Heat Transfer Augmentation Dealing with Aerodynamic Device (Flag Vortex Generator)

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Abstract- The use of flexible plates or "flags" as vortex generators inside a channel was successfully demonstrated as an alternative heat transfer augmentation technique. This paper aims to present a brief review of flag vortex generators for thermal augmentation. Although flag dynamics is widely reported, the review reveals that this heat transfer technique is not widely explored, specifically on the heat transfer performance of flags. Extensive and intensive experimental results are lacking to validate numerical and theoretical predictions. This paper further provides methods of Heat Transfer augmentation, with their classification. Non-exhaustive list of existing gaps, challenges, and potential research areas in using flags as vortex generators for thermal enhancement, which aims to guide future research directions in this thermal-fluid-structure problem. There is a need to conduct further investigations on this technique to fully establish its thermal characteristics.

Indexed Terms- Flags, VG, Heat Transfer,

I. INTRODUCTION

Heat transfer augmentation or heat transfer intensification is very importance in the applications of thermal systems where overheating can damage the components or assemblies of the system. Hence, in order to avoid such type of problems, some heat transfer intensification techniques are being used in industrial applications. Augmentation of heattransferintensityinalltypesofthermotechnicalapparatusisofgreatsignificanceforindustry. Beside the savings of primary energy, it also leads to a reduction in size and weight. Several heat transfer augmentation techniques have been developed.

Heat transfer augmentations the practice of modifying a heat transfer surface or the flow cross section to either increase the heat transfer coefficient between the surface and a fluid or the surface area so as to effectively sustain higher heat loads with a smaller temperature difference. Some practical examples of heat transfer enhancement. I.e., fins, surface roughness, twisted tape inserts and coiled tube, which are generally referred to as passive technique. Heat transfer augmentation may also be achieved by surface or fluid vibration, electrostatic fields or mechanical stirrers. These latter methods are often referred to as active techniques because they required the application of external power. Increases in heat transfer due to surface treatment can be brought about by increased turbulence, increased surface area, and improved mixing or flow swirl. These effects generally result in an increase in pressure drop along with the increase in heat transfer.

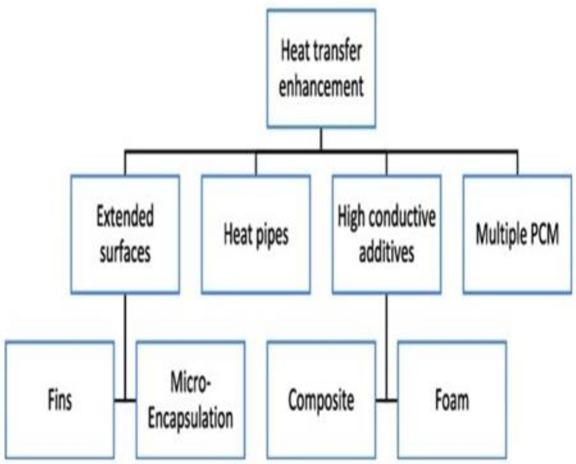
Using passive techniques in order to enhance heat transfer characteristics in heat exchanger has been an interesting topic for scientists and researchers during recent decades.

Numerica land experimental studies have been conducted in order to improve heat transferred by these techniques. The demand of reduction of the cost and dimensions of heat exchanger has motivated the searchers to investigate different ways of heat transfer augmentation

II. OBJECTIVES

- Investigation of Heat transfer enhancement in Flag as Vortex Generator.
- Pressure drop estimation in Flag Vortex Generator.
- To enhance the heat transfer augmentation with minimum pressure, drop.
- Thermal Performance enhancement analysis in Flag Vortex Generator.

III. METHODS FOR HEAT TRANSFER AUGMENTATION



IV. CLASSIFICATIONS OF ENHANCEMENT TECHNIQUES

Heat transfer enhancement techniques refer to the improvement of thermo- hydraulic performance of heat exchangers. Existing enhancement techniques can be broadly classified into three different categories:

4.1 Passive Techniques
4.2 Active Techniques
4.3 Compound Techniques

4.1 Passive Techniques: -
These techniques generally use surface or geometrical Modifications to the flow channel by incorporating inserts or additional devices. They Promote higher heat transfer coefficients by disturbing or altering the existing flow behavior (except for extended surfaces) which also leads to increase in the pressure drop. Heat transfer augmentations by this technique scan be achieved by using Treated Surfaces, Rough surfaces, extended surfaces, displaced enhancement devices, Swirl flow devices, and Coiled tubes.

4.2 Active Techniques: -
These techniques are more complex from the use and design point of view as the method requires some external power input to cause the desired flow modification and improvement in the rate of heat transfer. It finds limited application because of the need of external power in many practical applications. In comparison to the passive techniques, these techniques have not shown much potential as it is difficult to provide external power input in many cases. Various active techniques are as follows:

4.2.1 Mechanical Aids: -
Examples of the mechanical aids include rotating tube exchangers and scrapped surface heat and mass exchangers. These devices stir the fluid by mechanical means or by rotating the surface.

4.2.2 Surface vibration: -
They have been used primarily in single phase flows. A low or high frequency is applied to facilitate the surface vibrations which results in higher convective heat transfer coefficients.

4.2.1 Fluid vibration: -
Instead of applying vibrations to the surface, pulsations are created in the fluid itself. This kind of vibration enhancement technique is employed for single phase flows.

4.2.2 Electro static fields: -
Electrostatic field like electric or magnetic fields or a combination of the two from DC or AC sources is applied in heat exchanger systems which induces greater bulk mixing, force convection or electromagnetic pumping to enhance heat transfer. This technique is applicable in heat transfer process involving dielectric fluids.

