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USE OF COMPUTATIONAL METHODS TO EVALUATE DAMPING DEVICE EFFICIENCY DURING THE DESIGN OF NUCLEAR POWER PLANT EQUIPMENT

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ABSTRACT

In this paper principles of application of complex experimental-theoretical approach are set forth which are used for solving tasks of engineering and validation of the strength of nuclear plant equipment while under dynamic stress. To develop an optimal design of elements and units of the equipment it is important to apply calculation methods which are based on the scheme of integrated time equations. The construction of behavioral models of material deformation and strength criteria as well as verification of the relations obtained is carried out on the basis of comprehensive experimental research. A number of examples are presented to demonstrate computational methods which prove efficiency of a few types of damping devices used in construction of nuclear power plants.

Keywords: experimental and computational analysis, deformation rate, shock loading.

INTRODUCTION

It is a pressing problem to ensure the strength and structural integrity of the equipment of nuclear power plants taking into account that there are dynamic effects of high intensity (Bazhenov, 2004; 2015). One of the ways to reduce dynamic loads on the equipment is an installation of damping devices (Kibets, 1997; Ryabov, 2000). In this connection this article is prepared to substantiate the use of computational methods to evaluate the efficiency of damping devices during designing of the equipment of nuclear power plants in the conditions of shock loading.

There are the following mechanical processes which are used as a rule for structural damping: impact energy absorption by inelastic resistance (significant plastic deformation) of the deformed construction element material, and impact energy absorption by the friction work in joints of elements. It is computational modeling which is used to develop damping device design. In modern software packages (ANSYS, LS-DYNA) there is full-scale mathematical 3D modeling that enables to make a deep and detailed analysis of dynamic processes. Computational and experimental research methods are used to construct and test mathematical models from LS-DYNA library (Jonson-Cook models, Allen, Rule & Jones model, Cowper-Symonds model), which describe the behavior of materials under shock loading.

RESULTS AND CONCLUSIONS

A few examples are given to show computational methods which prove efficiency of a few types of damping devices used in construction of nuclear power plants. Comparative analysis is carried out using calculation results obtained with ANSYS/LS-DYNA PC and results of available experimental data. A conclusion is drawn that computational methods can prove the efficiency of damping devices only in case that there is true data of damping characteristics which can be obtained as a result of experimental study of model constructions (Figure 1).

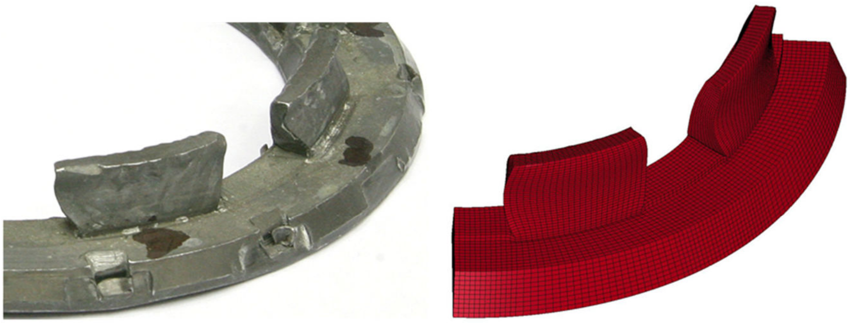

Fig. 1 - Comparison of residual form of damper obtained as a result of experimental test (left) and as a result of calculation (right)

It is shown that installation of damping devices is an effective means to reduce dynamic loads on the equipment of nuclear power plants and it allows localizing the zone of dynamic impact. If there is a set of necessary conditions then the usage of computational methods to evaluate efficiency of damping devices at a design stage allows avoiding expensive full-scale tests and helps to increase competitiveness of products due to lowering their prime cost.

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