

THE EFFECT OF MAGNETIC FIELD ON THE ELECTROPOLISHING OF VERTICAL CYLINDERS IN PHOSPHORIC ACID

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ABSTRACT

The rate of electropolishing of vertical copper cylinders in ortho-phosphoric acid was studied by measuring the limiting current at which polishing takes place using a two compartment cell. Variables studied were phosphoric acid concentration, temperature and magnetic flux density. The polishing current was found to increase with the decrease of acid concentration. Magnetic field was found to increase the polishing current. The effect of temperature on the limiting current was found to obey Arrhenius equation.

INTRODUCTION

Electropolishing is a metal finishing process in which the metal to be polished is made an anode in electrolytic cell. The cell current is adjusted at a certain value called the limiting current, below this current no polishing takes place but etching takes place instead of polishing. Mechanistic studies [1-6] have shown that the limiting current at which polishing takes place depends on the physical properties of the solution, geometry of the article to be polished and the hydrodynamic conditions of the solution (degree of stirring). The object of the present work is to study the effect of some variables such as solution temperature and the application of magnetic field on the limiting current. Temperature affect the physical properties of the solution (density, viscosity and diffusivity of the dissolution product); while magnetic field when coupled with electric field induces a solution flow [7,8]. No previous studies have been reported on the effect of magnetic field on the rate of electropolishing.

EXPERIMENTAL TECHNIQUE

Fig. 1 shows the apparatus used and the electrical circuit. The cell used was a cylindrical glass container 8 cm in diameter and 35 cm in height divided into two compartments by a cylindrical porous diaphragm 9 cm in diameter and 15 cm. in height to prevent the stirring effect caused by the hydrogen bubbles evolved at the cathode from reaching the anode compartment. The cathode of the cell consisted of a

cylindrical copper sheet 10 cm in diameter and 16 cm in height placed in the outer compartment of the cell. The cell was mounted in a uniform magnetic field caused by a solenoid carrying current. The cathode also acted as a reference electrode by virtue of its large surface area compared with that of the anode. The electrical circuit consisted of 6 volt d.c power supply, a variable resistance and a multirange ammeter connected in series with the cell and a high impedance voltmeter connected in parallel with the cell. Three concentrations of H_3PO_4 were (8M 10 M and 12 M) all of which were prepared from Analar Grade H_3PO_4 .

The temperature of the experiment was regulated by enclosing the cell in a thermostated water bath. The polarization curves from which the limiting currents were determined were plotted at different magnetic flux densities by increasing the cell current stepwise and measuring the corresponding cell voltage. The magnetic flux density (B) was determined according to the well-known relation.

$$B = \mu_0 n_0 I \text{ Weber/m}^2 \text{ (Tesla)}$$

where, $\mu_0 = 4\pi \cdot 10^{-7}$ Weber/Ampere. meter.

n_0 = number of solenoid turns per 1 meter.

I = current passing through the solenoid in Amperes. Before each run the flat bottom of the cylindrical anode was insulated with polystyrene lacquer and the surface of the cylinder was degreased with trichloroethylene, polished with fine emery paper and finally rinsed in distilled water.

RESULTS AND DISCUSSIONS

Fig. 2 shows typical polarization curves with a well defined limiting current at different phosphoric acid concentration, the limiting current increases with decreasing phosphoric acid concentration with a consequent increase in the rate of polishing. The increase in the limiting current with decreasing phosphoric acid concentration may be attributed to the decrease in acid viscosity which favours the transfer of the dissolution products away from the anode surface. Mechanistic studies [1-3] of electropolishing have shown that conditions that favours the transfer of the dissolution products (copper phosphate) away of the anode surface leads to an increase in the limiting current and the rate of polishing. Fig. 3 shows that the limiting current increases with increasing the magnetic flux density at different temperatures. This may be ascribed to the flow of the solution induced by the interaction of the magnetic field and the electric field of the electrolytic cell. [7,8] This flow assists in removing the dissolution products away of the anode surface with a consequent increase in the rate of polishing (limiting current). Fig. 4 shows that the rate of polishing and the limiting current increases with increasing solution temperature according to Arrhenius equation, ^(1,2)

$$I_L = I_0 e^{-E/RT}$$

where, I_L is the limiting current; I_0 is a constant; E is the activation energy, R is the universal gas constant and T is the absolute temperature.

