

Review Article

REVIEW PAPER ON FORCED CONVECTION HEAT TRANSFER AUGMENTATION USING ANNULAR BLOCKAGES

¹A. A. Herle, ²Prof. P. R. Kulkarni

Address for Correspondence

¹PG Student, ²Professor, Mechanical Engineering, Dept, Dr. J. J. Magdum College of Engineering, Jaysingpur, Kolhapur, India.

INTRODUCTION

The study of improved heat transfer performance is referred to as heat transfer enhancement, augmentation, or intensification. In general, this means an increase in heat transfer coefficient. Energy- and materials-saving considerations, as well as economic incentives, have led to efforts to produce more efficient heat exchange equipment. Common thermal-hydraulic goals are to reduce the size of a heat exchanger required for a specified heat duty, to upgrade the capacity of an existing heat exchanger, to reduce the approach temperature difference for the process streams, or to reduce the pumping power. The study of improved heat transfer performance is referred to as heat transfer enhancement, augmentation, or intensification. In general, this means an increase in heat transfer coefficient. [1] General techniques for enhancing heat transfer can be divided in three categories. One is passive method such as twisted tapes, helical screw tape inserts, rough surfaces, extended surfaces, additives for liquid and gases. The second is active method, which requires extra external power, for example mechanical aids, surface fluid vibration, use of electrostatic fields. Passive methods are found more inexpensive as compared to other group. The third category includes combined application of active and passive techniques to obtain enhancement in heat transfer that is greater than that produced by either of them when used individually, is termed as compound enhancement.[2] Passive techniques, where inserts are used in the flow passage to increase the heat transfer rate, are advantageous compared with active techniques, because the insert manufacturing process is simple and cheap and these techniques can be easily employed in an existing heat exchanger.[3] The Proposed dissertation work consists of an experimental investigation of heat transfer enhancement through Plain tube with annular blockages insertion over a plain tube of heat exchanger.

RELEVANCE /MOTIVATION

In this dissertation work it is proposed to carry out the experimental investigation of enhancement of heat transfer using annular blockages in heat exchanger because heating and cooling of fluids flowing inside conduits are among the most important heat transfer processes in engineering. The design and analysis of heat exchanger require knowledge of heat transfer coefficient between the wall of conduit and the fluid flowing inside it. The size of boilers, economizers, super heaters and pre-heaters depends largely on the heat transfer coefficient between the inner surface of tube and fluid. [5]

LITERATURE REVIEW

Kreith F. et al. [1], they discussed about different techniques used to enhance the heat transfer. In that three method i.e. passive technique, active technique and compound technique for single phase forced are discussed in detail. In case of passive technique the turbulence promoters are inserted in a tube, the promoter produces a sizable elevation in the Nusselt no. Or heat transfer coefficient at constant Reynolds no. Or velocity. Also the correlations are recommended for tubes with transverse or helical repeated ribs with turbulent flow. Under active techniques, mechanically aided heat transfer in the form of surface scraping can increase forced convection heat transfer. Compound techniques are not practical but some of examples of Compound techniques are rough tube wall with twisted-tape inserts, rough cylinder with acoustic vibrations, internally finned tube with twisted-tape inserts, finned tubes in fluidized beds, externally finned tubes subjected to vibrations, rib-roughened passage being rotated. Along with this passive & active enhancement techniques for pool boiling, convective boiling/evaporation, vapour space condensation are discussed.

Suhas V. Patil et al. [2], this paper is a review of research work in last decade on heat transfer enhancement in a circular tube and square duct. In this paper emphasis is given to works dealing with

twisted tape, screw tape inserts because according to the recent studies, these are known to be economic tool in the field of heat transfer enhancement.

Dr. Anirudh Gupta et al. [3], In this journal the Passive heat transfer techniques improved by the different researchers are discussed, which shows many researchers are taking interest to enhance heat transfer rate with passive methods. Dimple, protrude and rough surfaces etc passive methods are used in heat exchangers, air heaters and heat sinks to enhance heat transfer. Also heat transfer enhancement techniques are discussed in detail which includes passive, active and compound technique. Passive techniques generally use surface or geometrical modifications to the flow channel by incorporating inserts or additional devices. Active 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. 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 exchange

A Dewan et al. [4], has reviewed Techniques for heat transfer augmentation such as passive, active or a combination of passive and active methods which are relevant to several engineering applications. Heat transfer enhancement in a tube flow by inserts such as twisted tapes, wire coils, ribs and dimples is mainly due to flow blockage, partitioning of the flow and secondary flow. Also they summarised of important investigations of twisted tape in laminar flow in tabular format and summary of important investigations of twisted tape in turbulent flow in tabular form.

Sandeep S. Kore et al. [6], the experimental investigation has been carried out to study heat transfer and friction coefficient by dimpled surface. Using data from experiment heat transfer, friction factor and thermal performance characteristics of duct are discussed with respect to Nusselt no., Reynolds no. And their effects it is observed that Nusselt number increases with Reynolds number for dimpled surface as well as for smooth channel, but rate of increase is more for the dimpled surface as compared to smooth surface. Also the effects of dimple depth, friction factor are discussed.

