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Review on Factors Affecting Fluid - Elastic Instability of the Heat Exchangers Tubes

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Abstract: A review on the research made by researchers on the finned tubes used in the heat exchangers is done. The aim is to improve the fluid elastic instability of the tubes used in the heat exchangers to avoid the failure of the tubes due the vibrations induced because of the fluid flow over the tubes. The fluid elastic instability point varies with various parameters. The parameters like fin geometries, fin pitch, fin height, fin thickness, fin density on different tube arrays have been reviewed in this paper. Main motive of the paper is to provide some brief knowledge about instability point of the fin tubes depending on the tube parameters and tube array.
Keywords: Fin geometries, fin pitch, fin height, fin thickness, fin density, Fluid elastic instability

I. INTRODUCTION

Heat exchanges facing the problem caused due to the failure of the heat exchanger tubes. This failure is causing the vibration which is induced by the fluid flowing. Many researchers did research to examine this effect caused by the fluid flow. These flow-induced vibrations are governed by the various phenomenon such as the fluid elastic instability (FEI), turbulent buffeting, vortex shedding, acoustic resonance and jet switching. The major failure is causing due the fluid elastic instability (FEI). Fluid elastic instability (FEI) occurs when the velocity of the fluid flow increases and reaches the value of the critical flow velocity. At this point tubes across the flow starts vibrating vigorously. Any increase the flow of the fluid causes further increase the amplitude of vibration which further causes the failure of tubes.

There are no fixed defined guidelines for the design of heat exchangers having finned tube arrays. The behavior of finned tubes in the cross flow of fluid is greatly affected by the parameters such as material of a fin and tube, type of fin, fin thickness, fin height, fin diameter, fin density, type of tube array, tube array pitch, type of flow etc. The study of effects of fin height and fin density and other parameters on flow-induced vibration (FIV) on different fin tube arrays is a step towards the improvement of design guidelines of heat exchangers.

II. LITERATURE REVIEW

This section includes literature survey of earlier research work carried out by various researchers regarding this work. This section presents the summary of this research work.

A. H. Arshad et.al. [1]

To investigate the effect of fin geometry on flow-induced vibration response, an experimental study on a parallel triangular finned tube array with P / Deff ratio 1.62 was conducted. Fins on a tube boost the rate of heat transfer, but they also influence the dynamics of the fluid around the tube.As opposed to simple tube arrays, the flow pattern through the finned tubes is complex.Th ere are various parameters in a tube array that influence the vibration of the finned tube exposed to air crossflow. Any of these para meters, i.e. fin thickness (1.30, 1.70, 2.30 mm) and fin density (4.5, 5.5, 6, 6.5), are focused in the present study and their effects on flowinduced vibration response are analysed in various rows of arrays of fin tubes. In a subsonic wind tunnel, the present experimen tation is conducted using a single flexible aluminium finned tube in a rigid array. For the purpose of research, seven tubes with ident ical dimensions, but distinct fin thickness and fin density are used.

Their amplitude response implies that by modifying the finned tube parameters, the flow induced vibration activity is greatly affected.

During spectral analysis, it was also observed that the Strouhal number is independent of the geometry of the fin because it remaine d constant in the different rows of the finned tube array under study.It shows that the vortex shedding has also attributed mainly in t he first, second and fourth rows of tube array to the finned tube vibration. In short, the low thickness of the fin increases the vibratio ns and becomes unstable tubes. The instability threshold is delayed as the density increases. The critical velocity is therefore greater for higher density finned tube.

B. Sandeep R. Desai And S. Pavitran[2]

Theoretical study of the fluid elastic vibrations of the finned tube arrays subjected to water cross flow was performed. The research has been conducted to predict the critical velocity for a finned tube array at instability.The array has a 2.6 pitch ratio and two 2.54 m m (10fpi) and 6.35 mm (4fpi) distinct fin pitches.Before performing experiments in the next step, this analysis is undertaken.For fin tubes without solid rods attached to them, the theoretical study is performed first.This provides knowledge that critical instability vel ocities seem to be much higher, so that the required pump flow capacity will be proportionately high. This creates problems for expe rimental fluidelastic instability simulation. In order to ensure that fluidelastic vibrations are welded to the fin tubes using a lower cap acity pump, strong rods 260 mm long are welded to minimise the normal frequency of the fin tube.To achieve the fluid elastic instability at lower fluid flow using lower capacity pump, solid rods of 260 mm length are welded to fintubes, this helps to minimize the natural frequency of the tube

C. Sandeep Rangrao Desai, Sampat Pavitran [3]

To evaluate the critical velocity at instability for plain andfinned tube arrays exposed to water crossflow, an experiment was perform ed. The geometry of the tube array is parallel triangular and end condition is cantilever. Pitch ratios considered are 2.1 and 2.6.The objective of the research is to determine the effect of raising the pitch ratio on the threshold of instability for plain tube array s and to define the effect of incorporating fins and fin density on the threshold of instability for finned tube arrays.For the tests, simp le tube array with two distinct pitch ratios 2.1 and 2.6 used and finned tube arrays with the same pitch ratio 2.6 but with two distinct fin pitches such as fine (10 fpi) and coarse (4 fpi) are taken into account.

