THE APPLICATION FOR THE ELECTROMAGNETIC FLOWMETER WITH HIGH-FREQUENCY MAGNETIC EXCITATION IN THE PULP MEASUREMENT

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Abstract: The electromagnetic flowmeters have been substituted for the traditional differential pressure type flowmeters step by step in paper industry. The electromagnetic flowmeter is currently a unique instrument for the pulp flow measurement. This paper describes in brief the measuring principle of the electromagnetic flowmeters with different modes of magnetic excitation, stresses the application, analysis and resolvent for the mode of the high-frequency magnetic excitation, and analyzes the problem occurred for the selection of the flowmeters in the pulp measurement.

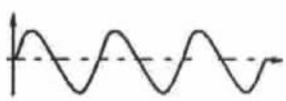
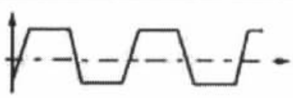
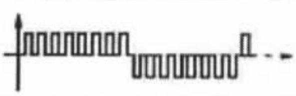
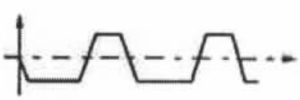
Keywords: Pulp Measurement, High-frequency Magnetic excitation

The electromagnetic flowmeters have been substituted for the traditional differential pressure type flowmeters step by step in paper industry, and higher requirement of use and accuracy has been needed, it improves the technical progress of electromagnetic flowmeters. Besides main flow, there are treatment processes for cleaning sewage and bleached pulp sewage in most of paper manufacturers. Electromagnetic flowmeters are used in all workshop sections as research. Presently various magnetic excitations are used for the measurement for pulps.

The technology of magnetic excitation is one of key technologies to judge the measuring capability of electromagnetic flowmeters, see table 1. To reduce the excitation frequency will increase zero stability, but decrease the resistance for low-frequency interference, and slower the response. To increase the excitation frequency will increase the resistance for low-frequency interference, but decrease the zero stability.

The mode of Alternate magnetic excitation (mains frequency excitation), mains of 50Hz/60Hz had been used directly to make sine wave magnetic fields before 1975. The reason for using alternate magnetic excitation is to avoid DC polarized voltage occurred at electrodes. The most disadvantage is quadrature interference and inphase interference caused by electromagnetic induction. It affects the stability of linearity and zero of flowmeters. Because continuous sine wave signal is used, the flowmeter is independence of polarized voltage, and the fluctuation of output is low. Because the coils for sensors are designed very big, high inducted voltage is inducted (1mV is conducted as velocity of 1m/s). However for low-frequency magnetic excitation, the inducted voltage is 0.2~0.3mV. It is suitable for the measurement of high consistence pulp. Therefor the flowmeters with improved alternate magnetic excitation has still been applied for the measurement of pulp.

Table 1:

Mode of magnetic excitation	Wave of magnetic excitation
Sine wave for mains	
Low-frequency rectangular wave	
Double frequency	
Programmable pulse width	

The double-frequency magnetic excitation was applied in 1980s , The excitation wave is superposed of rectangular waves of low frequency(6~25Hz) and high frequency(75Hz). The relative flow signal is individual received, so two signals with high frequency and low frequency are received, after process we can get the flow signal. High frequency greatly reduces the polarized voltage in the electrodes caused by pulp, reduces the fluctuation of output, and fastens the response. Therefore for double frequency magnetic excitation, zero is stable, accuracy is high, response is fast and the resistance of pulp noise is strong. It is good combination for low-frequency and high-frequency magnetic excitations.

The magnetic excitation for low-frequency rectangular wave (1/8~1/32 of mains frequency) have solved the interference of mains frequency, which is the long puzzled problem for electromagnetic flowmeters. It improves zero stability and measuring accuracy. In order to settle the problem for pulp measurement, we use the magnetic excitation of high-frequency rectangular wave, which pulse wide is programmable. It maybe reduces a little bit stability of zero, and increases the winding eddy current loss and hysteresis loss for sensor. For the requirement for the construction and applied material of magnetic circuit, it is higher than magnetic excitation of high-frequency rectangular wave.

The remarkable problem is the zero stability is bad for the flowmeter with high-frequency magnetic excitation. The most reason is:
On the plane formed by out loop of electrodes of sensor and flow medium, maybe there are some magnetic line of force through the alternate magnetic field to induct the inducted voltage with "Transformer affect"------ quadrature interference. This kind of interference is 90° phase with flow signal. According to theory of magnetic field, alternate quadrature interference will induct again, that is quadrature again, to induct in-phase interference which phase is the same as flow signal. The phase of in-phase interference is the same as one of flow signal, but it is not changed with flow, it forms the zero of sensor. Quadrature interference and in-phase interference can be showed individually as equation (1) and equation (2):

Quadrature interference:

$$e_1 = \frac{dB}{dt} = 2\pi f B_m \sin\omega t \qquad (1)$$

In-phase interference:

$$e_2 = \frac{d^2B}{dt^2} = (2\pi f)^2 B_m \cos\omega t \qquad (2)$$

Here, B is magnetic induction for sensor. For alternate magnetic field, $B = B_m \sin\omega t$.

From equation (2), zero of sensor is proportional to square of applied magnetic frequency. That means zero will be increased16 times if magnetic frequency is increased 4 times from 1/8f (f is mains frequency) to 1/2f. It was proved by experience. For sensor DN50, the velocity of zero is m/s when 1/8f; it is 40mm/s when 1/2f.Forturenately the zero is stable, zero is available to be corrected.

The other important problem is the transition for the wave of magnetic excitation is integration time. Because of the time constant for the inductance and resistance of magnetic coils, the wave polar transform for the magnetic current with rectangular wave is integration with hysteresis. This process time makes the amplitude of the front edge of inducted signal wave unstable. If this instability continues to sample time, the measured output will be unreal and occur measuring error. Therefor the sample time for the converter should be ahead one quarter of magnetic excitation period from the trailing edge of signal to avoid the integral for the front edge of wave continuing to sample period. And it also limits the integral time for the front edge of wave is one quarter of magnetic excitation period. Now we use magnetic excitation of 1/2f, that is the sample time is 10ms, and the integration time also is about 10ms.

For the pulp easily makes noisy and contains solid or fibre liquid, it will improve efficiently the fluctuation of output to use high-frequency magnetic excitation. The flow fluctuations are shown as Table 2, which measured by using various magnetic frequencies in site for Rpmang60 DN150 electromagnetic flowmeter measured the pulp of 3.5% consistence. The fluctuation is 3.7% when the frequency of 50/40Hz, and the fluctuation is reduced to 0.9% when the frequency is increased to 50/2Hz. It is highly effective.

Table 2: The flow fluctuations for various frequencies

DN150（Rpmag62Y-01501311011）

Magnetic excitation （Hz）	Displayed flow (Peak fluctuating range) （m^3/h）	Percentage of the average
50/40	223～240	3.7％
50/20	215～218	1.4％
50/10	213～219	1.6％
50/2	210～212	0.9％

Reference:

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