 101
 natural supply points, 100, 101
 path of, 61
 for tuning, 148
 path length, 62, 63, 82, 116, 190
 pressure differential, 124, 125
 rate of, 133, 238
 restrictor, 52, 146, 147, 182
 dam, 113
 plug type, 129
 principles, 122–125, 129
 rules for, 129
 reversed direction of, 109, 110, 133
 slots, 45
 smooth distribution, 216
 supply ducts, 63, 143
 supply slots in tools, 67
 testing new tooling, 181
 tool entry, 115
 radius, 115
 tools slots for, 66
 turbulence, effect on overvoltage, 204
 turbulent, 241
 turning segmental parts, 156
 uniform, 241
 velocity, 15, 16, 61
 viscous pressure losses, 109
 volume of, 62
 Fluidized bed, 238
 Force of separation, 240
 Forgings, 67–69
 Galvanic, cell effect, 180
 corrosion, 54, 180, 238
 Gap, machining, 14, 17, 177, 238
 methods of measurement, 180
 safe starting value, 182
 selection factors, 140
 suggested values, 141
 Gap size, 61, 189
 in die sinking, 83
 effect, of feed rate, 178
 of temperature, 199
 Gas bubbles, 14
 effect on flow, 187, 225
 Gas turbine, 3
 industry, 202
 Gauging, in-process, 151
 Generating, tool insulation, 79
 principle of, 79
 Glass ball peening, 4, 46, 171
 Glossary of terms, 235–241
 Gravitational setting of hydroxides, 208
 Grit air blasting, 46, 66, 171, 184
 Gusset, W., 2
 Heat, exchanger, 33, 239
 process generated, 32, 33
 treatment, 45
 Heaters, for electrolyte, 33
 Heating, by steam, 49
 History of ECM, 2
 Holes, final sizing of, 160, 161
 Hoses, 31; *see also* Pipes
 Hydrochloric acid, 212
 Hydrodynamics, 239
 Hydrogen, bubbles, effect of, 80
 evolution, 133
 explosive limit, 27
 gas liberation, 207
 removal of, 27
 safety factor, 27
 Hydrogen ion, concentration, 208, 212, 218
 effect on anodic dissolution, 213
 roll in dissolution process, 224
 Hydrolysis of water, 207
 Hydrometer, 239
 Hydrostatic force, 239
 Hydroxide, 11, 12, 14, 17, 31, 34, 37, 133,
 207, 212
 formation of, 208
 gravitational settling, 163
 Hygrosensor, 239
 Inclusion, 239
 Industry, 3
 gas turbine, 3, 4, 8, 202
 Inspection, of component, 201
 Sampling, 201
 Installation, costs of, 48, 49
 machine, 48
 Instrumentation maintenance, 200
 Inter-granular corrosion, 164, 239

Insulation, 56, 239
 coating procedures Anocoat 6004–5,
 227–229
 Anocoat 6006, 229, 230
 synthetic rubber, 231, 232
 effect of flow velocity, 131
 failure of, 129
 generating tool, 79, 129
 materials, 131
 tool, 53, 129, 130, 146
 strength and reliability, 131
 synthetic rubber coating, 130
 Investment, capital, 4
 machinery and tooling, 3, 7
 Ion, 203
 chromium, effect on throwing power, 221
 diffusion through anode films, 204
 hydroxyle, 207
 migration of, 11, 13, 203, 204
 through anodic film, 218, 225
 in solid films, 215
 Iron dissolution reaction, 206
 Jacquet, current potential curve, 214
 Jet-engine, 4, *see also* Aeroengine
 Jobbing shops, 8
 Keys, adjustable, 57
 Kinetic energy, 186
 Labor cost, 4, 41, 65
 Lasers, 180
 effect on machining rate, 225
 Machinability of materials, 162
 breakdown of costs, 47
 beam type, 25
 capital depreciation, 65
 cleaning, 200
 costs of standard type, 48
 electrochemical, 20
 general features, 26
 horizontal frame type, 22
 installation of, 48
 investment cost, 3, 7
 maintenance, 199
 manning, 200
 numbers in operation, 8