D. Desai S. R. and Pavitran S.[4]

An experimental research on fluid elastic instability is conducted and vortex shedding is performed in simple and finned arrays. The tubes are exposed to the crossflow of water. The parallel triangular array is the array pattern used. The considered pitch ratios are 2. 1 and 2.6, while the considered fin density is 4 fpi and 10 fpi. The results for two finned tube arrays for critical velocity at instability are presented.Extensive results on vortex shedding are also provided, in addition to results on fluid elastic vibration behaviour, to re search the phenomenon in tube arrays subjected to water cross flow. With pith ratio, the impact on the fluid elastic instability change s. In contrast to higher pitch ratios, lower pitch ratio instability occurs early on.

E. Sandeep R. Desai and Maniyar [5]

Experimental research on normal square finned tube arrays with water crossflows has been performed. In total, six tube arrays have been tested of which three have a pitch ratio of 2.1 and three have a pitch ratio of 2.6.Three different arrays are checked under each t ype, such as plain array, coarse finned array and fine finned array and coarse (4 fpi) and fine (10 fpi) are called fin densities.

The purpose of the analysis was to discover the velocity of the fluid at which each of the arrays becomes fluidelastically unstable. T he research helps to study the impact on the threshold of instability of pitch ratio, tube array pattern,and fin density. The findings ind icate that, due to the inclusion of the fins, instability is delayed. It is also concluded that regular square arrays should be favoured in order to prevent fluidelastic vibrations over parallel triangular arrays.

F. Desai S. R. and Rohit Kengar [6]

Fluidelastic instability experiments were conducted on rotated square finned tube arrays that were subjected to water cross flow.For the rotated square finned tube arrays subjected to water cross flow, this work is performed to find the critical velocity at instability.I n all, two distinct pitch ratios, each with a single tube array, a coarse finned tube array, and a fine finned tube array are tested for a t otal of six tube arrays. The pitch ratios considered in the analysis are 2.1 and 2.6, and coarse (4 fpi) and fine (10 fpi) fin densities are also considered.By performing experiments in the water cross flow, the influence of array pattern, pitch ratio and fin density on the instability is studied. By comparing the results of the present study with published results by previous authors for parallel triangular finned tube arrays in the water cross flow, the effect of the tube array pattern is studied.

G. Baoqing Liu et.al.[7]

Experimental studies on fluidelastic instability of three bundle distributions in single phase(air) and two-phase(air-water) cross flow, namely normal square tube arrays having pitch to diameter ratios 1.28 and 1.32 and also normal triangular tube array which has a pitch-to-diameter ratio of 1.32, have been performed. The comparison of the effects of the fluid-elastic threshold with previously published data indicates strong single-phase flow compatibility. The effects of pitch-to diameter ratio and tube bundle configurations on air-water cross-flow induced fluid-elastic instability were also compared and analysed by measuring unstable tube bundle behavior. It was found that, with a decrease in pitch to diameter ratio, fluid-elastic instability is more likely to occur and that of the normal square tube array is more stable than normal triangular tube array. It was proposed that the instability constant K in normal triangular and Normal Square tube bundles be 3.4 and 4.0, respectively, from the analysis of the tube array geometry.

H. Wang J. and Weaver D.S [8],

Experiments have been performed to study fluid elastic instability in regular and parallel triangular serrated finned tubing array.Fine finned (4.2mm/5.7fpi) and coarse finned (8.4mm/3.3fpi) tubes as well as bare tubes were taken into account as base for each tube a rray geometry. The findings in the finned tube arrays were compared with data available as well as current data for fluid elastic insta bility. For the triangular arrays, the experimental results indicate that the configuration of the fin strongly influences.

I. Lumsden, R.H. and Weaver [9],

Experimental tests were carried out on the normal square square tube array pattern and the rotated square tube array pattern with air as a flowing fluid.It also studies the influence of density on the tube 's behaviour. The three styles of fin pitch are used as a plain tub e, 3.3 Fpi, 5.7 FPI.The analysis carried out showed that the addition of fins to the tubes delays critical velocity. The effect of fins on fluid elastic instability also depends heavily on the geometry of the array.