4.2.5 Injection: -
In this technique, same or other fluid is injected into the main bulk fluid through a porous heat transfer interface or upstream of the heat transfer section. This technique is used for single phase heat transfer process.

4.2.6 Suction: -

This technique is used for both two phase heat transfer and single-phase heat transfer process. Two phases nucleate boiling involves the vapor removal through a porous heated surface whereas in single phase flows fluid is withdrawn through the porous heated surface.

4.2.7 Jet impingement:

This technique is applicable for both two phase and single-phase heat transfer processes. In this method, fluid is heated or cooled perpendicularly or obliquely to the heat transfer surface.

4.3 Compound Techniques: -

A compound augmentation technique is the one where more than one of the above-mentioned techniques is used in combination with the purpose of further improving the thermo-hydraulic performance of a heat exchanger.

V. VORTEX HEAT TRANSFER ENHANCEMENT TECHNIQUE

Each Flag acts as a "Vortex Generator" which provides an intensive and stable heat and mass transfer between the surface and gaseous heating/cooling media. Taking advantages of VHTE, as

a) higher heat transfer coefficient
b) negligible pressure drop penalty
c) potential from fouling rate reduction
d) simplicity in design and fabrication
e) compactness and/or lower cost.

This method is potentially used in heat transfer enhancement in convective passages for industrial boilers, process heaters and furnaces and heat exchangers variety for other industries like automotive (radiators, oil coolers etc.), heat treating (recuperates etc.), power electronics (convective coolers etc.), aerospace, military, food processors etc.

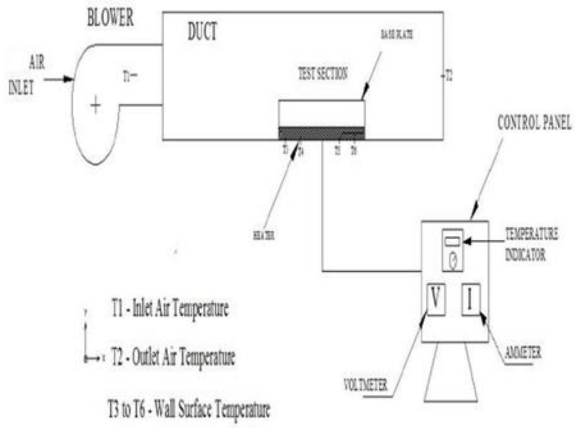
In this paper we are used Flags induct for heat transfer because of it is a good way to promote the flow mixing in a duct. This new concept we using flags in channel it can help us to increase the heat transfer enhancement and flag surface present the highest performance of the heat transfer enhancement. The flag surface it canals so called as artificial surface act as extended surface (fin surface) and them a in purpose of extended surface to increase the heat transfer rate. The advantages of the flags in channel section are fluid mixing is more as compared to smooth or flat plate and boundary layer separation occurs in channel section which will help in heat transfer enhancement.

(Image: - Flag as a Vortex Generator)

VI. EXPERIMENTAL SETUP

An insulated duct with the specified dimension of 150 mm width and a height of 100mm, length 1000mmmade of glass are used for this experimental study. The smooth flat plate specimen made up of aluminium material with the width 150mm, height 150mm and having a thickness of 10mm was placed inside the duct.

The location of the specimen inside the duct were ensured such that the flow was hydro-dynamically fully developed condition to ensure prior to the plate. Blower is used to supply cold air into duct or over the flat plate.



(Figure: - Schematic diagram of Experimental Setup)

The electric heater with a capacity of 300 W had been placed beneath the aluminium plate impart thermal energy to the air flow along with flat plate. As a result of this, the temperature was increased and as per the requirement of configuration, the heat input was controlled. There is a temperature sensor along with digital temperature indicator to measure in let and out let temperature of air. The temperature sensor (TS-01) was providing to measure.

Inlet air flow temperature and temperature sensor (TS-02) was providing to measure outlet airflow temperature. The temperature sensor (TS-03 toTS06) was providing to measure surface temperature of plate. Anemometer is used to measure outlet velocity of air flow.

VII. SEQUENCE OF OPERATION

Experiments were carried out first on plain aluminium horizontal square plate and then on horizontal square plate with inline arrangement of flags and staggered arrangement of flags. With flat plate Initially, the experiment was carried out in the duct without flags.

(Image: - Experimental Setup)

The working fluid air flows through the duct section with least resistance and at various mass flow rates. Plate with Flags: The flags were placed on the plate shown in figure. With the same flow rate as used in flat plate experiment was carried out for inline and staggered arrangement of flags.

The presence of the flags inside the duct causes resistance to flow and increases turbulence. The mass flow rates of air and the heat input were kept constant as that of flat plate experiment.

CONCLUSION

As we used Flags induct for heat transfer because of it is a good way to promote the flow mixing in a duct. This new concept of using flags in channel can help us to increase the heat transfer augmentation and flag surface present the highest performance of the heat transfer enhancement and the purpose of extended surface is to increase the heat transfer rate. Fluid mixing flags in channel section is more as compared to smooth or flat plate and boundary layer separation occurs in channel section which will help in heat transfer augmentation. The paper shows experimental setup and the sequence of operation, Experiments were carried out first on plain aluminium horizontal square plate and then on horizontal square plate with inline arrangement of flags and staggered arrangement of flags. With flat plate initially, the experiment was carried out in the duct without flags.

This paper work shows that the Staggered Flag Arrangement with using "Flags" is leads to greater heat transfer enhancement. The main purpose of extended surface to increase the heat transfer rate. The advantages of the Flags are fluid mixing is more and boundary layer separation occurs in Channel which will help increase heat transfer Rate.

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