price of, 7
 services, 48
 shift operation, 200
 strength of, 18, 58
 suppliers of, 7
 thermal expansion, 32
 vertical 'A' frame type, 20
 vertical 'C' frame type, 22
 vertical underdrive type, 22
 Machining, conventionally, 79
 distortion of component, 66
 forces, 57
 cycle time for, 42
 operation sequence, 101
 rates of, 14, 18, 209–211
 Machining of, rods and bores, 220
 turbine engine casing, 110
 vertical walls, 129
 Magnetic forces, 58
 Maintenance, 42, 199, 200
 Manifold, auxiliary, 26
 Material allowance for machining, 70–76,
 189
 crystalline structure, 188
 electrical conductors, 59
 etching characteristics, 221, 222
 fixtures, 51, 54
 grain size, 188
 heat treatment, 188
 inclusions, 192, 193
 removal rate, 65
 shape prior to ECM, 52, 67, 69, 70
 stability of, 59
 structure of, 163
 tooling, 51, 54–56, 141
 Metal, dissolution, 11
 hydroxide, 11
 removal, efficiency, 211
 rate, 14, 18, 209–211, 239
 Metalography, 163, 164
 Micron, 239
 Mil, 240
 Milling, mechanical, 3
 Mist collector, 240
 Mounting plate, 240
 Polishing, of components, 66
 mechanical, 171
 plateau, 214–216
 Potassium dichromate, 220
 Potential, uniformity on work surface, 189
 Price gradient, 163
 effect on surface finish, 221, 222
 variation over anode surface, 222, 223
 Potentiostatic control of anode potential, 218
 Precipitate, hydroxide, 12
 Pressure, control, 32
 differentials along flow path, 124, 125
 of electrolyte, 15, 57, 61, 63
 Process, by-products, 133, 190
 energy, 186
 forces, 64
 selection to suit tool, 181
 Pump, capacity, 17, 30, 124
 centrifugal, 29
 defining output, 30
 fault check list, 194–196
 Production, operation of tools, 198–201
 time losses, 200
 Personnel, training for production, 198
 pH of electrolyte, 218
 pipes, checking and servicing, 193
 corrosion, 31
 electrolyte supply, 26, 31
 materials, 31
 Pitting of component surfaces, 164, 223
 Planing, 240
 Plastics, reinforced, 131
 Platen movements, 26
 Polarization, 225
 activation, 204
 changes with current, 213
 concentration, 204, 212
 effect on throwing power, 219
 ohmic, 214
 Polishing, of components, 66
 mechanical, 171
 plateau, 214–216
 Potassium dichromate, 220
 Potential, uniformity on work surface, 189
 Short circuit, 17, 240
 Potential gradient, 163
 effect on surface finish, 221, 222
 variation over anode surface, 222, 223
 Rate of metal removal, 14, 18
 Reverse flow, 82, 106, 107, 133
 Ridges, 45
 on components, 66, 67
 due to flow slots, 100
 for deflecting flow, 103
 use for flow supply points, 106
 Rods, final sizing of, 160, 161
 Safety of operator, 165
 Salt deposits, 27
 Scrap, 4
 Settling tanks, 17
 Set up times for tooling, 200

Shot peening, 66
 Shuttle loading of components, 200
 Side gap, 240; *see also* Overcut
 Slip gauges (go blocks), 57
 Slots, blending for smooth flow, 106
 cross section geometry, 113
 curved, 106
 exhaust, 109, 110, 112
 flow supply, 129
 intersecting, 109, 110
 radii for suitable flow, 113
 for reentrant areas, 106
 single per tool, 109, 110
 supply for flow, 112, 113
 terminating in tool corners, 106
 Sludge, 240; *see also* Hydroxide
 Smut, 240; *see also* Cathode, plating
 Sodium, bromide, 164
 chlorate, 5, 164, 202, 221
 for machining ferrous metals, 220
 chloride, 163, 164
 fluoride, 164
 nitrate, 163, 164
 Spare parts for tooling, 199
 Spark, detection, 185, 192, 198
 protection, 39
 Sparks, 17, 39, 192, 193, 240
 Stainless steel for tools, 56
 Static machining principle, 79
 Special merits, 88
 Static tools, principle of operation, 86
 for quality finished surfaces, 82
 series of, 87
 Storage, 49
 Stray, corrosion, 102, 103
 current, 24
 damage to anodic surfaces, 104
 machining, 129, 156, 241
 Stress, 45, 46, 66
 annealing, 45
 component distortion, 77
 cyclic, 164, 170
 detection of, 189
 relieving prior to ECM, 45, 189
 surface residual, 170
 Striations on a surface, 186
 Surface, bright spots, 187
 etching characteristics, 163, 164
 films, 45
 integrity, 40, 163

