THEORETICAL AND EXPERIMENTAL ASPECTS ABOUT THE MONITORING HYDROLOGICAL PARAMETERS.

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Abstract: The paper presents some theoretical and experimental aspects about the monitoring hydrological parameters.Thus the author analysis the new solutions and proposes a minisystem what includes:

- A minicurent meter for velocity water in rivers and channels with measuring range;0,025 – 10 m/sec based on new structure of D.C. microelectric generator.The D.C.microgenerator is a rotary electric micromachine with permanent magnet excitations.

The minicurent meter has the control possibilities ; the level and the submerged angular position because of an electromechanical drives system with d.c.micromotor or step by step micromotor. The control direction of water flow to surface and submerged currents because of an rotary transducers (resolver or snchros which are the brushless transmitters
-The control water level with magnetoelectric or electrical resistance microsensors on 0– 1,5 m. In paper are comented and other technical solutions based on electromecanical components.
Keywords: Hydrologic, flow,electromechanical component, microgenerator.

THEORETISCHE UND EXPERIMENTELLE ASPEKTE DER UBERWACHUNG HYDROLOGISCHER PARAMETERN

Zusammenfassung: Der vorliegende Beitrag bezieht sich auf einige theoretische und experimentelle Aspekte der Uberwachung hydrologischer Parametern.In diesem Sinne schlagt der Autor ein Minisystem vor, aufgebaud aus :

- einer Vorrichtung zum Messen der Wassergeschwindigkeit in Flussen und Kanalen mit Werten zwischen 0,025 m/s und 10 m/s,die sich auf das Prinzip eines elektrischen Mikrogenerators stutzt.Dieser Generator ist eine dauermagnetisch erregte elektrische Maschine.Die Vorrichtung besitzt auch Kontrollmoglichkeiten :das Niveau und der Winkelstand durch ein elektromechanisches System,oder Scherittmotor angetrieben ist.Die Uberwachung der Fliessrichtung erfolgt durch einen Winkelgeber (Resolver oder Selsyn,beide Geber ohne electrische Bursten),und
- Kontrolle des Wasserpegels mit magnetoelektrischen Mikrosensoren oder durch Widerstands geber . Im Beitrag sind auch andere technische Lasongen vorgetragen,die sich auf elektromechanische Bestandteile stutzen.
Schluesselworte: Hydrologischer,winkelstand,elektromechanisches,Mikrogenerator.

1. Introduction

By the general flow equation (Carafoli and Oroveanu,2001),(Bradeanu ,1979) ;

$$Q = \int_{AB} \rho \cdot \bar{v} \cdot \bar{n} ds = \rho \int_{AB} \frac{d\varphi}{dn} ds = -\rho \int \frac{d\psi}{ds} ds == \rho\left[\psi(A) - \psi(B)\right] \tag{1}$$

the rate water flow Q is determined if we know;the density ρ ,the flow velocity v and the flow direction ($\bar{v},\bar{n}$). In equation (1),AB is the path, $\varphi(x,y,t)$ -represents the velocity potential function;

$$\frac{\partial^2\varphi}{\partial x^2}+\frac{\partial^2\varphi}{\partial y^2}=0 \quad (2)$$

and $\psi(x,y,t)$-current function;

$$\frac{\partial^2\psi}{\partial x^2}+\frac{\partial^2\psi}{\partial y^2}=-2\omega \quad (3)$$

where;

$$\overline{\omega}=\frac{1}{2}\nabla\times\overline{v} \quad (4)$$

In hydrology ,the main flowmeters are:

- Turbine flowmeter or current meters which serve for determination of current velocities (low starting 0,025 m/s - up to 10m/s) in water courses;canals,rivers and the sea. The velocity of the water displaces the blades and the sum of the fluid velocity with respect to the blade v_{fb} and the blade rotational velocity v_b equals the entering axial velocity vector v_f :

$$\overline{v}_f=\overline{v}_{fb}+\overline{v}_b \quad (5)$$

In real case,retarding torques from blade fluid friction,bearing friction,tip clearing (windage),etc., are present and cause the exit velocity to be displaced from the entering vector;the blades therefore rotate at a speed below the theoretically predicted speed (Miller,1983).This decrease in rotational velocity,referred to a slip,results in an exit swirl velocity component that changes with retarding torque.The velocity component provides the kinetic energy to balance the retarding torques.

A signal is generated from each revolution of a propeller by means of a permanent magnet. Are two methods :

-With mechanical counter limited to 6-10 impulses per second.
-With reed-switch and electromechanical or electronical counter.

