Heat Dissipation from a Heated Equilateral Triangular Cylinder in an Oscillating Channel Flow

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Abstract- Experiments are carried out in order to investigate heat transfer enhancement from a heated triangular cylinder in a channel by pulsating flow. The amplitude of the pulsating flow is fixed at A=0.05. Experiments have been performed to investigate heat dissipation from a heated equilateral triangular cylinder in a channel by oscillating flow. During the experiments, the input power and oscillating amplitude (*A*) are fixed. The effects of the Reynolds number based on the mean flow velocity and the oscillating frequency (0 Hz $<f_p<$ 60 Hz) on the heat transfer enhancement are examined. The Reynolds number was determined for each oscillating condition. The heat enhancement factor is measured according to Reynolds number. The occurrence of the "lock-on" phenomenon is demonstrated for a triangular cylinder. "Lock-on" phenomenon is the phenomenon when the pulsating frequency is within the lock-on regime; heat transfer from the triangular cylinder is significantly enhanced. Various graphs have been plotted between the temperature & frequency .These graphs show the effect of various pulsating frequency on the heat transfer enhancement. It has been found that pulsating frequency increases the heat transfer rate at different Reynolds numbers. Heat transfer increases with increase in the Reynolds number. During the experiment it has been found that at a particular frequency, the heat transfer rate is maximum.

Keywords – Lock on, Pulsating flow, Heat transfer enhancement, Triangular cylinder

I. INTRODUCTION

As heat enhancement technique are adopted in electronic devices to maintain low circuit temperature. Most of the electronics failures occur due to the unavailability of the temperature control. Therefore it is necessary to remove excessive heat from the such kind of circuits. The last 100 years, the flow around slender cylindrical bluff bodies has been the subject of intense research, mainly owing to the engineering significance of structural design, flow induced vibration, and acoustic emissions. In recent years, such studies have received a great deal of attention as a result of increasing computer capabilities, improvements in experimental measurement techniques. The vast majority of these experimental investigations have been carried out for the flow around a triangular cylinder, whereas, from an engineering point of view, it is also necessary to study flow around other bluff body shapes, such as sharp edge rectangular cross sectional cylinders. Structures that typically have circular or near circular cross sections include architectural features on buildings, the buildings themselves, beams, fences and circular or near circular cross sections include architectural features on buildings, the buildings themselves, beams, fences and occasionally stays and supports in internal and external flow geometries. When these structures are exposed to cross flow the separation takes places from the upper and lower portion of the body. Due to instability the phenomenon of vortex downstream.

II. EXPERIMENTAL APPARATUS AND SYSTEM OPERATION

The experimental setup consists of flow around a triangular cylinder, as illustrated in Figure 1. The cylinder is undergoing a transient vertical oscillation motion that changes harmonically with time. The equilateral triangular cylinder with side length (l) is placed in a channel of height (H) and length (L). The leading edge of the triangle is placed at a distance (x_u) from the channel's inlet, and its trailing edge is at distance (x_d) from the outlet. Figure 1 shows the triangular cylinder with the important geometrical parameters. Y and X are the dimensional coordinates normal and along to the cylinder surface. The blockage ratio, which is defined as the ratio of the side of the triangular cylinder to the channels height, is 1/10. The cylinder undergoing a vertical displacement oscillation motion and the following harmonic expression describes the motion: $U_I=U_O(1+A\sin 2\pi f_p t)$ [33]