Mark E et al. [7], this paper focuses on reviewing convectional single phase heat transfer enhancement

Int. J. Adv. Engg. Res. Studies/IV/II/Jan.-March,2015/

techniques for application of MICROCHANNELS, MINICANNELS and MICRODEVICES. The summery of enhancement techniques for Micro channels and Mini channels is done. The passive enhancement techniques used in single phase flow augmentation include flow disruptions, secondary flows, surface treatment and entrance effects. The active enhancement techniques used in single phase flow augmentation include vibration, electrostatic fields, flow pulsation and variable roughness structure.

Arthur E. Bergles et al [8], focuses on characterization of twisted-tape-induced helical swirl flows for enhancement of forced convective heat transfer in single-phase and two-phase flows. A frequent usage is to retrofit existing heat exchangers in order to upgrade their heat load capacity. When twisted tapes are incorporated in the design of a new exchanger, then, for a specified heat duty and process application, significant size reduction can be achieved relative to that in a plain tubular exchanger. Structure and Scaling of Single-Phase Swirl Flow in that twisted tape induced swirl flow pattern & computational characteristics of swirl in circular tubes with twisted tape inserts with variation of Reynolds no. are studied. The primary mechanism entails imparting a centrifugal force component to the longitudinal fluid motion, which superimposes secondary circulation over the main axial flow to promote cross-stream mixing. Heat transfer coefficient and friction factor correlations for both laminar and turbulent regimes are presented, and the damping effect of swirl on the transition region is highlighted.

Giovanni Tanda et al. [9], paper focuses on cooling techniques for vanes and blades of advance gas turbine operate at high entry gas temperature. Rib turbulators periodically deployed along the main direction of the flow, were one of the first improvements of blade internal cooling. For doing this experimental study is carried out on forced convection heat transfer in channels with rib turbulators inclined at 45 deg. Heat transfer performance, relative to a smooth channel with the same pumping power, is generally better for the higher rib pitch-to-height ratio regardless of the number of ribbed walls one or two.

Jozef Cernecky et al. [10], the paper deals with visualization of temperature fields in the vicinity of profiled heat transfer surfaces and a subsequent

analysis of local values of Nusselt numbers by forced air convection in an experimental channel. The effect of heat transfer area roughness on heat transfer enhancement by forced convection experiments were carried out at Re 462 up to 2338 at the distances between heat transfer surfaces of 0.025m and 0.035 m. Holographic Interferometry was used to Visualization of Temperature Fields.

PROPOSED WORK

It is proposed to carry out “Experimental investigation of Forced convection heat transfer augmentation using annular blockages” For this dissertation work; the proposed work is divided into the following phases.

Phase I:

Review of Literature: Detailed information of existing techniques available for augmentation of forced convection heat transfer.

Phase II:

Determining the diameter of annular blockages which are inserted in pipe for heat transfer augmentation and the specifications of component required for the experimental set up.

Phase III:

Fabrication of experimental set-up.

Phase IV:

Testing of experimental set up by using different annular blockage and find out results.

Phase V:

Comparison of result obtained from different annular blockage. The Experimental data collected for plain tube is taken as reference data to evaluate the performance of other arrangements.

Phase VI:

Completion of Project and prepare Project Report.

a. Scope

From the literature review it is seen that there is some scope for research work in the area of heat

transfer it is proposed to carry out some theoretical, experimental and analytical studies on forced convection heat transfer augmentation using annular blockages. Heat transfer augmentation techniques are commonly used in areas such as process industries, heating and cooling in evaporators, thermal power plants, air-conditioning equipment, refrigerators, radiators for space vehicles, automobiles, also with the growth of the nuclear power industry and need to improve the performance of reactors etc.

b. Methodology

Theoretical Analysis:

1. Determining detailed dimensions of annular blockages like diameter, the annular blockages considered while experimentation are taken with 10%,20%,30% & 40% reduction with respect to tube diameter.
2. During experimentation pressured difference across the orifice meter, temperature of the heated surface and temperatures of air at inlet and outlet of the test section and Pressure drop across the test section are measured. The mass flow rate of air is determined from the pressure drop across the orifice meter, the useful heat gain of the air is calculated, and the Nusselt number is calculated. The friction factor was determined from measured vales of pressure drop across the test section. Reynolds number based on hydraulic diameter is calculated.
3. Using the data obtained from experiments, the heat transfer, friction factor and the thermal performance characteristics of fluid for annular blockages with different diameter are calculated. These calculated data is analyzed to find out increased heat transfer from annular blockages.

c. Proposed experimental setup:

