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Heat Transfer Enhancement in Double Pipe Heat Exchanger Using Twisted Tape Inserts: A Review

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KEYWORDS

Double pipe heat exchanger, Twisted tape insert, Heat transfer enhancement, CFD, Passive technique, Thermal performance

ABSTRACT

Heat exchangers are widely used in thermal engineering applications such as power plants, refrigeration systems, air conditioning, and chemical industries. Improving heat transfer efficiency while minimizing pressure drop is an important research area. Passive heat transfer enhancement techniques such as twisted tape inserts are widely used due to their simplicity and cost effectiveness. This review paper presents a comprehensive study on heat transfer enhancement in double pipe heat exchangers using twisted tape inserts. The influence of twist ratio, Reynolds number, pressure drop, and thermal performance are discussed. Various experimental and CFD studies are reviewed. The results show that twisted tape inserts significantly improve Nusselt number and heat transfer coefficient due to swirl flow and turbulence generation. Although pressure drop increases slightly, overall thermal performance improves. This review provides useful insights for design and optimization of heat exchangers

1. INTRODUCTION

Heat exchangers are important thermal devices used to transfer heat between two fluids at different temperatures. Double pipe heat exchangers are simple in construction and widely used in small scale industries. However, heat transfer rate in smooth tubes is limited due to boundary layer formation. Heat transfer enhancement techniques are used to improve thermal performance.

Twisted tape inserts are passive heat transfer enhancement devices inserted inside the tube. They create swirl flow, increase turbulence, and improve mixing between fluid layers. This results in increased heat transfer coefficient and improved thermal efficiency. This review paper summarizes research works on twisted tape heat exchanger performance.

2. HEAT TRANSFER ENHANCEMENT TECHNIQUES:

Heat transfer enhancement methods are classified into active, passive, and compound techniques. Passive techniques such as twisted tape inserts improve heat transfer without external power input. Twisted tapes are widely used due to simple construction and low cost.

2.1 Active Techniques

Active techniques require external power input such as vibration, pulsation, or mechanical mixing. These methods improve heat transfer but increase complexity.

2.2 Passive Techniques

Passive techniques enhance heat transfer by modifying geometry or flow. These include:

- Twisted tape inserts
- Wire coil inserts
- Extended surfaces
- Ribbed tubes
- Helical inserts

Twisted tape inserts are widely used due to simple construction.

2.3 Compound Techniques

Combination of active and passive methods is called compound technique.

3. TWISTED TAPE INSERTS

Twisted tape is a thin metal strip twisted along its length and inserted inside the tube. It generates swirl flow which enhances turbulence and reduces thermal boundary layer thickness. This improves heat transfer coefficient. Performance depends on twist ratio, Reynolds number, and tape geometry.

4. LITERATURE REVIEW:

- Crespo-Quintanilla et al. reported improved heat transfer performance using twisted tape inserts with performance evaluation criteria up to 3.06.
- Shelare et al. reviewed various twisted tape geometries and observed significant improvement in Nusselt number.
- Suri et al. experimentally studied perforated twisted tapes and reported improved thermal performance.
- Lin et al. investigated twisted tape with winglet vortex generators and observed improved heat transfer.
- Skullong et al. studied delta wing twisted tapes and reported 50% increase in Nusselt number.
- Patil et al. analyzed double pipe heat exchanger and observed improved thermal performance using inserts.

5. CFD ANALYSIS

CFD analysis using ANSYS Fluent is widely used to analyze twisted tape heat exchangers. The simulation provides:

- Temperature distribution
- Velocity contours
- Pressure drop
- Turbulence intensity
- Heat transfer coefficient

CFD results confirm improved mixing and turbulence with twisted tape inserts.

6. PERFORMANCE PARAMETERS

The performance of twisted tape heat exchanger is evaluated using:

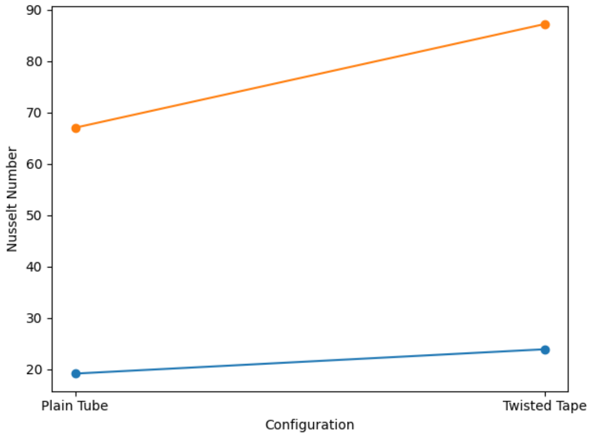
- Reynolds number
- Nusselt number
- Heat transfer coefficient
- Friction factor
- LMTD
- Thermal performance factor

These parameters indicate thermal performance improvement.

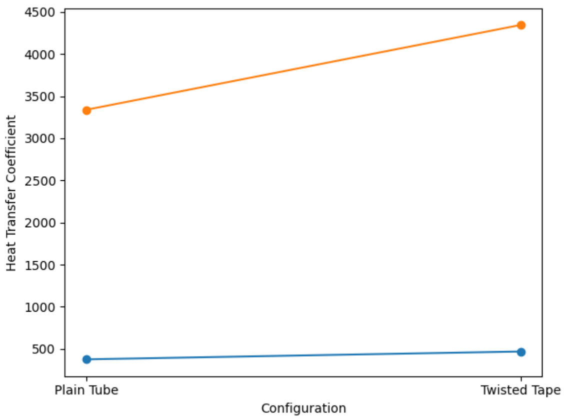
7. DISCUSSION

From literature, twisted tape inserts increase heat transfer rate significantly. Swirl flow enhances mixing between fluid layers. This reduces thermal resistance and increases heat transfer coefficient.

Although pressure drop increases due to obstruction, overall thermal performance improves. CFD results also confirm improved turbulence and temperature distribution.



Comparison of heat transfer coefficient for plain tube and twisted tape configuration.



8. CONCLUSION

Twisted tape inserts are effective passive heat transfer enhancement techniques. They increase Nusselt number, Reynolds number, and heat transfer coefficient. Swirl flow generated by twisted tape improves mixing and thermal performance. Although pressure drop increases slightly, overall efficiency improves. Twisted tape heat exchangers are suitable for industrial thermal applications.

Future Scope:

Future work can include different twisted tape geometries such as perforated and serrated designs. Different twist ratios can be tested. Nanofluids can be used to enhance heat transfer further. CFD optimization studies can be performed. Industrial scale heat exchanger design can also be developed.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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