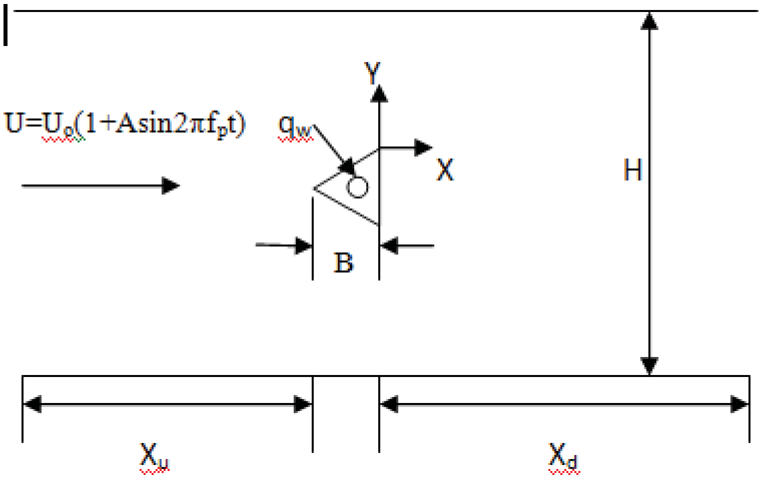

Figure 1 Heated equilateral triangular cylinder in a channel

To eliminate the effect of walls of wind channel we have to follow the equation L/D ≥ 50 and in present study L/D is 65. Where D is side length of work piece. Laptop has software which name is NCH TONE GENERATOR which work as oscilloscope and Function generator and give values in digital form. The software can produce the sound frequency 0-10000 Hz. But we perform our experiment within limit of sound frequency 0-60 Hz. We have to work with these sound frequencies because at higher sound frequency the woofer will damage. Function generator is a device which creates sound at different frequency and oscilloscope shows the value of frequency of sound

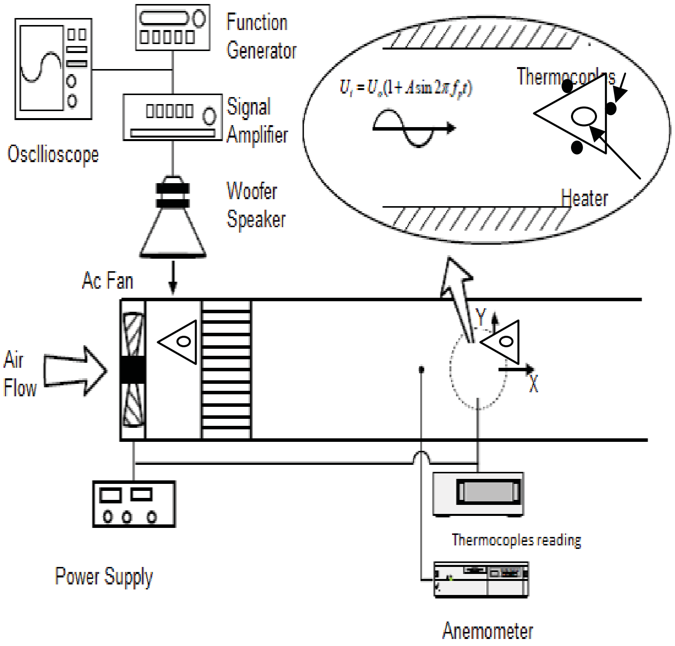

Figure 2: Experimental apparatus

III. SYSTEM OPERATION

The experiments were performed in a channel fabricated with 10 mm thick cast iron with the same basic set-up as reported in. The channel is an open circuit, suction type with height H = 120 mm, width W = 150 mm, and length L = 960 mm. A steady main airflow was supplied by a AC fan. The inlet flow is straightened through a honeycomb and a fine grid mesh. All side of triangular cylinder, made of aluminium, was 15 mm. A triangular cylinder was installed at Xu= 60 mm and Xd= 275 mm in the channel. A 10 inch diameter woofer speaker was used to produce an oscillatory flow. Temperatures were measured by thermocouples. The inlet flow is straightened through a honeycomb and a find grid mesh. The uniformity of inlet airflow was confirmed by measuring the velocity distribution with a hot wire anemometer.

