

Study of Electrochemical Polishing Applications in some alloys to obtain high surface finish

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Abstract

Electrochemical polishing with 10% Sodium chlorate electrolyte was used to investigate chemical polishing for three metal alloys used widely in mechanical industries, to obtain high surface finish.

The relationships between polishing time – surface roughness, and current density – surface roughness was studied for hot work tool steel, cold work tool steel and dure aluminum. From which it has been shown that it was possible to obtain surface roughness $2.8 \mu\text{m}$ at polishing time (120min) for hot work , $2.31 \mu\text{m}$ at polishing time (120min), for cold work tool steel and dure aluminum respectively. Three more experiments were also carried out to study the relation ship between current density and surface roughness at (120 min) for each experiment. It was possible to get surface roughness ($2.5 \mu\text{m}$) at current 0.15 Amp/cm^2 for hot work tool steel, $2.8 \mu\text{m}$ at current 0.15 Amp/cm^2 for cold work tool steel and $2.3 \mu\text{m}$ at current 0.1 Amp/cm^2 for dure aluminum.

This study was applied in Nasser state company for mechanical industries / central tool plant to obtain high quality polishing for injection mould cavity, spure gear, bevel gear and combustion chamber parts.

Keywords:

Electrochemical Polishing, cold work tool steel, hot tool steel , surface roughness, dure aluminum.

Introduction

The subject of this study is to develop low impact, low temperature technique to polish and debure injection mould and die casting cavities, press working sheet metals punches and dies and other mechanical machining parts/ Electrochemical polishing was chosen for this application.

Electrochemical machining is a technique which metals are polished and debured by the passage of anodic current through the metal work piece (the anode), across an electrolyte and into a second metal electrode (the cathode) [1]. The rate of metal removal due to cutting is independent to the hardness of the work piece. The process is shown schematically in Fig(1):

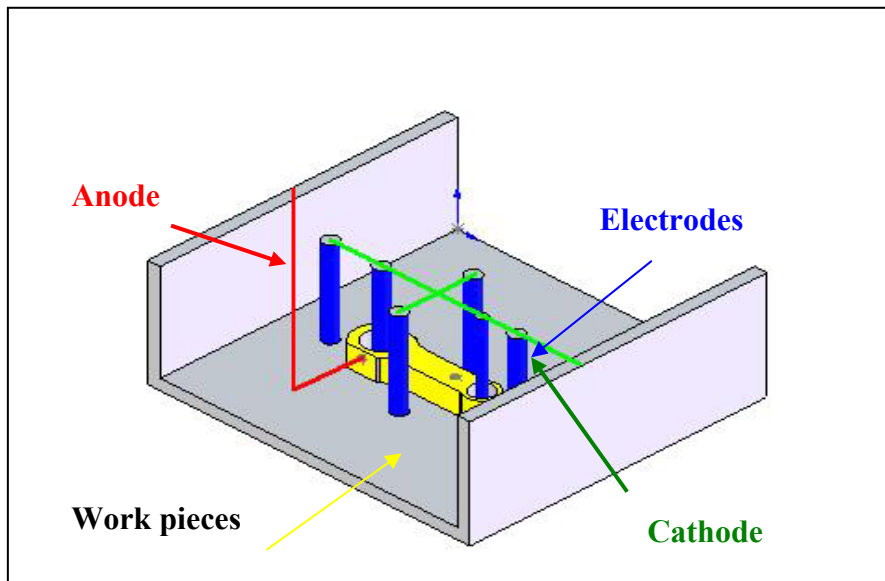


Fig. 1 Schematic of Electrochemical polishing

The tool electrode used in the process does not wear and therefore soft metals can be used as tools to form fine polishing surface on harder parts, unlike conventional machining methods. The chemical properties of the electrolyte may benefit current distribution. A localization of current flow to smallest dimensions of the anode is desirable to minimize the time required for polishing at a fixed current [2].

Type of electrolytes used in the process affects the quality of surface finish obtained in ECM. Depending on the material, some electrolytes leave an etched finish. This finish results from the nonspecular reflection of light from crystal faces electrochemically dissolved at different rates. Sodium chloride electrolyte tends to produce an etched, matte finish with steels and nickel alloys.