mechanically worked, 170
 oxide films, 164
 pitting, 164
 post ECM treatments, 171, 173
 preparation for ECM, 184
 striations, 186, 187
 texture improvement, 164
 Surface finish, 148, 188, 189, 221
 damage, 104
 effect, of current density, 222
 of electrolyte, 189, 223
 by generating, 80, 82, 156
 improvement of, 45
 obtaining a uniform standard of, 99
 by static tool, 82
 using reverse flow, 107
 Swimming pools, 32, 37
 series of, 37
see also Tanks
 Tanks, component washing, 49
 electrolyte clarification, 37
 storage, capacity, 32, 36
 system, 36
see also Swimming pools
 Temperature, changes in gap, 133
 control of electrolyte, 18, 33, 37
 of electrolyte, 32
 Tenons, 57
 Thermal conductivity, 241
 convection, effect on ion migration, 204
 expansion of tooling, fixturing and machines,
 series of, 32
 shock of components, 66
 Throwing power, effect of passivity, 220
 of electrolytes, 219, 241
 Time of operation, 65
 Titanium, alloys, 65
 corrosion resistance, 60
 dissolution process, 164, 212, 224
 Tolerance, of final component, 72, 74
 processing factors, 140
 Tool, alignment, 51, 56, 142
 error, 189
 annual clearance for flow, 124
 automatic operation of, 181, 182
 breakthrough, 82
 contour error, 189
 copper, 56

oxidizing of, 130
 correction, *see* Tool shape correction
 corrosion of, 51
 damage, 40, 129, 184, 192, 193
 die set alignment, 57
 electrolyte slots, 66, 67
 feed, high rates of, 159
 feed rates, 63, 65, 140
 for turning, 152
 flow supply ports, 116
 geometry, of adjacent tools, 91, 93
 for different feed directions, 93
 insulation of, 53, 129, 146
 to minimize field effects, 191
 land, 79
 sizes of, 133
 lip clearance, 239
 location of, 26
 materials, 51, 54, 56
 movement of, 19
 natural flow points, 106
 overcut, 79, 82, 133, 177
 using tapered tools, 159
 plan area of, 95, 99
 platen, electrical connection to, 27
 position indication, 28
 production operation of, 198–201
 repair of, 56, 197
 reverse flow, 106
 shape of, 67; *see also* Tool shape correction
 stainless steel, 56
 tapered, 147, 156–161
 trepanning type, 82
 turret mounting of, 57
 two stage operation of, 84
 vibration of, 19, 58, 180
 wear of, 4
 Tool design, check list for, 141–146
 for component features, 100
 for flow distribution, 100
 for flow slots, 106
 general aspects of, 7, 50
 procedure for, 51, 65
 Tooling, basic concepts of, 51, 54
 corrosion of, 27
 cost of, 65
 cost reduction, 67
 damage to, 42
 deflection forces, 191
 design and operation of, 9
 control of, 18

development period for, 185
 for fatigue specimens, 174, 176
 faults and their correction, 185–197
 fault, check list for, 194–196
 location, 185, 186
 general guide to, 144
 investment for, 3, 7
 maintenance of, 42, 199
 preventing repetitive faults, 197
 set up times, 200
 shuttles for multi-part loading, 200
 spare parts for, 199
 strength and stability, 18, 140, 142
 thermal expansion, 32, 199
 vibration of, 192
 warm up time for, 199

Tool shape correction, 67, 132–141, 189, 219
 analysis for die sinking, 136, 137
 field concentration, 88
 formulae for, 136, 137
 tables for, 138–140
 for turning, 150

Tool shape for static operation, 87, 88
 Tools for die sinking, 129
 for generating, effect of cavitation, 186
 principle of, 156
 multi, 45
 for turning, feed direction of, 154, 155
 full area type, 148
 plastic inserts for, 155
 segmental, type, 147–149
 size, 152, 154

Transfer of matter, 208–211
 Transformer, saturable reactor type, 38
 Trepanning principle, 82, 241
 Tri-sodium phosphate, 241
 Turning, basic concepts of, 148
 of segmental components, 156
 voltage response required for, 39

Valency, of anodic dissolution, 212
 of metals, 206, 209, 210, 241
 Vapor honing, 171
 Velocity of electrolyte flow, 15, 16, 61
 Vibration, ultrasonic, effect on machining
 rate, 225
 Vibropolishing, 46, 66, 171
 Viscosity, 241
 Voltage, applied, 13
 control of, 18

decomposition, 204
effect on gap, 178
gradient, 4, 163
effect on surface finish, 170
high spiked waveform, 225
high values of, 165, 225
losses, at electrodes, 178
in circuitry, 191
in thin components, 170, 190
machining value of, 239
regulation of, 38, 39
response for turning, 39
Voltmeter, 241
Volume, peripheral, 241

Water, for cooling, 33
hammer, 58
lines and pipes, 49
Wild cutting, *see* Stray, machining
Work, electrical connection to, 60
Work enclosure, 26
washing of, 48
Work table, 21
electrical connection to, 27
fixed type, 238
movable type, 240
Zinc, dissolution of, 218
Zone of machining, 239

