ON AXIAL ELECTRIC POTENTIAL DISTRIBUTIONS AND WATER FLOW IN PIPES WITH COATED INNER SURFACE

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Introduction. An increase in water flow velocity near the pipe wall has been observed by using laser velocimetry when pipe was exposed to a particular electrical DC-potential [1, 2]. The electrical DC-potential (0..8 V) was applied between a ring (counter electrode) which was electrical insulated from rest of the pipe and located at the inlet of the pipe, and the pipe itself (positive end). The potential of the pipe was measured to be +0.63 V against the $Ag/AgCl/KCL_{sat}$ reference electrode. Due to the electric conductivity of water and the geometry and location of the counter electrode, it is suggested that there will be a distribution of the current density along the pipe which decreases with the increasing distance from the ring. Consequently, there will be a distribution of the pipe potential as well. However, if the counter electrode was designed as a rod with the same length as the pipe and placed inside the pipe like a coaxial capacitor, the electrical pipe potential will be the same over the entire pipe length [3]. The objective of this work was to study the distribution of the pipe potential under conditions of cylindrical counter electrodes and various applied electrical DC-potentials.

1. Experimental setup and procedure. For the potential studies a pilot plant rig was constructed. A schematic overview of the entire rig is given in Fig. 1.

A closed-loop two-level open-tank system was designed with a vertical height difference of 7.5 m and a total water volume of approximately 2000 l (volumes of the upper and lower reservoirs, 1.0 and 2.2 m^3 respectively). The verification study

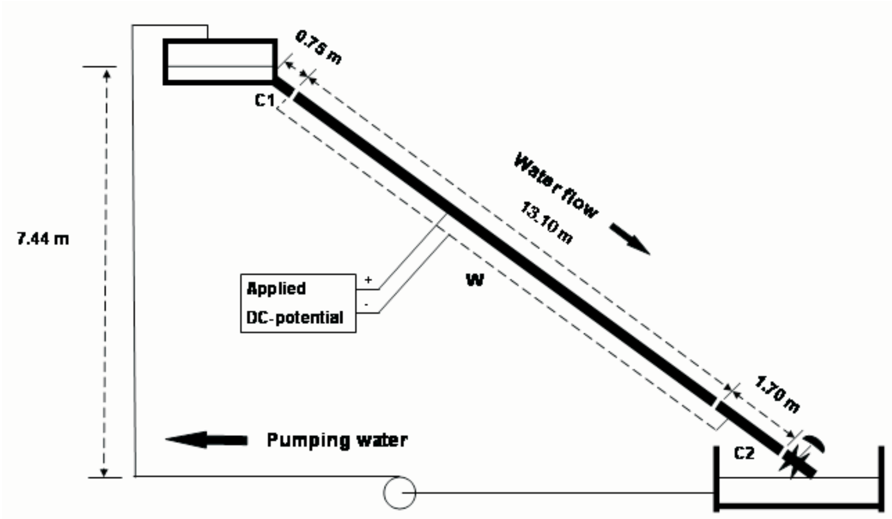

Fig. 1. Schematic overview of the pilot plant for potential studies.

system was realized as a 13.1 m slanting (28.8°), 52 mm diameter pipe made of black steel. Inside, the pipe was coated with an epoxy based coating (Jotamastic 87, Jotun). The thickness of the film was about 200 μm. To control the water flow a valve was mounted at the lower end of the pipe. Sections of the top and the bottom parts of the pipe were substituted by uncoated inserts made of stainless steel and were electric insulated from the pipe. The top (C1) and the bottom (C2) inserts were 0.75 m and 1.70 m long, respectively, and their diameters were the same as for the pipe. The measured open-circuit potentials (OCP) in the middle of the inserts were −162 mV and −106 mV, respectively. The inserts were electrical connected and acted as the counter electrode. The potentials were applied between the counter electrode and the pipe itself by a constant potential source. The electric potentials of the epoxy coated pipe and the inserts were measured against the $Ag|AgCl|KCl_{sat}$ reference electrode inside the pipe at 25 different positions, starting at the inlet and at every 0.5 m. The circulating fluid was tap water (measured conductivity 0.2 mS/cm). All the measurements were carried out at the mean flow rate 1.4 m/s (Reynold's number 70.000) and the temperature 30°C.

