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COMPARISON OF SERIAL HARMONIC IDENTIFICATION AND MIXED HARMONIC IDENTIFICATION TO AIR HEAT EXCHANGER

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To solve the problems of production process control, the operator must know the parameters of the model. The model reflects the presentation of the essential aspects of the system (process), which represents the knowledge of this system (process) in a convenient form [1].

Significant advantages of using active frequency identification in comparison with meandering in conditions of limiting the departure of the output parameter were presented [2]. It is necessary to use other approaches for objects with fast dynamics.

Serial harmonic identification (SHI). The formation of a series of harmonic consecutively one by one and the separation of the identification by frequency can be one of the simplest solutions. Using this approach to ensure accuracy it is necessary to choose amplitudes at each frequency so that the amplitude excursion at the output at different frequencies is nearly the same.

The method has some features. Thus, when the frequency is varied, a transient process is observed. For an object with a transfer function

$$W(p) = \frac{1}{(T_1 p + 1)(T_2 p + 1)} \tag{1}$$

the equation for describing the dynamics with a step change in the frequencies will have a general view

$$y(t) = a\sin(\omega t + \phi) + b\exp\left(\frac{-t}{T_1}\right) + c\exp\left(\frac{-t}{T_2}\right), \tag{2}$$

where T_1 and T_2 are response time constants; p - is the Laplacian.

The research show that the use of this algorithm is better to start with a low frequency. For most technological decisions, it is possible to determine the transfer constant at the first period. Maximum error is observed at frequencies multiplicity 1.6-1.7. At the beginning of a new amplitude measurement cycle, the transfer constant at the highest-frequency CH can be fixed only on the 6th-9th period.

Mixed Harmonic Identification (MHI). Another solution would be to use the expansion in a Fourier series for all harmonics over period of the slowest one. However, it should be taken into account that during the control harmonics with a non-frequent frequency selecting, in order to reduce the quantizing effect, correction of the results at each period to reduce the influence of one control harmonic on another will be required.

Thus, for an object of the second order, during using of five control harmonics on an active change in object's amplitude-frequency characteristic (AFC), the error can reach up to 30%. High-frequency harmonics are mostly subjected to this. During averaging over a large number of time step of identification, the value converges. In order to level this error, correction coefficients should be calculated by concurrent simulation and expansion. The work algorithm of this procedure is similar to the known solution from control theory - reference model-based control. Another solution can be the use of control harmonics with multiple periods.

The testing of the harmonic identification method was supposed to be carried out on the basis of the training stand. It is a model of air heat exchanger. The output parameter is the temperature, and the control channel is the change in air flow. To change the air flow rate, a frequency inverter is used. The object has non-linear properties both in terms of the static transfer constant and the dynamic properties. Integration of the object control system with Matlab allowed analysing the above methods. In addition to frequency identification with above methods the measurements were taken by forming a meander signal.

During the experiment, the stand was subjected to uncontrollable disturbances: changing the hydrodynamic and thermophysical parameters of the air around the stand (firing, airing, changing weather conditions). When determining the parameters of the transfer characteristics (1) the dispersion of values exceeded more than 40%. The parameters k, $T1$, $T2$ were found by minimizing the mean standard deviation of the experimental data from the theoretical one. The longer duration of the transfer process made it possible to obtain proximity of the parameters at different time periods and to reduce the effect of noises.

AFC of the SHI produced better results for the low-frequency part of the spectrum in comparison with the HI and is much worse for the high-frequency part. The available operating time of the experimental facility allowed only one identification cycle. It should be noted that, because of the limitation on the control action for MI and HI, it was not possible to provide equivalent power of the test signals, as was the case in [2].

References

1. L.A. Zadeh, From circuit theory to system theory, vol. 50, Proc. IRE, 1962, pp. 856-865.

2. N. Oliferovich, D. Hryniuk and I. Orobei "Harmonic identification of technological objects in real time", Electrical, Electronic and Information Sciences (eStream), 2016 Open Conference of, 2016 p. 1-4.