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Evaluation of a helical coil heat exchanger in a forced convection environment

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Aims and scope

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Abstract

Heat transfer methods aim to maximize heat transmission and minimize pressure loss. Published efforts have focused on active and passive heat transport techniques. Curved tubes, such those in helical coil heat exchangers, improve heat transmission without active intervention. Experimental and computational studies of helical coils under forced convection have been done. This work examined the heat transmission and pressure drop of forced convection helical coil tubes using experimental and CFD methods. CATIA V5 builds, ICEM 14.5 meshes, and ANSYS 14.5 solves a three-dimensional model. A k-turbulent flow model and algorithm simulate fluid flow and heat transfer to properly predict heat transfer characteristics. Experiments and computer simulations determined the temperature and pressure loss at a particular flow rate and input temperature. The

model is validated by comparing numerical simulation temperature differences to experimental data. A boundary condition that maintains a constant temperature in numerical analysis may provide incorrect results. This makes the boundary condition a connected system. To calculate temperature, a K-turbulence model (RNG) solver is used with curvature correction and swirl dominated flow. The project includes turning a 12-mm straight tube into a 120-mm helical coil with a 25-mm pitch. To simulate forced convection, this coil is placed in a duct. Experiment is done at 353 K and 343 K with 1.23, 1.66, and 2.1 l/min flow rates. The CFD simulation used the same design and flow conditions. One end of the duct has a fan that blows air over the coil and lets hot water run through it. With a constant wall temperature as the boundary condition, the conjugate heat transfer between the water and air in the coil and fan is examined in a cross flow pattern. Different flow rates were used to validate temperature difference data. The experimental and CFD values varied by 7% or less due to measurement errors in system temperature and heat losses.

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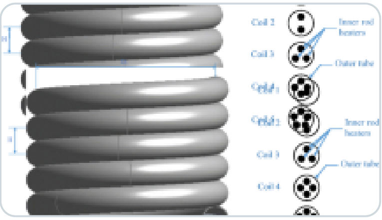

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Data availability

No datasets were generated or analysed during the current study.

Code availability

Not applicable.

Abbreviations

r: Radius of tube (m)

r_c: Radius of coil (m)

P: Pitch (m)

n: Number of turns

A: Area of coil (m^2)

l: Length of coil (m)

D_h: Hydraulic diameter, (m)

h_i: Inner Heat transfer coefficient (W/m^2K)

h_o: Outer Heat transfer coefficient (W/m^2K)

U: Over all heat transfer coefficient (W/m^2K)

ε: Effectiveness

ρ: Density (kg/m^3)

Re: Reynolds number

De: Dean Number

Pr: Prandtl number

Nu: Nusselt number

LMTD: Logarithmic temperature difference

NTU: Number of Transfer units

CFD: Computational fluid dynamics

Q: Heat transfer rate, W

m: Mass flow rate, kg/s

v : Velocity of fluid, m/s

μ : Dynamic viscosity, m^2/s

ΔP: Pressure drop, Pa

C_{min} : Minimum Specific heat, kJ/kg·K

k : Thermal conductivity, W/m·K

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Contributions

Neeraj Sunheriya, Jayant Giri: Wrote the paper with input from all authors, Contributed to the design and implementation of research, to the analysis of result and to the writing of the manuscript.

T.Sathish, Rajkumar Chadge: Contributed to the design and implementation of research.

Chetan Mahatme, A.Parthiban, Praveen Barmavatu: Contributed to the design and implementation of research.

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Ethics declarations

Declarations

Not applicable.

Ethics approval

Not applicable.

Consent to participate

Not applicable.

Consent to publication

Not applicable.

Competing interests

The authors declare no competing interests.

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