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RESEARCH OF ELECTROLYTE LOW LOSS IN TYPICAL ECM GAPS

This paper presents the results of research of hydraulic loss during electrolyte flow through gaps typical for ECM machining. The research was conducted on a test station where inducing an oscillatory movement of electrodes was possible. Appropriately prepared electrodes with curvilinear outlines were placed in a machining unit which allowed for measuring the pressure of the electrolyte flow in eight points on the electrode surface and also interelectrode gap inlet and outlet. Additionally, the results of pressure measurements were compared with results obtained from a computer simulation.

1. INTRODUCTION

Electrolyte pressure is an important parameter in ECM machining [1],[3],[4]. It is set directly, after assuming constant pressure at the inlet of the IEG or assuming a constant gap power flow Q supply [9]. Correct pressure distribution in the interelectrode gap determines, inter alia, the machining accuracy. Therefore it is important to verify the pressure distribution in the gap obtained from computer simulation and compare it with the actual values. Additionally, this will evaluate the accuracy of the mathematical model calculations. A mathematical model of the ECM machining process and a program simulating the process for curvilinear electrode surfaces is shown in [7],[8],[10]. What is more, pressure measurement of the electrolyte at the inlet and outlet of the interelectrode gap makes determining local loss coefficients possible [2],[5].

2. ELECTROLYTE FLOW RESEARCH

Pressure distribution tests were conducted in an adapted to this purpose machining unit (Fig. 1). It is characterized by the possibility to transfer the pressure level outside of the interelectrode gap, to the digital sensors.

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Fig. 1. Machining unit adapted to measuring SM pressure

Electrolyte pressure tests were performed for samples with geometrical shapes and dimension layout as the one shown in Fig. 2.

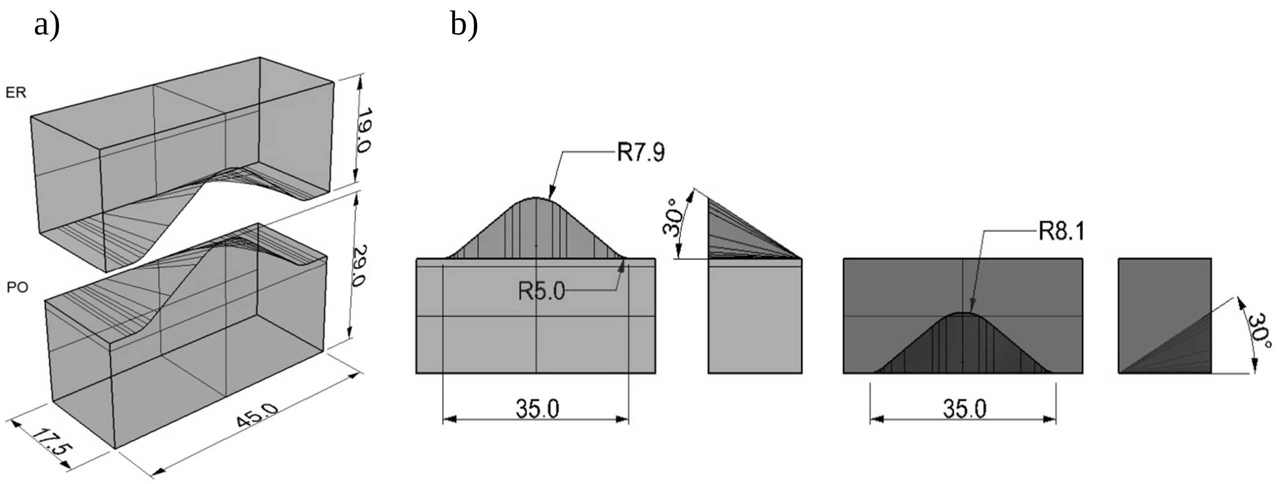

Fig. 2. Geometric form and layout dimensions for ER and PO: a) isometric view, b) projection

In order to induce an oscillating TE movement and synchronizing pressure measuring in accordance to a changing IEG, unit was placed on the test station described in paper [6]. The measuring system's layout is shown in Fig. 3. The unit's electrolyte supply system consists of an electrolyte reservoir with a capacity of 80dm3, a JP-7115 screw pump, along with a safety valve and a VLK-3kA-D rotameter. This arrangement allows the test station to be supplied with electrolyte pressure of 0.1 ÷ 1.2MPa and flow intensity in the range of 1 ÷ 10dm3/min. The control system of mutual positioning of the electrodes and pressure measuring was designed based on Mitsubishi FX 3U driver and a PC.