The increase of the limiting current with temperature may be attributed to the decrease of solution viscosity which facilitates the removal of the dissolution products away of the anode surface.

REFERENCES

1. W.J. McG. Tegart, *The Electrolytic and Chemical Polishing of Metals*, Pergamon, New York, (1959).
2. W.C. Elmore, *Electrolytic Polishing*, *J. Appl. Phys.* 10(1938) 724.
3. P.A. Jacquet, *Mettallography* 5(15), 415 (1972).
4. D.R. Gade, *Corros. Sci.*, 12 (1972), 113.
5. S.S. Iskander, I.A.S. Mansour and G.H. Sedahmed, *Surface Technology*, 11(1), (1980), 67.
6. I.A.S. Mansour, T.H. El-Sherify, G.H. Sedahmed and M.A. Ghabashy, *Surface Technology*, 16(1982), 249.
7. Cousins, C.A.: Dash, J.; Gorg C., *J. Appl. Phys.* 55 (1984), 2606.
8. Mohanta, S. and Fahidy T.Z., *J Appl. Electrochem.* (1978) 8,5.

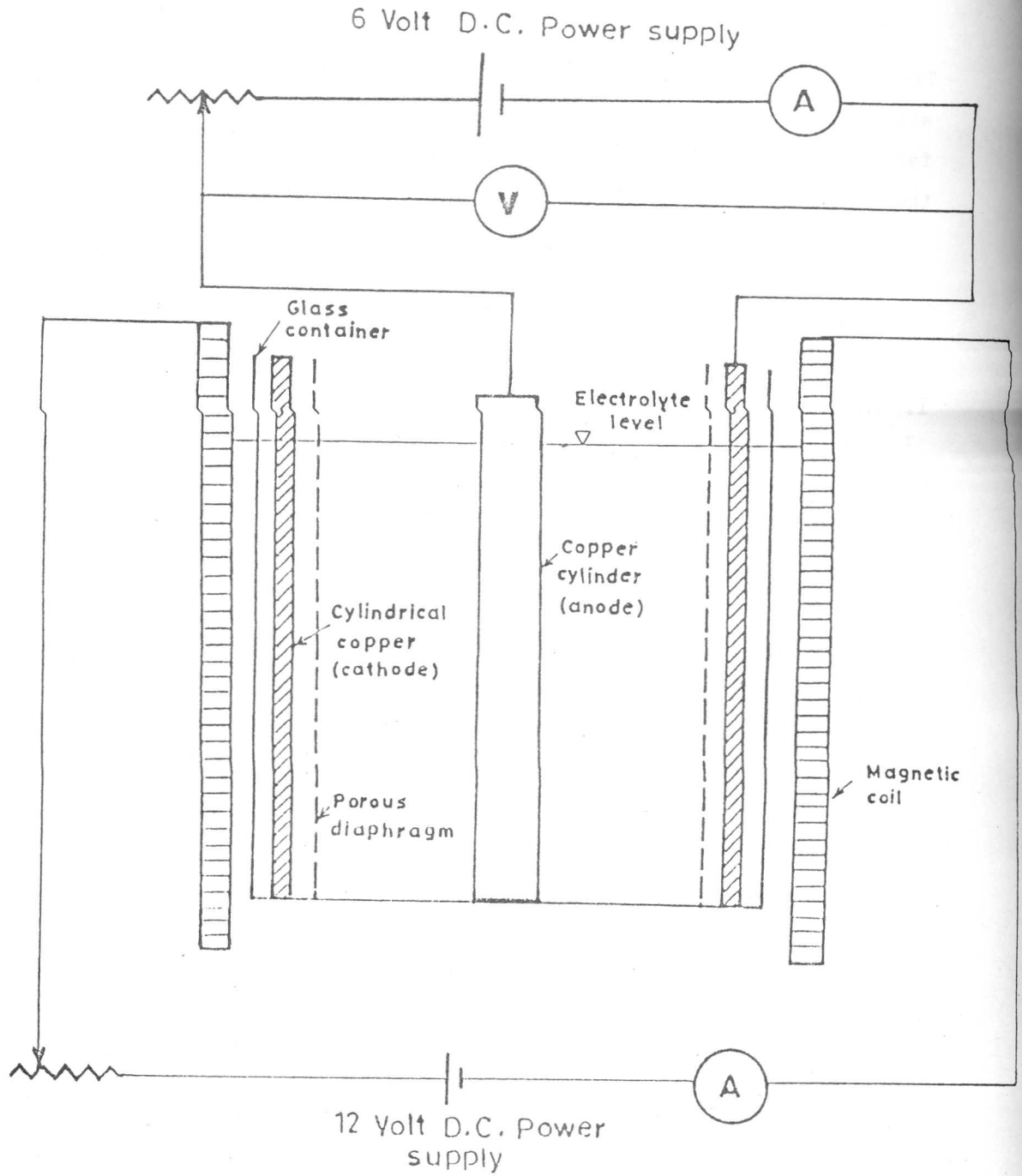


Fig.1, Experimental apparatus .

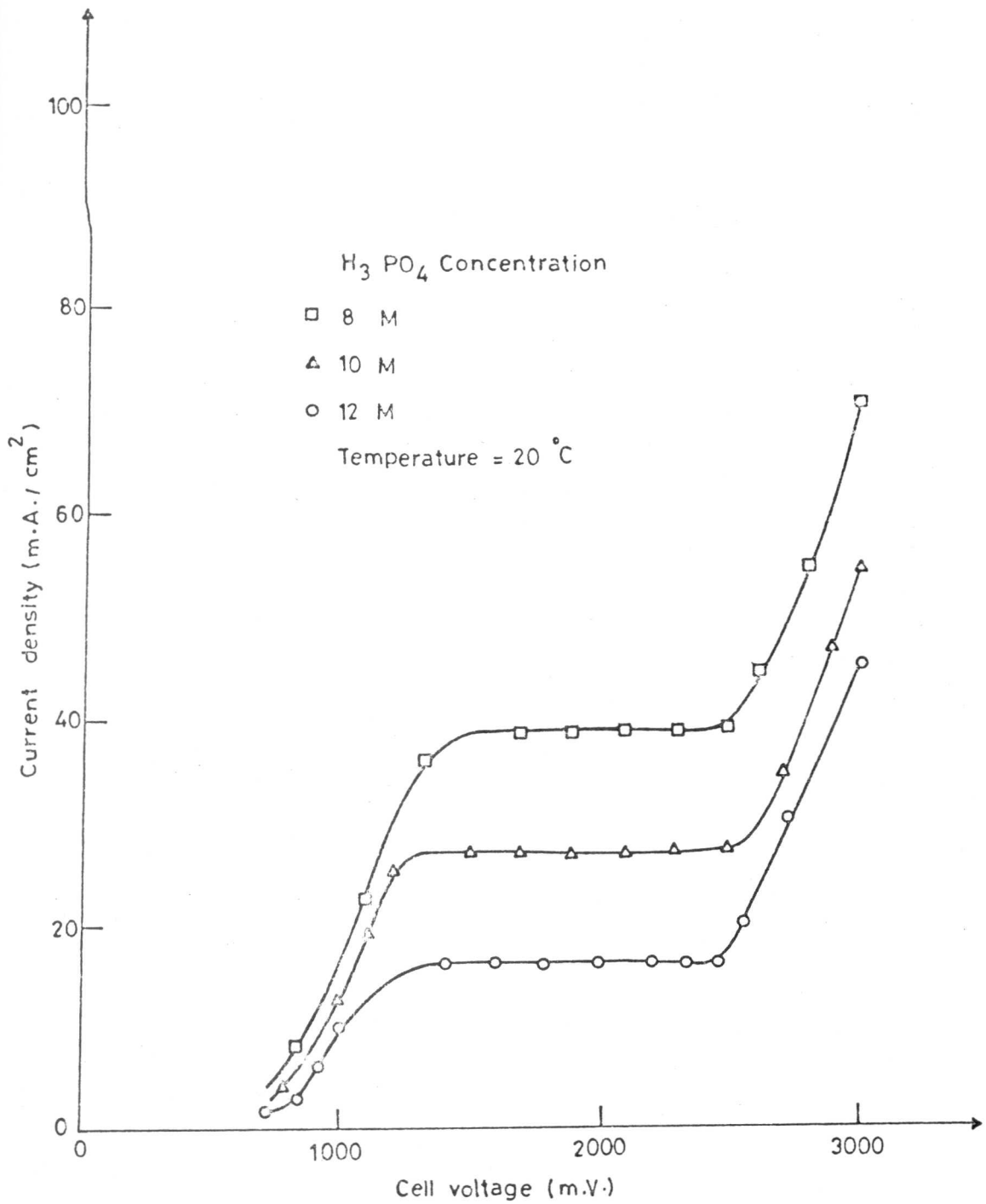


Fig.2, Polarization curve at a magnetic flux density 55×10^{-4} Tesla.