III.CONCLUSIONS

The usage of fins on the tube surface has increased in recent days, and in the future it will increase further.Because of the ability to i mprove thermal efficiency. he effect of water crossflow on the vibration caused by fluid flow on tubes with fins on their surface mus t be understood.It helped to learn about the state of research in this field after doing a literature survey.Various crossflow fluids, suc h as water , air and mixed flow (air-water), are performed in the experiments. Research has been carried out with Desai and Pavitran[2],[3],[4], Desai and Maniyar[5] and Desai and Kengar[6] on the impact of finned tube parameters on FEI on she ll and tube heat exchangers with regard to water cross flow.NNormal triangular, parallel triangular, normal square and rotated square tube arrays have been tested with plain and finned tubes with various pitch ratios and fin pitches. They tested it for fluid elast ic instability and the behavior of vortex shedding. while in air cross flow, Wang J. and Weaver D.S [9] and H. Arshad et.al. [1] conducted experiment to study fluidelastic instability in normal square, rotated square and parallel triangular finned tube arrays for different pitch and fin density. Also H. Arshad et.al. [1] have studied he influence of fin thickness and fin density on fluid elastic instability has been investigated. Baoqing Liu et.al. [7], have studied the normal triangular tube array was studied with a single-phase cross flow and the two-phase flow and pitch ratio effect. Many researchers have studied theeffects of air or a mixed flow but water as a moving medium, according to a literature review, less study has been performed. Research has been done on the effect of lower tube array pitch ratio, change in fin density and change in tube array on theinstability threshold with distinct fl uid flow. The fluid-elastic instability point of fin tube arrays are greatly affected by the various parameters such as type of tube array pattern, type of the flow, fin geometry (fin height, fin thickness), fin density, pitch ratio etc. more study has to be done in this area to explore the various design aspects.

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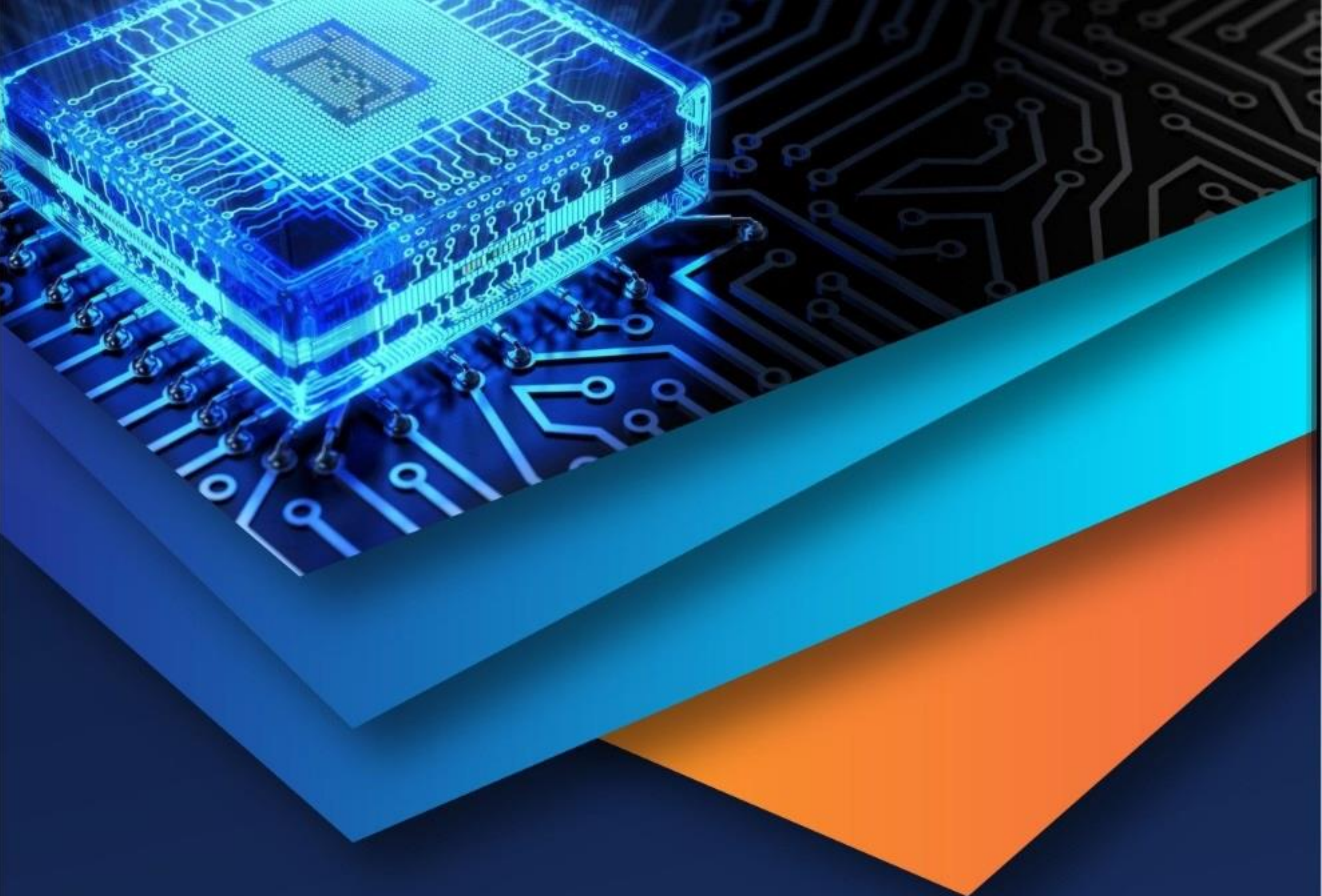

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