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INVESTIGATION OF THERMAL HYDRAULIC VIBRATION PROBLEMS FOR A NUCLEAR REACTOR AND AN ANALYSIS OF VORTEX SHEDDING

Abstract

The purpose of this study is to analysis the problems of vibration in power equipment. The occurrence of vibrations represents a serious problem in operation and in the design of nuclear power plant units. However it is quite impossible to eliminate vibrations completely. This is due to the fact that there are many factors that contribute to its appearance. One of the major components that are mostly affected by vibrations is Pipeline .In a nuclear power plants they are one of the most extensive and important elements. Alternative forces caused by Vortex shedding have a severe impact on piping vibrations. The coincidence of pressure pulsations with structural frequency also causes piping vibrations. This study has shown a relation between Strouhal number and Reynolds number which are the most influencing parameters in case of thermodynamically vibration analysis. The other major purpose of this study is to have an enormous discussions in order for reducing unbalanced forces and vibrations. Changing the piping structural frequency or pump helps to eliminate pressure pulsations. Pulsation damper or suction stabilizer have an effect on piping acoustical properties.

Key Words: Vortex Shedding, Alternative forces, Srouuhal number, Reynolds number, Unbalanced forces, Pulsation damper, Suction stabilizer, Pressure pulsations etc.

It is very usual that all piping with flow will vibrate to some degree. The most influencing potential sources for steady–state vibration are Pump induced pressure pulsations and flow turbulence. There exist distinct frequencies which are the multiples of the pump speed that cause to occur pump induced pressure pulsations. Pulsations originate at the pump and travel throughout the entire discharge piping. In case of Suction pumping, it is also possible to get induced pulsations especially with reciprocating pumps. When the pressure pulsations coincide with structural frequency of the piping there must be sever effects of piping vibration. There is another sever effect in unbalanced forces in pipe legs caused by pump- induced pressure pulsations. There occurs unbalanced force if the pressure on one elbow is not equal to the pressure on the other elbow.

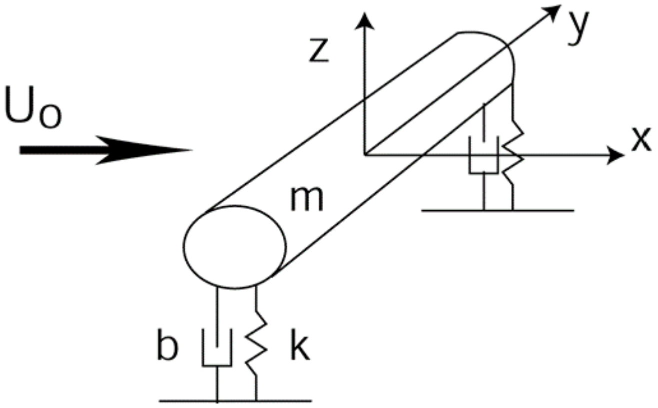


Figure 1: Rigid cylinder is now similar to a spring-mass system with a harmonic forcing term. [1]

When a fluid such as air or water flows past a bluff body at certain velocities there takes place an oscillating flow called Vortex Shedding. In engineering design this phenomenon has major importance because the shedding of vortices also creates alternative forces, which occur more frequently as the velocity of the flow increases. If the vortex shedding frequency is near the structural vibration frequency of the body resonance can occur. A dimensionless number called Strouhal number (S_r) is commonly used as a measure of the predominant shedding frequency (f_s). Strouhal number can be defined as

$$S_r = f_s L/U \quad \text{.............................} \quad (1)$$

Where L is the characteristic length that is equal to the diameter D in case of a circular cylinder and U is the freestream velocity. Another dimensionless quantity called Reynolds number (Re) is used to predict similar flow patterns in different fluid flow situations. The strouhal number can be defined as function of Reynolds number. In the Reynolds number range 250 < Re < 2×105 this empirical formula can be stated as

$$S_r = 0.198\,(1-19.7/Re) \quad \text{..................} \quad (2)$$

For analysis of hydrodynamic instability caused by the turbulent motion there comes in great importance the term the pressure pulsation. In other ways, At low Reynolds numbers the intensity of the pressure pulsation is about

$$P := \rho \cdot (u)^2 \quad \text{..................} \quad (3)$$

And for large values of Re $P := 0.7 \cdot (\rho \cdot u)^2$ .... (4)

Based on the criteria of the Euler (E ') depending on pressure pulsation amplitude and the Reynolds number can be stated as

$$E' = 2gH/U^2 \quad \text{...} \quad (5)$$

Where H – the amplitude of the pressure pulsation and U –average speed.

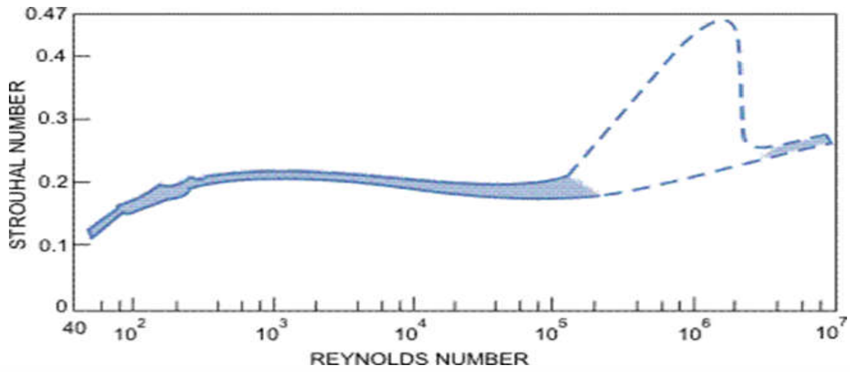


Figure 2. Strouhal number versus Reynolds number for circular cylinders [2]

It is clearly known from the figure that the Strouhal number is about 0.2 over a large Reynolds number interval. At high Reynolds numbers the vortex shedding does not come out with distinct frequency but rather over a narrow band of frequencies.