- Electromagnetic flowmeter is based on Faraday's law of magnetic induction (Miller,1983),(Mocanu,1991),(Richter,1998).
- When a conductive fluid passes through a magnetic field (produced with permanent magnet, DC excitation,50-60 Hz AC power line sinusoidal excitation or pulsed excitation of any frequency) a voltage is generated at right angles to the velocity and magnetic field vectors.The signal voltage is a summation of individual voltages generated by differential volumes moving at differing velocities across the water course:

$$e_s=k\cdot d\cdot B\cdot\overline{V}_f \quad (5)$$

where k is constant, d is the distance between electrodes, B the magnetic induction and $\overline{V}_f$ the average velocity.For axisymmetric profiles is introdused a "weightlifting function" by (Shercliff, 1961) that average velocity.But real output voltage u is set from the voltage of moving water u_m and from the electrochemical potentials u_{ch} :

$$u=u_m+u_{ch}=\oint_c\left(\overline{v}\times\overline{B}\right)dl+u_{ch} \quad (6)$$

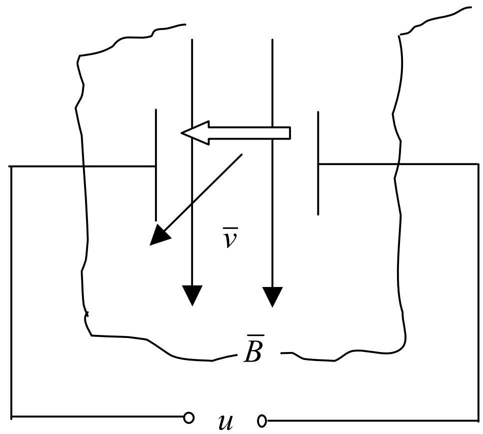

Fig.1.Principle of operation of the electromagnetic flowmeter.

The electrochemical potential (voltage) is changeable in water course because differents pollution factors and the flowmeters are designed driven by alterning magnetic field .The alterning magnetic field adds transformer component to output voltage :

$$u=-\frac{d\Phi}{dt}+\oint_C(\overline{v}\times\overline{B})dl+u \quad u=-\frac{d\Phi}{dt}+\oint_C(\overline{v}\times\overline{B})dl+u_{ch} \tag{7}$$

The voltage signal is detected and supplied to the high resistance differential amplifier.
Others flowmeter principles are (Richter,1998) :

- Magnetic flowmeter . The moving fluid in the electric field incurs magnetisation and the output magnetic field strength depends on the speed of the running fluid :

$$\overline{M}=\overline{v}\times\overline{P} \tag{8}$$

where $\overline{P}$ is the electric polarization of fluid [4]:

$$\overline{P}=\chi\overline{E} \tag{9}$$

with χ - electric susceptibility and $\overline{E}$ - electric field strength.

- Capacitive flowmeter.This flowmeter is based on electromagnetic principle.The square electrodes are placed on the outside of measurig structure.This electrodes do not conductive contact the moving fluid.

The electromagnetic flowmeters which are used in water hydrologie have the range; -5 to 5 m/sec (calibrated for positive flow),electric conductivity; $>2\mu S/cm$ and $\pm 0,5\%$ accuracy (SEBA),(VALEPORT).

- Ultrasonic flowmeter with two basic types; counterpropagation (time of flight) and reflection(Doppler effect) (Miller,1983),(Mason,1979).

The operation of the counterpropagation is based on the fact that speed of an acoustic pressure wave increases in the direction of flow and decreases when directed against the flow,which causes differing transit times. Doppler ultrasonic flowmeters operate by the reflection of sonic energy from scatterers (particulate matter)in the fluid,back to receiver.If the scatterers are moving at the velocity of the flui,the Doppler frequency shift is proportional to the volumetric flow rate.The receiver may be the same transducer as the transmitter or a separate transducer.A typical meter consists of two piezoelectric transducers clamped to the pipe or contained within a housing.

A synthetic analysis of hydrological flowmeter is presented in table1 and is function by four criteria.

Table 1

	Operation	Reliability	Accuracy	Cost
Turbine flowm. mech.counter	* *	* *	*	* * *
Turbine flowm. electrom.counte r	* * *	* * *	* *	* * *
Electromagnetic flowmeter	* *	* * *	* * *	* *
Magnetic flowmeter	* *	* *	* *	* *
Capacitive flowmeter	* *	* *	*	* *
Ultras.counter. flowmeter.	* * *	* *	* *	*
Ultras.Doppler flowmeter	* * *	* *	* *	*

The main specific hydrological parameters and characteristics are:
- Temperature of water.
- Water level and variations of level.
- Water flow velocity.
- Water flow direction.
- Water sediments and turbidity.
- Water quality ; pH/Redox,conductivity,dissolved oxygen.