IV. RESULTS AND DISCUSSION

Comparison of mean temperature at different Reynolds No. (Re) on aluminium work piece
Comparison of mean temperature at different frequency along with different Reynolds No. (Re) shown in graph, this can be easily understandable

4.1 Comparison of mean temperature with different Reynolds No. along with different frequency

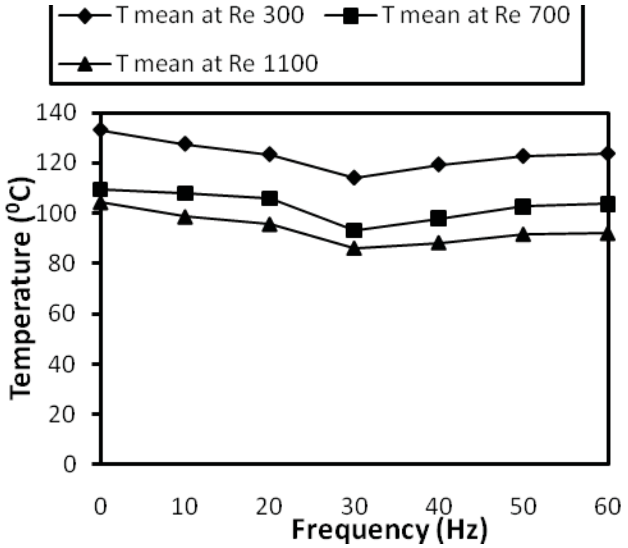

Figure 3: Variation of mean temperature with different Reynolds No. along with different frequency

Figure 3 maximum value of heat removal rate is at frequency 30 Hz along with Reynolds No. 1100 is 95.5^{0}C

One more thing we can observe from the graph 1 the value of mean wall temperature at all frequency at different Reynolds No. is decreasing regularly.

In all the three results the temperature drop is maximum at frequency 30 Hz and Reynolds No. 1100.

Comparison of heat transfer enhancement factor (E) variation at different Reynolds No. (Re)

There are three results of heat transfer enhancement factor (E) at different Reynolds No. 300, 700, 1100.If we want to check the maximum value of heat transfer enhancement factor (E) then comparison of results is necessary. As we know that the convective heat transfer is linearly depended on surface area means if we want to increase the convective heat transfer than we have to increase the surface area but in present study the surface area is limited so we have to increase the available air mass than by increasing Reynolds No. the mass of air increases, now the much air is available for removing heat from the surface.

4.2 Comparison of Enhancement factor (E) at different Reynolds No.

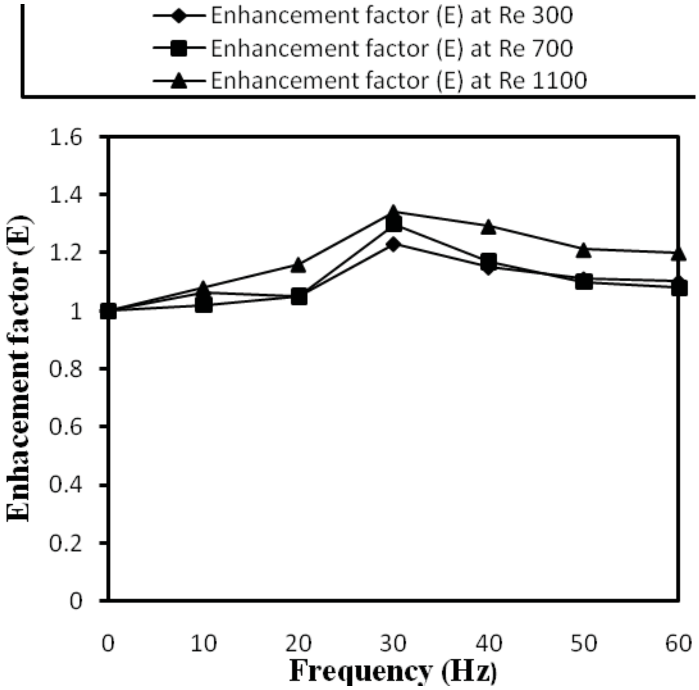

Figure 4 Variation of Enhancement factor (E) with different Reynolds No. (Re) along with different frequency
Figure 4 shows the maximum value of heat enhancement factor is at frequency 30 Hz along with Reynolds no. 1100.