The production of an electrochemically – polished surface is usually associated with the random removal of atoms from the anode work piece, whose surface has become covered with an oxide film. This is governed by the metal – electrolyte combination used. Nonetheless, the mechanisms controlling high – current density electro polishing in ECM are still not completely understood. For example, with nickel – based alloys, the formation of a nickel oxide film seems to be a prerequisite for obtaining a polished surface; a finish of this quality, of $0.2\mu\text{m}$, has been claimed for Nimonic (a nickel alloy) machined in saturated sodium chloride solution. Surface finishes as fine as $0.1\mu\text{m}$ have been reported when nickel – chromium steels are machined in sodium chlorate solution. The formation of an oxide film on the metal surface is considered the key to these conditions of polishing.

Sometimes the formation of oxide film on the metal surface hinders efficient ECM and leads to poor surface finish. For example, the ECM of titanium is rendered difficult in chloride and nitrate electrolytes because the oxide film formed is so passive. Even when higher voltages about 50V are applied to break the oxide film, its disruption is so non-uniform that deep grain boundary attack of the metal surface can occur.

Occasionally, metals that have undergone ECM have a pitted surface while the remaining area is polished or matte. Pitting normally stems from gas evolution at the anode; the gas bubbles rupture the oxide film.

Process variables also affect surface finish. For example, as the current density is raised the finish generally becomes smoother on the work piece surface. A similar effect is achieved when the electrolyte velocity is increased. In tests with nickel machined in hydrochloric acid solution the surface finish has been noted to improve from an etched to a polished appearance when the current density is increased from about 8 to 19 A/cm² with constant flow velocity [2].

The purpose of this study is to design, a polishing and deburring./... system and study the parameters affect on electrochemical polishing.

Experimental work::

The experimental work (Fig. 2) designed to debure and polish cavities of injection mould and die casting, gears and other machining mechanical parts. The work piece (the anode) after degreasing process and cathode were immersed in 10% sodium chlorate.

The anode and cathode held to the power supply (30 V, 10 Amp). The work piece fixed in the electrical cell by polyethelene fixture.

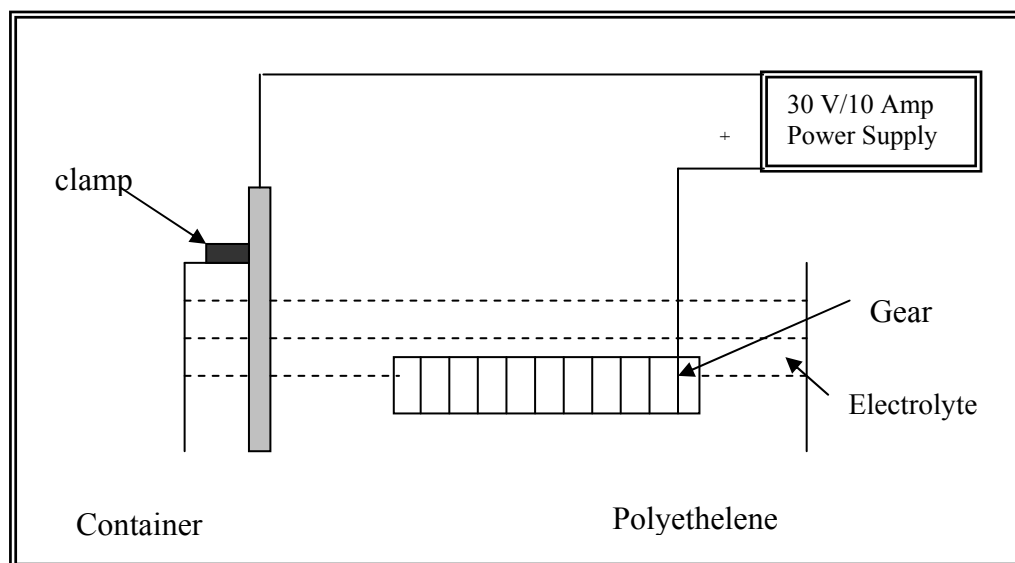


Fig. 2 Schematic of electro polishing system

Experimental tests and results:

Three types of alloys were used in the experimental tests. The first one (X40CrMo121) which is hot work tool steel according to (DIN). This alloy widely used in industry of hot forging dies injection mould and die casting dies.

Hardness of this alloy between (54-58) HRC the chemical composition of this alloy as shown in table 1.

Table 1 chemical composition of (X40CrMoV121)

C%	Cr%	Mo%	V%	S&P%
0.4 -0.45	1.0-1.2	0.6-1.0	1	0.04

The second is (X210Cr12) which is cold work tool steel according To (DIN). This alloy is widely used to produce press working sheet metal dies. Hardness of this alloy between (63-65) HRC. The chemical composition of this alloy as shown in table 2.