The author proposes some theoretical and experimental aspects about the monitoring hydrological parameters; flow velocity,flow direction,water level, water sediments and turbidity and new posible solutions.

2.The microelectric generator for water flow velocity

The solution includes a structure permanent magnetic poles in rotor and windings in stator (fig.2).The structure has not the magnetic circuit (ferromagnetic stator and rotor armature).In permanent magnet microgenerators appearance and general construction are similar to those of the more conventional electromagnet type except that the field structure or perts of it replaced by one of new permanent magnet materials (Poffet and Osseni,1986).
There has been a most signicant increasa in the use of permanent magnets to excite electrical microgenerators (Puchstein,1961),(Binny and Riley,1986),(Poffet and Osseni,1986).
For this microgenerators the electric voltages generated is function by the velocity of the rotor :

$$U_{gen} = f(v) = K_g n(v) \tag{10}$$

where the relations between the velocity of the rotor (in m/s) and the rotation n(in rpm) ;

$$n = \frac{v}{\pi D} \tag{11}$$

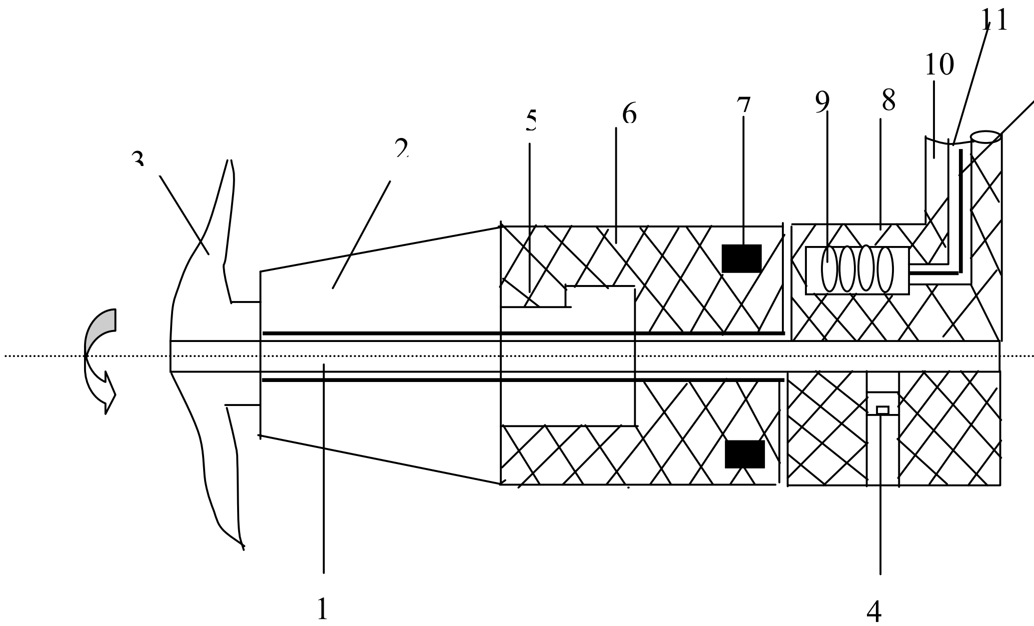

Fig.2 Flowmeter electric microgenerator structure.
1-axis,2-propeller support,3- propeller,4- mounting stator system,5-coupling rotor support,6-microgenerator body rotor,7- micropermanent magnet pole,8-microgenerator body stator,9-winding,10-pin insulator,11- troughing,12-winding connection.

and K_g microgenerator functional ratio ;

$$K_g = \frac{2}{\pi} \cdot N \cdot p \cdot \tau \cdot B_\delta \cdot l \qquad (12)$$

with; N -number of coil per windings, p -number of poles, τ -pole pitch;

$$\tau = \frac{\pi D_m}{2p} \qquad (13)$$

B_δ-magnetic flux density (or magnetic induction)in air gap of microgenerators, l-length of permanent magnet, D- diameter of the rotor, D_m -the diameter of permanent magnet repartition.

For our hydrologic applications are estimated the following functional and constructive parameters :

- v ; 0,1 …. 10 m/s;
- D_m ; 5…30 mm;
- n ; 60 … 5000 rpm;
- p ; 2….6;
- N ;20…200 turns;
- B_δ ;0,2…0,8 T (tesla);
- τ ; 1,9…47 mm.