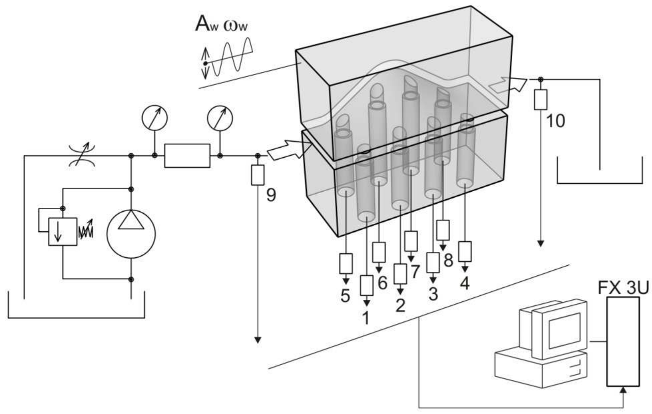

Fig. 3. SM pressure measurement diagram

Electrolyte pressure was measured in two rows of holes, with 4 holes 9mm apart from one another in each row. This allowed to measure pressure in two sections of the sample:

- Section I in a lower curvature point of the sample - points 1 to 4 (Fig. 3),
- Section II in a high curvature point of the sample - points 5 ÷ 8 (Fig. 3).

In addition, IEG inlet (Section 9) and outlet (point 10) pressure was measured. In order to conduct the measurement with laminar and turbulent flow, the flow rates were set respectively:

$$Q_1 = 1.3 \frac{dm^3}{\min} - \mathrm{Re} = 2272$$

$$Q_2 = 2.6 \frac{dm^3}{\min} - \mathrm{Re} = 4868$$

Because of the possibility of clogging the measuring holes with electrochemical dissolution products the tests were conducted in conditions without ECM machining, and using 15% solution of $NaNO_3$. For this reason, on the test station only longitudinal vibrations of TE with a frequency of 2 Hz were induced. Values of a changing as a result of vibration IEC and measurement points are shown in Fig. 4, while the sample with holes for pressure measurement are shown in Fig. 5

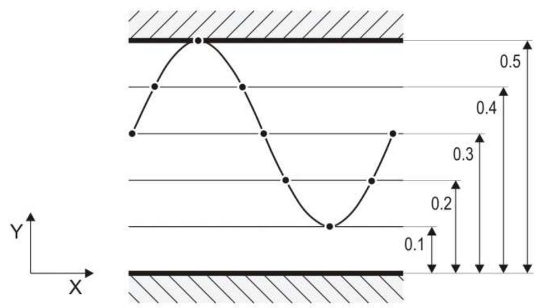

Fig. 4. Pressure measuring points for a changing TE position

Fig. 5. A sample with holes for measuring the electrolyte pressure

3. RESEARCH RESULTS

The results of pressure distribution tests for the sections I and II supplied with a constant flow volume Q_2, compared to distribution schedules obtained from the computer simulations are shown in the diagrams Fig. 6, Fig. 7. The tests show that the discrepancy between the pressure values obtained from measurements and calculations do not exceed 10%. The largest differences occur for small gaps of 0.1mm and 0.2mm at the beginning of the flow. This is explained by local hydraulic losses occurring at the inlet to the TE.

For the accepted TE power supply the largest pressure losses occur for the smallest gaps. At the same time, after comparing the pressure distributions for both two sections, we can state that in section I pressure greater than in section II occurs. It should be emphasized that the pressure differences were recorded for both the calculated schedules and conducted measurements. As it was mentioned before, this effect is most visible for small gaps.

Pressure measurements on the length, the inlet and the outlet of the gap helped to determine loss coefficients according to formulas:

$$\zeta_1 = \frac{2\Delta p_1}{\rho v^2}, \lambda_h = \frac{4h\Delta p_L}{\rho L v^2}, \zeta_2 = \frac{2\Delta p_2}{\rho v^2} \quad (1)$$

where:

ζ_1, ζ_2 - inlet and outlet local loss coefficients,
λ_h - IEC length loss coefficient,
$\Delta p_1, \Delta p_2$ - inlet and outlet pressure decrease,
Δp_L - IEC length pressure decrease.

The results of loss coefficients calculations for an oscillating TE were shown in the following diagrams (Fig. 8÷10).

Local and length loss coefficients increase with an increase of IEC width. However, we should remark that they also decrease according to increase of *Re*. In a case of a turbulent flow through a larger gap (h > 0.3) the outlet loss is basically constant, between $\zeta_1 = 1.5 \div 1.6$.