Table 2 chemical composition of (X210Cr12)

C%	Cr%	S&P%
2.1	12	0.03

The third is AlMgCuO5 according to (DIN). This alloy is widely used to produce aircraft parts, ships and blow mould dies [3]. The chemical composition of this alloy as shown in table 3.

Table 3 chemical composition of (AlMgCuO5)

Al%	Mg%	Fe%	Cu%
95-96	0.75-0.95	0.4-0.6	2.5-2.65

The relationship between polishing time- surface roughness, and current density – surface roughness was study for each alloy, the results for each experimental as shown in fig.3,4,5,6,7 and 8 respectively.

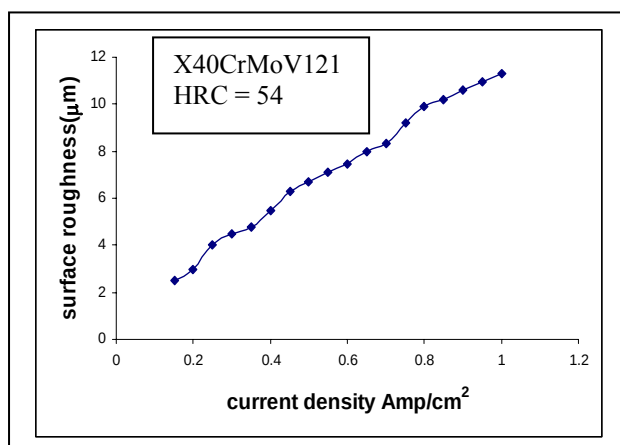


Fig.3 the relation ship between surface roughness and current density for hot tool steel

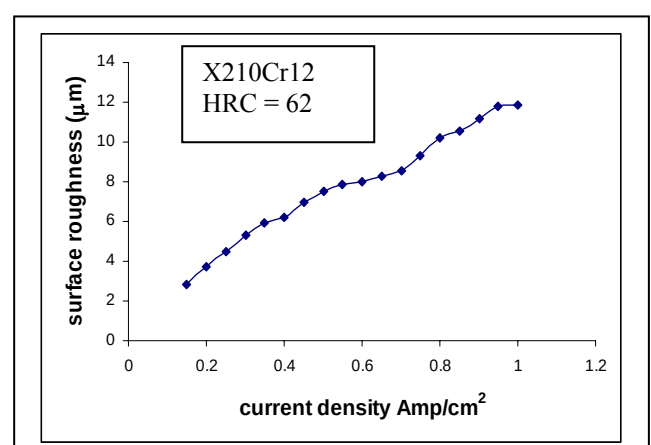


Fig.4 the relation ship between surface roughness and current density for cold tool steel

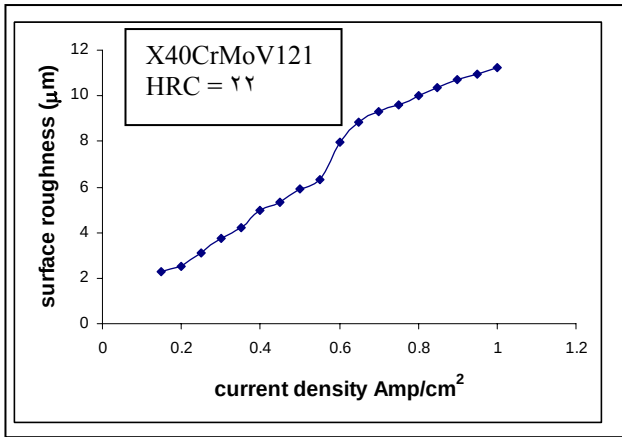


Fig. 5 the relation ship between surface roughness and current density for dure aluminum

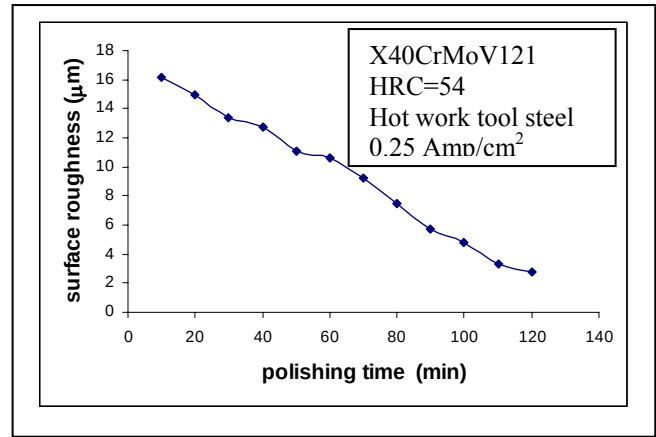


Fig. 6 the relation ship between surface roughness and polishing time for hot tool steel