4.3 Comparison between overall performance of aluminum and silicon work piece at Reynolds no 1100
The wall temperature of aluminium work piece decreases up to frequency 30 Hz and again increases from 30 Hz to 60 Hz whereas the wall temperature of silicon work piece decreases up to 20Hz and increases from 20 Hz to 60 Hz .The temperature decrease and temperature increase is more in aluminium work piece as compared to the silicon work piece.

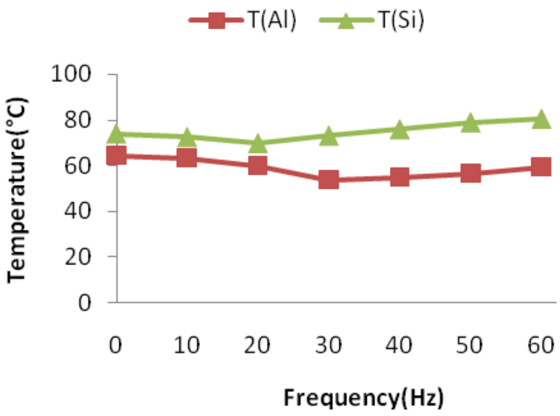

Figure 5: Comparison of overall performance between Al and Si at Reynolds no.1100

V. CONCLUSION

The experimental study has been carried out to investigate heat dissipation from a heated triangular cylinder in an oscillating channel flow. Impact of the pulsating frequency (0 Hz <*fp*<60 Hz) and the Reynolds number based on the mean velocity (*Re* = 300,700 and 1100) on heat transfer enhancement was investigated. Input power and the velocity amplitude were fixed in the present experiment.The obtained results lead to the following conclusions:
It is found that heat enhancement increased with the rise of Reynolds number of steady flow and maximum at frequency 30 Hz along

1. with Reynolds number 1100 on aluminium work piece
2. It is found that temperature drop is maximum at frequency 30 Hz along with Reynolds number 1100
3. Lock on phenomenon shows during frequency 0 to 30 Hz.
4. At frequency 40 Hz the system start vibration it shows the phenomenon “vortex induced vibration”.
5. It is found that heat enhancement increased with the rise of Reynolds number of steady flow and maximum at frequency 20 Hz along with Reynolds number 1100 on silicon work piece
6. Lock on phenomenon shows during frequency 0 to 20 Hz.
7. At frequency 30 Hz the system start vibration it shows the phenomenon “vortex induced vibration”.

In the conclusion, Experimental investigations have shown that flow pulsation resulted in an increased heat transfer rate when the lock on phenomenon occurred

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VI. NOMENCLATURE

A - Pulsating amplitude
B -Side length of a square cylinder, mm
E -Heat transfer enhancement factor, Nu_P/Nu_s
f -Dimensional frequency, Hz
fp -Pulsating frequency, Hz
h -Heat transfer coefficient, W/m^{2}k
H -Height of flow channel, mm
k -Thermal conductivity of air, W/mK

L -Length of flow channel, mm
Nu -Nusselt number
qw -Input heat flux, W/m2
Re -Reynolds number, UoB/ν
St -Strouhal number, fB/Uo
T -Local surface temperature, K
Ti -Inlet air temperature, K
Ui -Inlet air velocity, m/s
W -Channel width, mm
X –Stream wise coordinate
Xd -Distance from the outlet to downstream face of the cylinder, mm
Xu -Distance from the outlet to upstream face of the cylinder, mm
Y -Transverse coordinate

Greek symbols
β -Blockage ratio
ν -Kinematic viscosity, m^2/s

Subscripts
p -Pulsating component
s -Steady-state component

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