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The behaviour of a tube bundle near the stability limit

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Abstract

Tube heat exchangers are inseparable components of a great number of energetic machinery, where one fluid flows through tubes and the other fluid flows around the tubes. Heat transfer occurs between these two fluids. Apart from the problem of heat transfer, the problem of fluid-structure interaction is very important too. Mainly the fluid flowing around the tubes may be very dangerous, because it causes vibrations of these tubes. Intensity of vibration depends on the velocity of the flow. Under the certain, so-called critical velocity, vibration amplitudes can have random pattern. The objective of this article is to determine the probability of up crossing of some fixed level. It is necessary to avoid such regimes of operations, in which the damage of a heat exchanger as a consequence of flow-induced vibration could be caused.

Keywords: fluidoelastic interaction, critical velocity, random vibration, stability limit

1. Introduction

The cases, in which it is necessary to transfer heat from one fluid to another fluid, are very important and very frequent in power engineering. The heat exchangers are used for these purposes. The exchangers consisting of many parallel tubes are mostly used. One fluid flows inside the tube and the other fluid flows cross-tube. The heat is transferred from the fluid with a higher temperature to the fluid with lower temperature. The fluid flowing around tubes can be the source of aerodynamic excitation. Besides the problems dealing with heat transfer it is necessary to solve very important questions dealing with the dynamic behaviour of the whole equipments. Under the certain conditions the vibration of tubes can be so intensive, that a serious damage can occur. This happens under the certain, so called critical, velocity of flow. We say that the loss of stability began.

More and more requirements on power production increase the call for designers, in order to machines operated near the stability limit. It is necessary to devote great attention to the stability limit determination for safeguarding the reliable and safety operation of the machinery. The problem of aerodynamic excitation is discussed in this paper. Physical nature of phenomena connected with the origins of non-stable states must be studied very carefully, too. When the turbulent excitation of cross-flowed tubes takes place, it is necessary to know the probability of up crossing of some fix level of amplitudes. In this paper it is supposed that vibration of tubes can be described by the equation of an oscillator with a light non-linear damping and a white noise excitation.

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