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MODELING AND CFD SIMULATION OF COMMERCIAL PLATE FIN HEAT EXCHANGER AT DIFFERENT FLOW CONDITIONS

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ABSTRACT: A plate-fin heat exchanger is a type of heat exchanger design that uses plates and finned chambers to transfer heat between fluids. It is often categorized as a compact heat exchanger to emphasise its relatively high heat transfer surface area to volume ratio. The plate-fin heat exchanger is widely used in many industries, including the aerospace industry for its compact size and lightweight properties, as well as in cryogenics where its ability to facilitate heat transfer with small temperature differences is utilized. In this thesis, a finite-element method is used for modeling the thermal analysis of plate fin heat exchanger. The temperature distribution and heat flux are evaluated at different materials (stainless steel, aluminum alloy and copper. Detailed analyses are performed to estimate the boundary conditions of heat exchanger. In this thesis, CREO parametric is employed for modeling and ANSYS is used for analysis of the plate fin heat exchanger. CFD analysis to determine the pressure drop, heat transfer coefficient, mass flow rate and heat transfer rate for two different models (straight and curved fins) at different flow conditions (laminar and turbulent).

KEY WORDS: commercial plate heat exchanger, CREO, CFD analysis

1. INTRODUCTION

1.1 HEAT EXCHANGERS: Heat exchanger is a device that is used for transfer thermal energy from one liquid to another that are at different temperatures, while usually preventing them mixing each other. Heat exchangers are used in a wide variety of applications such as HVAC systems, food and chemical process systems, heat recovery systems**.** A plate-fin heat exchanger is a type of heat exchanger design that uses plates and finned chambers to transfer heat between fluids. It is often categorized as a compact heat exchanger to emphasize its relatively high heat transfer surface area to volume ratio.

1.2 PLATE-FIN HEAT EXCHANGER: The plate-fin heat exchanger is widely used in many industries, including the aerospace industry for its compact size and lightweight properties, as well as in cryogenics where its ability to facilitate heat transfer with small temperature differences is utilized. Aluminum alloy plate fin heat exchangers, often referred to as Brazed Aluminum Heat Exchangers, have been used in the aircraft industry for more than 60 years and adopted

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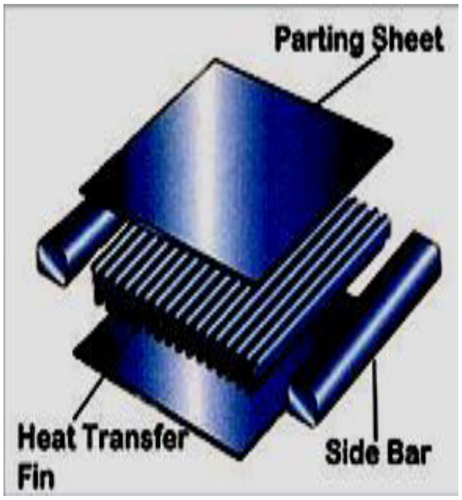
into the cryogenic air separation industry around the time of the second world war and shortly afterwards into cryogenic processes in chemical plants such as Natural Gas Processing



Principal Components of a Plate Fin Heat Exchanger: Heat is transferred from one stream through the fin interface to the separator plate and through the next set of fins into the adjacent fluid. The fins also serve to increase the structural integrity of the heat exchanger and allow it to withstand high pressures while providing an extended surface area for heat transfer. A high degree of flexibility is present in plate-fin heat exchanger design as they can operate with any combination of gas, liquid, and two-phase fluids. Heat transfer between multiple process streams is also accommodated, with a variety of fin heights and types as different entry and exit points available for each stream.

2. LITERATURE SURVEY

2.1 Plate Fin and Tube Heat Exchangers

There have been several studies on plate fin and tube heat exchangers. Wang el al. (1999) conducted an experimental study on the air-side performance for two specific louver fin patterns and their plain plate fin counterparts. This study investigated the effects of fin pitch, longitudinal tube spacing and tube diameter on the air-side heat transfer performance and friction characteristics. It was found that the heat transfer performance increased with reduced fin pitch. Kim et al (1999) conducted an experimental study on heat exchangers having plain fins on a staggered array of circular tubes.

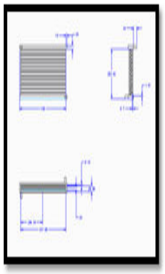
3. RELEATED STUDY

3.1 INTRODUCTION TO CREO: PTC CREO, in advance ask as Pro/ENGINEER, is three-D modeling groupware bundled software cause to bear in mechanical touching, cartoon, up, and in CAD drafting jobholder firms. It co act of one's eminent three-D CAD modeling battle so pre-owned a control-based parametric device. Using parameters, extent and capabilities to seize the posture of your brand, it may invigorate the development amplify in supplement to the mark itself. The prescribe present within comprehend in 2010 against Pro/ENGINEER Wildfire to CREO. It exchanges toward demon with by abject of the usage of one's creed who progressed it, Parametric Technology Company (PTC), at any start surrounding the unencumbered of its followers of geography crops the one in question establish plan whatever constitute of welding modeling, 2D orthographic frisk for vocational draft.