To modify the pump or to change the piping acoustical frequency there are some ways to eliminate the pulsations. The addition of pulsation damper and suction stabilizer can help to change the piping acoustical properties.

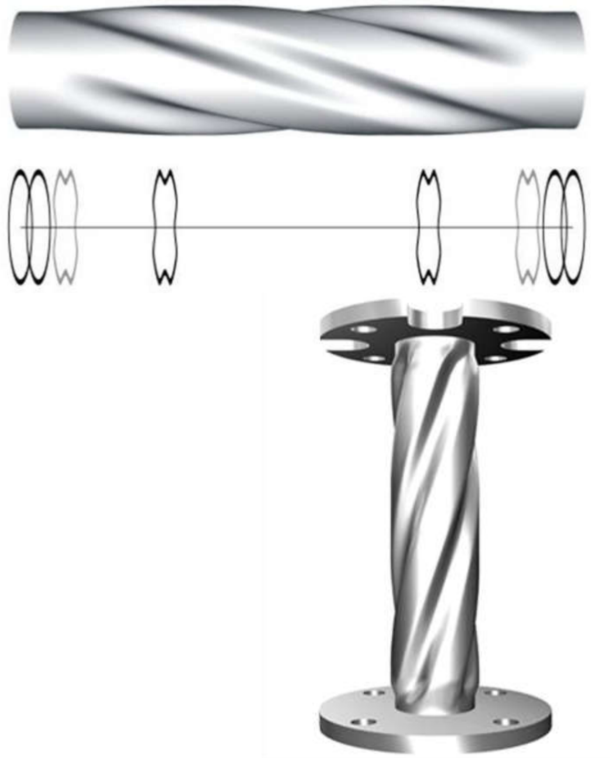
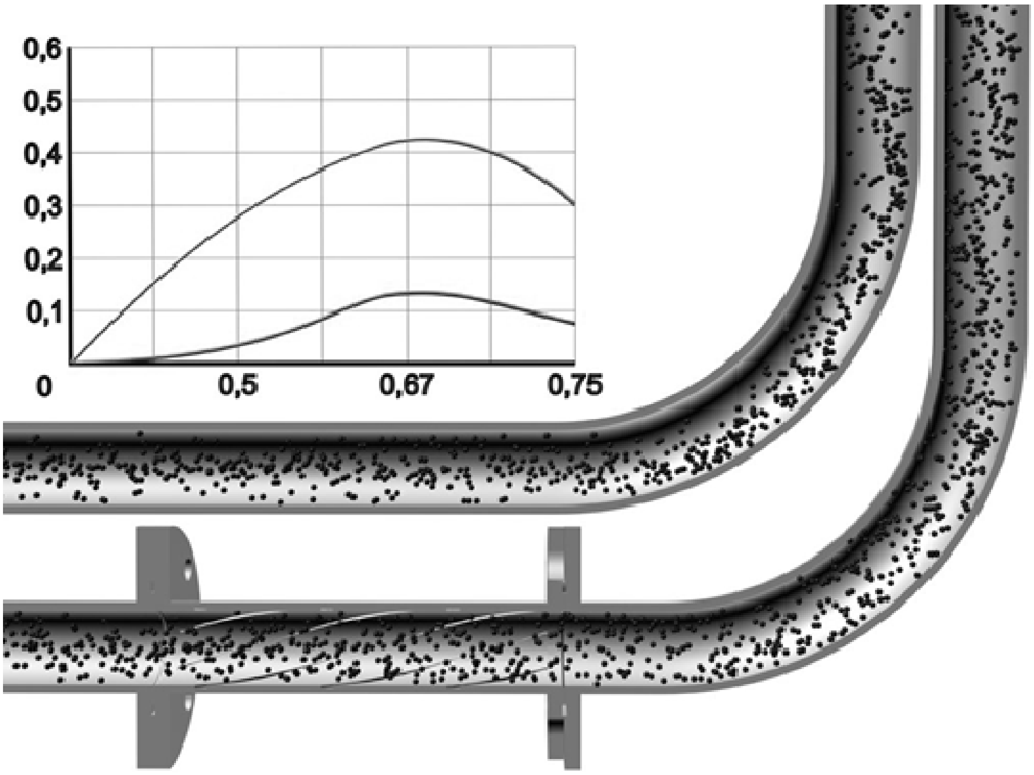


Figure 03. Model for Swirl insert for reducing piping vibration



Fugure 04. 3D Max analogue modeling testification by inserting swril insert

Piping vibration is very common problem in design engineering for pipelines. In this study we tried to find some reasons and its analytical solutions. By our 3DMax model and replasing swril hose we can have an idea of reducing pressure pulstions. We have also observed by modifying filter associated piping the acoustic resonance can be reduced. If th high amplitude vibrations are recorded on main steam drain pots that are cantilevered form the main line , by adding tieback support the problem can be solved easily. When valves on small bore warm up lines are wide open they cause two phase flow mixing in the downstream header to the condenser , results in cavitation induced vibration. If the small bore valves on the warm up lines are throttled down to the near closed position vibration on the downstream header can be disappeared.

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