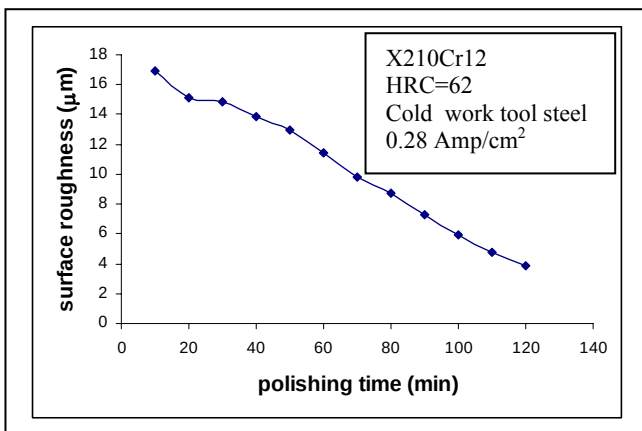


Fig. 7 the relation ship between surface roughness and polishing time for cold tool steel

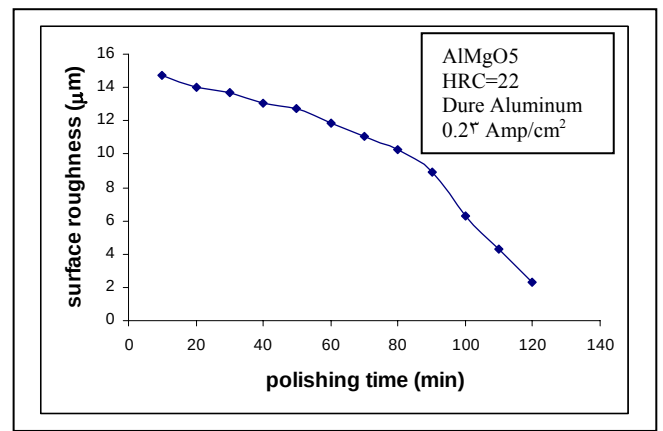


Fig.8 the relation ship between surface roughness and polishing time for Dure Aluminum

Results discussion:

The reported experimental with ECM support the use of this technique to debure and polish tool cavity and mechanical parts with goals discussed in the introduction:

1. from fig 3,4,5 which are represent the relation ship between current density and surface roughness of hot and cold work tool steel and dure almunine respectively, we obtain high surface finish (low roughness) 2.5, 2.8, 2.5 at current density 0.15 Amp/cm², and when current density rise the surface roughness will increase because of dissolution of sodium chloride, this effect make low conductivity of electrolyte [4].
2. There no different between the results of hot and cold work tool steel because the electrochemical process dose not depend on the hardness and chemical composition of the steel alloy [5].

3. from fig. 6,7,8 which are represent the relation ship between time of machining and surface roughness, we obtain high surface finish (low roughness) at time (120 min), this time of machining is suitable and economic in industrial operations.

Conclusions:

Electrochemical process is best known for the bright polish left a surface, there are some important, often overlooked benefits of this metal removal method. These benefits include deburring and micro finish improvement.

These metal improvement benefits offer great promise to design and production engineers for cost savings and product improvement.

All forms of corrosion on or near the surface. Unfortunately all fabricating and handling practices invariably degrade surface conditions and surface properties. Surface contaminants, including grease, dirt, iron, and other metallic particles are inherent to the metal machining, welding and fabrication process. Mechanical cutting, machining, handling and polishing will leave iron and abrasive particles embedded within a material surface. These surface contaminates disrupt the formation of stainless steels (and other corrosion resistant materials) naturally corrosion resistant oxide layer and are the origin of future corrosion. Electro polishing removes surface material and surface contaminants. Electro polishing dissolves free iron, inclusions, and particles from the surface of the steel.

Electro polishing improves the near surface chemistry of stainless steel. Not only does it remove embedded particles and inclusions, it also improves the atomic ratios of the materials alloying elements.

Electro polishing improved micro finishes can do more than improve the appearance of a part. Superior micro finishes can improve seals, lower friction, reduce real surface area, allow for easier sanitation, and improve heat and light reflection.

The roughness of a surface can be measured and quantified by a profilometer. A profilometer will produce a reading of the surface roughness in either micro – inches (μin) or micrometer (μm). The electro polishing process may improve a surface finish reading by up to 50%. Because electro polishing is not a surface coating; there is no risk of the surface distorting or peeling over time.

References:

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