2. Results. The results of the potential distribution measurements are given in Figs. 2-5. All the measurements were carried out along the whole coated pipe, starting at the inlet. In Fig. 2, the measured axial OCP distributions for the pipe under conditions of unconnected inserts and pipe (curve A) and connected inserts and pipe (curve B) are given.

In Fig. 3, the measured axial potential distributions for the pipe under conditions of applied electrical voltages of 800 mV (curve B), 1000mV (curve C) and 1600 mV (curve D) are given. Positive ends on the pipe. Curve A is the OCP distribution for the pipe under conditions of connected inserts.

In Fig. 4, the measured axial potential distributions for the connected inserts under conditions of applied electrical voltages of 800 mV (curve B), 1000mV (curve C) and 1600 mV (curve D) are given. Positive ends on the pipe. Curve A is the OCP distribution for the connected inserts.

In Fig. 5, the measured axial potential distributions for the pipe under conditions an applied voltage (1000 mV) between the pipe and the connected inserts

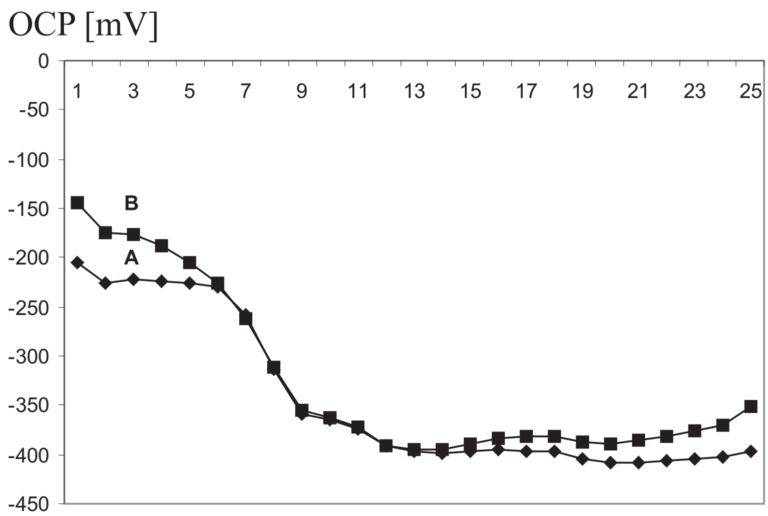

Fig. 2. The measured axial OCP distributions for the pipe under conditions of unconnected inserts and pipe (A) and connected inserts and pipe (B).

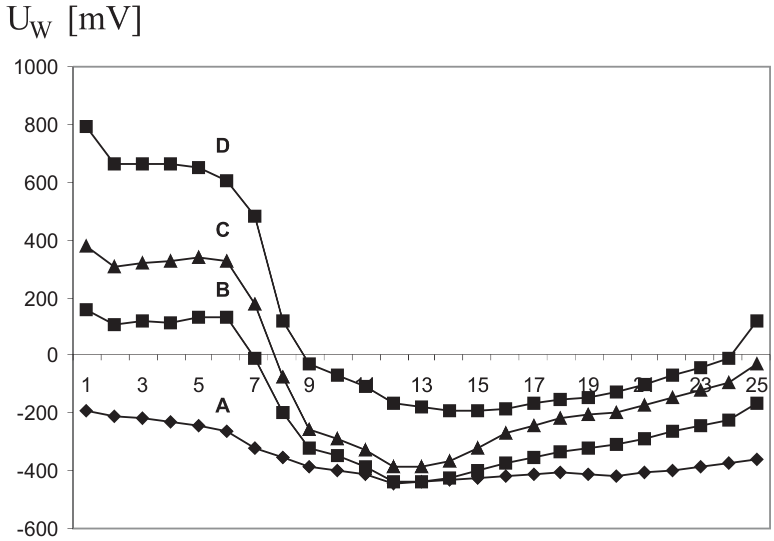

Fig. 3. The measrued axial potential distributions for the pipe under conditions of applied electrical voltages of 800 mV (B), 1000mV (C) and 1600 mV (D). A is the OCP distribution for the pipe under conditions of connected inserts.