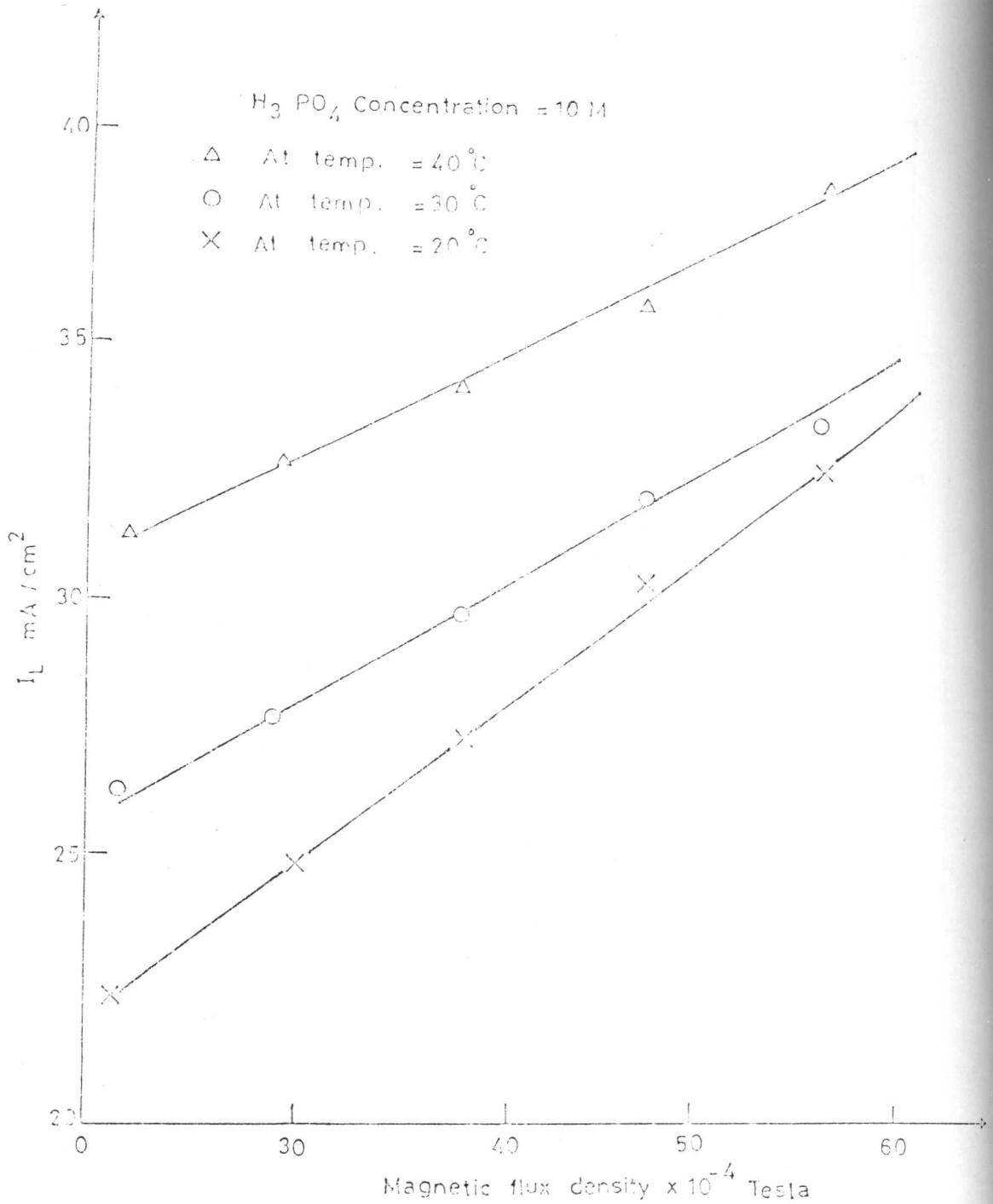


Fig.3 Magnetic field effect on the limiting polishing current

