SYSTEM FOR MEASURING OF AIR CONCENTRATION IN AIR-STEAM MIXTURE DURING THE TRANSIENTS


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Summary: Description of system for measuring of air concentration in air-steam mixture during the transients is represented in paper. The system was installed on EREC BCV-213 test facility. Test facility was used to carry out the large-scale tests of bubble-vacuum system for the nuclear power plant with VVER-440/V-213 reactor. The true air concentration in place of measurement was defined based on air concentration measured in discrete sampling using identification technique.

INTRODUCTION

The bubble-vacuum system (BVS) for localisation of accidents was developed in Russia at the end of 70th and intended for effective decreasing of pressure and temperature during the loss of coolant accident (LOCA) in the nuclear power plant with VVER 440/V-213 reactors. The main unit of BVS is the bubble-condenser (BC) which consists of special plates filled with water and located in the separate rooms connected with air trap room. BC serviceability was proved only by experimental results obtained on a number of installations on which BC full-size units were tested. However these results didn’t cover all processes occurring in BVS. Many phenomena were not studied. Therefore it was necessary to carry out additional large-scale BVS tests to prove completely the BVS serviceability and accordingly to increase safety of nuclear power plants with VVER 440/V-213 reactors.

MEASUREMENT SYSTEM AND METHOD DESCRIPTION

The experimental installation with 1:100 volume scale factor with full-size BC units was built in Electrogorsk Research and Engineering Centre (EREC). The experimental installation was developed to study thermal hydraulic processes occurring in BC during LOCA. These thermal hydraulic processes are mainly fast transients due to emergency discharge of coolant from pipe to environment. That is why parameters defining these processes may change fast. One of those parameters defining the operation of BC is to air concentration in air-steam mixture coming into BC from pressurised rooms through connecting passages. Existed techniques of air concentration measuring do not allow to define precisely an air concentration in air-steam mixture at initial stage of LOCA (fast transient). Therefore to measure an air concentration in air-steam mixture coming into BC in first 5-10 sec of LOCA it is necessary to develop a method allowing to define more precisely an air concentration in that time. That method of air concentration measuring in air-steam mixture was developed in National Aerospace University “KhAI” together with EREC. The measuring system was also elaborated applicable to a measuring method developed. The concept of measuring system is based on discrete sampling. The principle scheme of system is shown in Fig. 1.

The main units of system are to sampler with large drops separator (1), transport line (2), distributor of air-steam mixture (3) and measuring vessels (4) (6 units). Air-steam mixture sample comes to measuring vessels consequently through distributor in a specified time interval. The electromagnetic valves (7) are used to open/close the air-steam mixture passages to measuring vessels. The pressure in measuring vessels increases due to filling by sample. To avoid the influence of the pressure increasing on the processes in the system the calibrated orifices (5) is used on which a supercritical pressure difference is implemented. Separators (1) and (6) as well as filter (8) are used to prevent the coming of drops into measuring
vessels. Drop moisture in transport line is checked by drop moisture gauge. In experiment the consequent air-steam mixture sampling to vessels is taken place. The time of vessel filling is about one second. The true air concentration change in the place of measurement is defined based on mass and air concentration measured in the samples taken from measuring vessels with use of parametric identification technique. For this purpose the mathematical model of transients in measuring system was developed [1]. Air concentration change in air-steam mixture in place of measurement was introduced to mathematical model by air concentration time-dependent function

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\psi(t) = \psi(0) - \sum_{j=1}^{r} \theta_j t + \sum_{j=1}^{r} \theta_j e^{-\psi(t)/t},
\]

where: \(\psi(0)\) - initial air concentration;
\(\theta\) - parameters vector to be identified;
\(t\) – time.

**EXPERIMENTAL RESULT**

The comparison analyses of data obtained in the same experiment with use of both discrete and continuous sampling methods was also carried out to increase the adequacy of results obtained (see Fig. 2). Continuous sampling method is based on continuous condensing of steam from air-steam mixture. The measured air concentration is determined by measured steam flow rate and air-steam flow rate. Error of air concentration measurement obtained with use of this method decreases while air concentration in mixture decreases, that processes occur in system in the first 5-10 seconds. That is why both methods supplement each other and give more complete and true information about air concentration in air-steam mixture. Discrete sampling method gives more adequate results in the first seconds of LOCA when air concentration is high and changes fast. The continuous sampling method gives more adequacy results at the end of experiment when air concentration is low enough.

**CONCLUSIONS**

The structure and parameters of the time-dependent function of the air concentration in sampler inlet was determined as a result of identification problem solution. The estimated error of method is about ±10%. The comparison analyses of data obtained in the same experiment with use of both discrete and continuous sampling methods was carried. This analyses showed that discrete sampling method in compare with continuous sampling method is more precise and comprehensive in the first seconds of experiment when air concentration changes fast. For steady-state processes both methods give the same results.

**References**