(curve A), and between the pipe and the unconnected inserts are given. Curve B is between the pipe and the insert C1, and curve C is between the pipe and the insert C2.

3. Discussion. When the inserts are connected to the pipe, the epoxy coated inner surface of the pipe is slightly positive polarized at the inlet and outlet parts of the pipe (Fig. 2). This may be due to that the OCP's for the inserts are more positve than for the pipe. Under conditions of applied voltages, the results show that the epoxy coated inner surface at inlet of the pipe is largely positive polarized, while it is slightly polarized at the oulet end (Fig. 3). This behavior may be due to the polarizibility of the inserts. The results shown in figures 4 and 5, indicate that the insert C1 is less polarizable than insert C2. Since applied

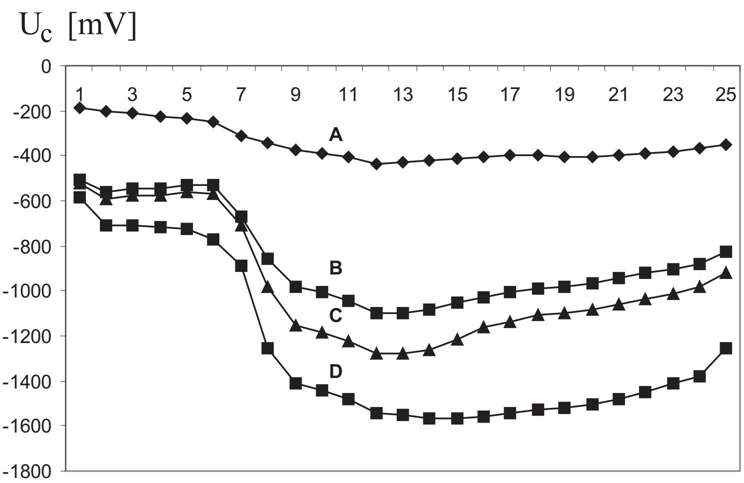

Fig. 4. The measured axial potential distributions for the connected inserts along the whole pipe under conditions of applied electrical voltages of 800 mV (B), 1000mV (C) and 1600 mV (D) are given. Curve A is the OCP distribution for the connected inserts.

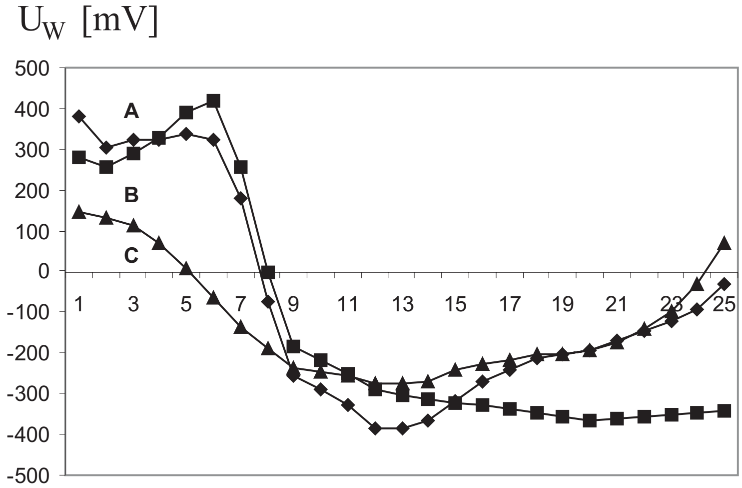

Fig. 5. The measured axial potential distributions for the pipe under conditions an applied voltage (1000 mV) between the pipe and the connected inserts (A), and between the pipe and the unconnected inserts. Curve B is between the pipe and the insert C1, and curve C is between the pipe and the insert C2.

electrical potentials to a coated pipeline through which water is flowing, have an impact on the flow regime, ref. [1]–[2], the results indicate that there is a possibility that the inserts made of material with different polarizabilities and open circuit potentials can have some effect on the flow regime.

4. Conlusion. The experimental obtained results indicate that the potential of the epoxy coated inner surface of a pipe is not only due to its open-circuit potential and its polarizability, but also due to the open-circuit potentials and the polarizabilities of connecting inserts, and to applied electrical voltages.

REFERENCES

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