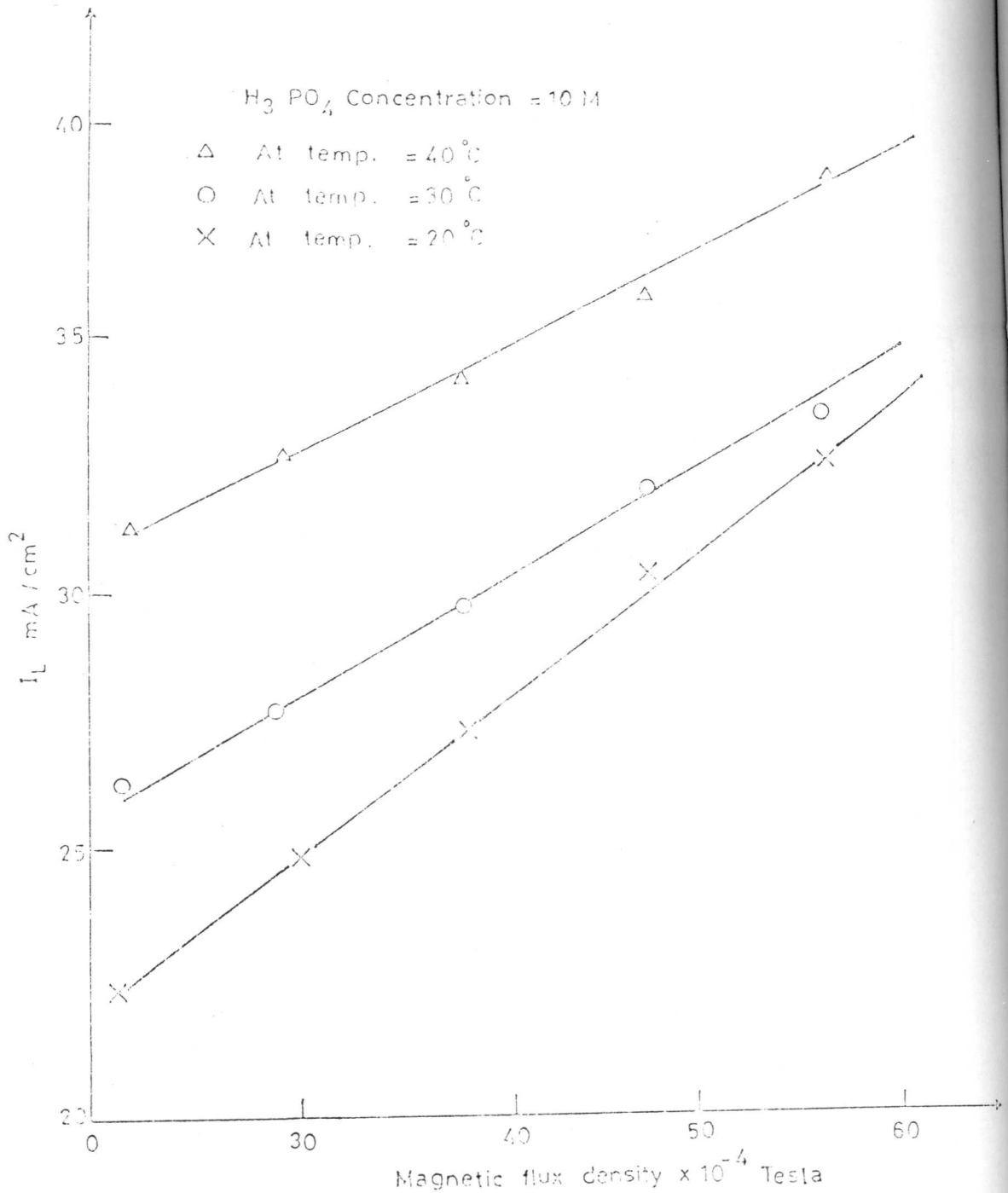


Fig.3. Magnetic field effect on the limiting polishing current.