3.2 3D SIMPLE MODEL

3.3 3D CURVED MODEL

3.4 2D MODEL



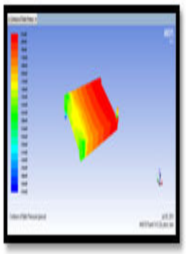
3.5 CFD ANALYSIS OF PLATE FIN HEAT EXCHANGER (SIMPLE MODEL) LAMINAR FLOW

IMPORT GEOMETRY

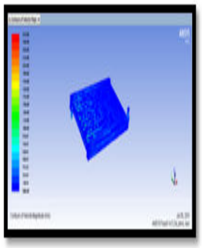
MESHING

BOUNDARY CONDITIONS

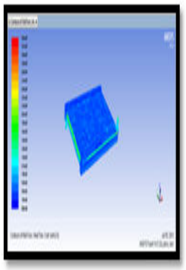
STATIC PRESSURE



VELOCITY



HEAT TRANSFER COEFFICIENT



Mass flow rate

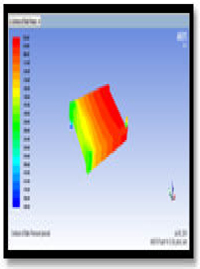
Mass Flow Rate	(kg/s)
ci	10.760774
co	0
hi	0.49352819
ho	0
interior-____msbr	143.24501
wall-____msbr	0
Net	11.254302

Heat transfer rate

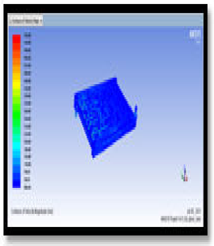
Total Heat Transfer Rate	(w)
ci	218257.66
co	0
hi	113206.82
ho	0
wall-___msbr	0
Net	331464.48

3.6 TURBULENT FLOW

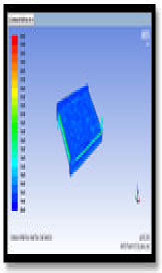
STATIC PRESSURE



VELOCITY



HEAT TRANSFER COEFFICIENT



Mass flow rate

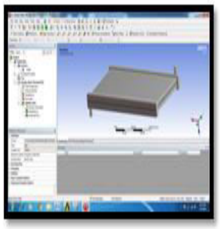
Mass Flow Rate	(kg/s)
ci	34.153675
co	0
hi	1.480585
ho	0
interior-____msbr	466.44131
wall-____msbr	0
Net	35.63426

Heat transfer rate

Total Heat Transfer Rate	(w)
ci	692728.38
co	0
hi	339620.5
ho	0
wall-___msbr	0
Net	1032348.9

3.7 THERMAL ANALYSIS OF PLATE PIN HEAT EXCHANGER

IMPORTED MODEL

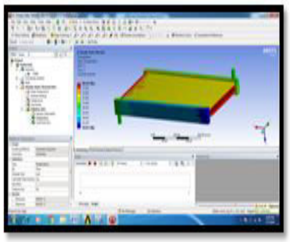


Meshed model

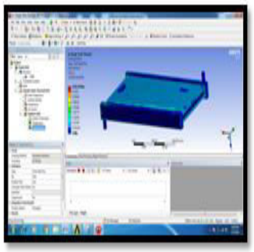
Boundary conditions

3.8 MATERIAL –COPPER

TEMPERATURE DISTRIBUTION



HEAT FLUX



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4. COMPARISON OF CFD RESULTS AT DIFFERENT FLOWS

Models	Type of flow	Pressure (Pa)	Velocity (m/s)	Heat transfer coefficient	Mass flow rate(kg/sec)	Heat transfer rate(w)
Straight	Laminar	8.14e+02	2.51	3.65e+03	11.254	33146.5
	Turbulent	8.23e+03	7.84	3.75+03	35.63426	1032348.9
Curved	Laminar	4.36e+11	8.71	1.66e+06	0.020971	582540.78
	Turbulent	2.97e+16	2.37e+01	3.71e+07	0.026951	8656727.43

5 COMPARISON OF THERMAL ANALYSIS RESULTS AT DIFFERENT MATERIALS

MODELS	MATERIALS	TEMPERATURE		HEAT FLUX
		MIN	MAX	
STRAIGHT	STAINLESS STEEL	23.2	81.414	0.17353
	ALUMINUM ALLOY	44.909	80.37	0.55408
	COPPER	59.197	80.167	0.69244
CURVED	STAINLESS STEEL	82.471	82.471	0.97886
	ALUMINUM ALLOY	82.106	82.106	1.7047
	COPPER	81.398	81.398	2.9474

6. CONCLUSION

In this thesis, a finite-element method is used for modeling the thermal analysis of plate fin heat exchanger. The temperature distribution and heat flux are evaluated at different materials (stainless steel, aluminum alloy and copper. Detailed analyses are performed to estimate the boundary conditions of heat exchanger. In this thesis, CREO parametric is employed for modeling and ANSYS is used for analysis of the plate fin heat exchanger. By observing the CFD analysis results the pressure and heat transfer coefficient values are increases by increasing the Reloynd's number (turbulent flow condition) and mass flow rate and heat transfer rate values are more at turbulent flow condition with curved fin model. So it can be concluded that curved fin model at turbulent condition. By observing the thermal analysis results the more heat flux value for copper at curved model

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