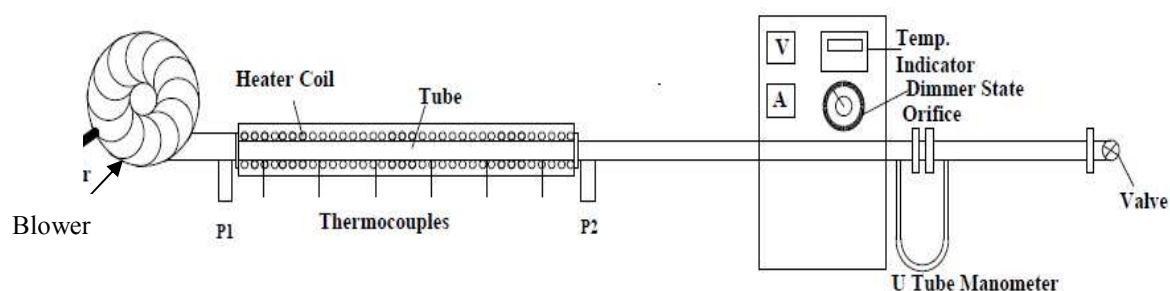
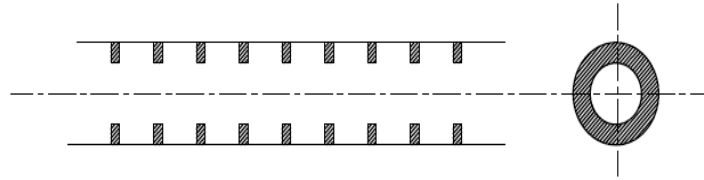


Figure1. Proposed Experimental Set up



Annular blockages

An experimental set-up has been designed and fabricated to study the effect of annular blockages on heat transfer and fluid flow characteristics in circular tube.

The test apparatus is an open air flow loop that consists of a centrifugal blower (1), flow control valve (2), orifice meter along with water manometer to measure mass flow rate of air (3), test section 0.5m length, 25mm diameter (4), Annular blockages (material aluminium) having thickness 3mm, outer diameter 25mm & inner diameter with 10%,20%,30% & 40% reduction in outer diameter.(5), heater nicrome wire with GI gladding(6), pressure sensor digital (7), Temp. Indicator digital (8), thermocouple (0 to 200°C) calibrated (9), dimmer state 2 amps & 0 to 200 volt (10), ammeter digital 0 to 2 amp (11), volt meter digital 0 to 200 volt (12).

REFERENCES:

1. Kreith F., Timmerhaus K., Lior N., Shaw H., Shah R.K., Bell K. J.,etal.“Applications.” The CRC Handbook of Thermal Engineering. Ed. Frank Kreith. Arthur E. Bergles. Boca Raton: CRC Press LLC, 2000, 408-457.
2. Suhas V. Patil and P. V.Vijay Babu “Heat Transfer Augmentation in a Circular tube and Square duct Fitted with Swirl Flow Generators: A Review” International Journal of Chemical Engineering and Applications, Vol. 2 , No. 5 , October 2011
3. Dr. Anirudh Gupta, Mayank Uniyal “Review of Heat Transfer Augmentation through Different Passive Intensifier Methods” IOSR Journal of Mechanical and Civil Engineering (IOSRJMCE) ISSN: 2278-1684 Volume 1, Issue 4 (July-Aug 2012), PP 14-21.
4. A Dewan, P Mahanta, K Sumithra Raju & P Suresh Kumar, “Review of passive heat transfer augmentation techniques”, Proc.Instn Mech. Engrs. Vol. 218 Part A: J Power & Energy, (2004), 509-527.
5. Frank Kreith & Mark S. Bohn “Principle of Heat Transfer,” Forced Convection Inside Tubes and Ducts. ISBN-13:978-81-315-0038-5, 355-404.
6. Sandeep S. Kore, Satishchandra V. Joshi, Narayan K. Sane “experimental investigations of heat transfer enhancement from dimpled surface in a channel” ISSN : 0975-5462 Vol. 3 No. 8 August 2011.
7. Mark E Steinke and Satish G. Kandlikar “Review Of Single Phase Heat Transfer Enhancement Techniques For Application In Micro Channels, Mini Channels And Micro Devices” Heat and technology vol.22, 2004
8. Raj M. Manglik & Arthur E. Bergles “Characterization Of Twisted-Tape-Induced Helical Swirl Flows For Enhancement Of Forced Convective Heat Transfer In Single-Phase And Two-Phase Flows” Fellow ASME Thermal-Fluids & Thermal Processing Laboratory, June 2013, vol. 5.
9. Giovanni Tanda and Roberto Abram “Forced Convection Heat Transfer in Channels with Rib Tabulators Inclined at 45 deg” Journal of Turbo machinery fellow ASME, APRIL 2009, Vol. 131 / 021012- 1 to 10
10. Jozef Cernecky, Jan Koniar and Zuzana Brodnianska “The Effect of Heat Transfer Area Roughness on Heat Transfer Enhancement by Forced Convection” Journal of Heat Transfer fellow ASME APRIL 2014, Vol. 136 / 041901-1 to 8.