The advantages of permanent magnet applications in microgenerators are in general high power factor , efficiency,lower maintenance,less weight and in our case no windings in rotor.The scope for permanent magnet excited microgenerators is now well known.Use is made configuration to demonstrate the relative merits of samarium–cobalt and neodymium -iron-boron magnets.It is clear from the results that the newer rare earth materials have a very significant potential for use in high performance microgenerators.

The appropiate geometry ;length and cross-sectional dimensions for a permanent magnet which is to maintain a specific magnetic field in a given air gap can be predetermined to a degree of approximation satisfactory for most purposes.The dimensions depend on (a) the length and cross-sectional area of the gap,(b) the flux density desired in the gap ,(c) the magnetic properties of the particular material ,and (d) certain other factors .

The magnetic properties are usually given in the form of a demagnetization curve obtained experimentally. The design procedure in hydrologic flowmeter is ;

- Given n field(function by v) ,assume a value of voltage generated U_{gen} ,to find the permanent magnet- B_{δ} and design geometry of permanent magnet structure and windings.

So is imposed the air gap value and revised micromechanical structure of the hydrologic turbine (bearing tolerance and the final dimensions of the rotor with the blade).

3.Water direction sensor.

The possible solutions for detecting the water flow direction are represented by the rotative electromechanical transducers ; synchros,brushless rotating transformers,resolvers or inductive potentiometers(Taylor,1970). This sensor includes a stabiliser tailpiece with special clamp mounted on the axis of the rotative electromechanical transducer.

The electromechanical characteristics is:

$$U = f(\alpha) \qquad (14)$$

where; U is the output voltage, α angle of direction.

The general field of features of this electromechanical components are:

Supply voltage 10 …40 V,Frequency ; 0,4 …10 kHz,Maximum absorbed current ; 0,3 A. Angle resolution ; 0,04 degrees,Residual voltage ; 5…20 mV,Ambient temperature ; - 20^0 … + 50^0 C.

4. Level water control.

A new possible level water solution is offered by the carbon materials . The present carbon technology realise the materials with controlable surface or volume electric resistivity and a good isotropie (0,1 ohm - 100 kiloohms / m by some experiments in ICPE-CA Unconventional Laboratory).

So, in hydrologie a new electric resistance transducer or sensor (with a small cost and movingless components) can to become a certitude.In Fig.3 is presented a water level sensor.

An other solutions is to utilize the rotative electromechanical transducer.

The initial electric resistence of carbon element is diminished by the water level and the electric resistence is proportional with the level :

$$l_w = f(R) \qquad (15)$$

where; l_w -is the water level and R;

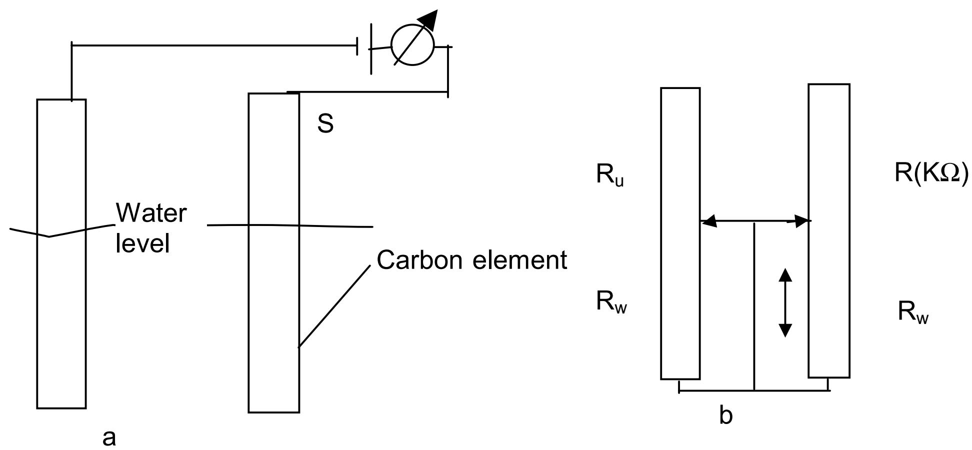

Fig.3 Water level electric sensor.a.Sensor b.Equivalent circuit.

$$R = 2R_u + R_{ww} \quad (16)$$

with; R_u – electric resistance of "dry" zone of carbon element and R_{ww} -electric resistance of the water between the carbon elements .A condition is; $R_{ww} << R_u$ with R_{ww} different of R_w which represents the resistence of "moist" (submerged) zone of carbon element.

5.Conclusions.

The new aspects on the hydrological monitoring systems has been presented in this paper.It has been swhown that is possible to utilise and other principles including; electric microgenerators, electromechanical rotative transducers and carbon conductive element for to obtain this systems. The main advantages are the possibility of miniaturization of systems ,the cost and a good manipulation.

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