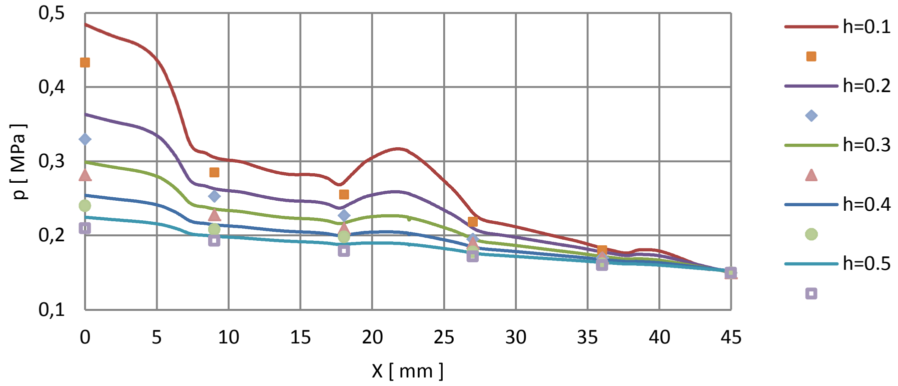

Fig. 6. The results of pressure measurements for the various slots in the cross-section I

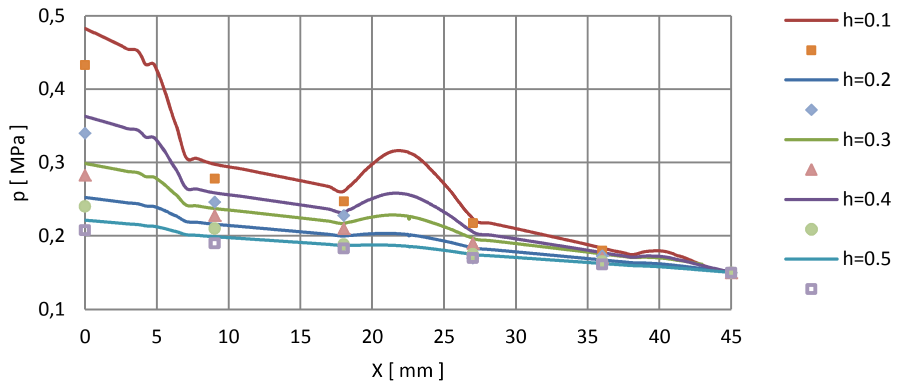

Fig. 7. The results of pressure measurements for the various slots in the cross-section II

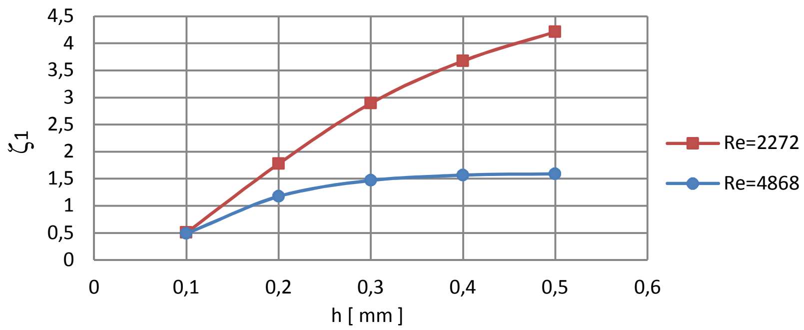

Fig. 8. IEC inlet local loss coefficient for laminar and turbulent flow

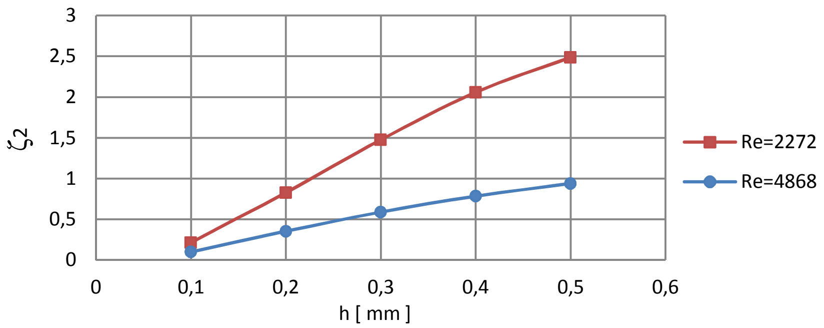

Fig. 9. IEC outlet local loss coefficient for laminar and turbulent flow

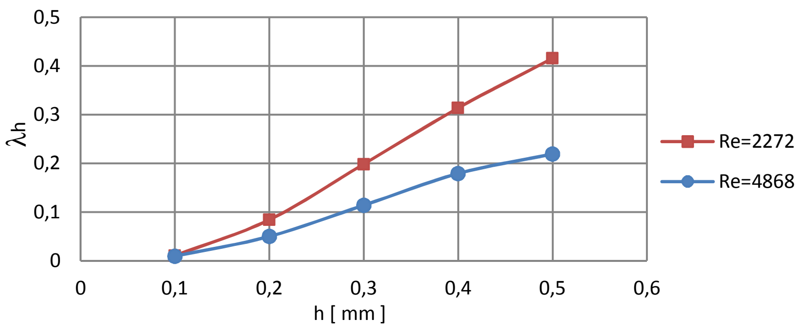

Fig. 10. IEC length loss coefficient for laminar and turbulent flow

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