Numerical Modeling Develop for Plate-fin Heat Exchanger

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Abstract-Hybridized Carbonate and Solid Oxide fuel cell power plants are currently under investigation to fulfill demands for high efficiency and low emissions. Selection and design of high performance heat exchangers are essential for such applications. In this work, various compact heat exchanger (CHEX) technologies pertinent to gas-gas recuperative duties are presented. The CHEX types considered include brazed plate-fin, fin-tube, micro channel, primary surface and spiral. Based on a comparative rating procedure, two CHEX designs namely, plate-fin and micro channel were chosen for further review.

Multiple numerical modeling efforts were carried out to develop plate-fin heat exchanger design recommendations. A model was created for the transient thermal simulation of counterblow heat exchanger partition plates. For this analysis, an alternating direction implicit finite difference scheme was written in the Java programming language to model temperature in the working fluids and partition plate. Thermal stress was then calculated in various partition plate designs for steady state and transient modes of operation. Thermal stress was modeled in two heat exchanger materials, stainless steel 304 and Inconel 625. A primary creep law was developed for Inconel 625 to simulate creep behavior in high temperature (up to 1150 °K) heat exchanger partition plates. The results of the transient thermal simulation clearly show the effect of temperature ramping rate on the rate of heat transfer between the working fluids and partition plate. Thermal stress results confirm that additional stress produced in heat exchanger partition plates during transient operation is negligible for temperature ramping rates consistent with high temperature fuel cells. Based on this result it is suggested that employing slow temperature ramping permits the use of higher performance heat exchanger designs, given that damage generally accrued during transient operation is circumvented. Thermal stress results also show that heat exchanger partition plate aspect ratio (Width/Length) plays a major role on the amount of thermal stress produced within the plate. More importantly, this change in aspect ratio has an even larger effect on creep behavior.

Keywords:- fin-tube, micro channel, Inconel 625, Thermal stress, heat exchanger, creep.

I. INTRODUCTION

Energy unit innovation has been distinguished to meet concurrent requests for more electric power and less contamination. Power modules are electrochemical gadgets that change over concoction vitality specifically to electrical vitality with high productivity. Because of their electrochemical transformation, power device frameworks hold low emanation levels and show "great neighbor attributes". Conveyed energy unit control frameworks are wanted since they could offer higher matrix unwavering quality than brought together power stations and go around advance establishment and support of transmission lines. Specifically, high temperature power devices can use existing flammable gas foundations adequately. Carbonate and Solid Oxide energy units work at high temperature (900 °K – 1300 °K) and reject a lot of warmth with the goal that hybridized power device and gas turbine (FCGT) control plants are under scrutiny. Ultra high fuel to power transformation efficiencies (>70% LHV) of such plans have been anticipated, Leo et al. (2000). Appropriate warmth exchanger choice and configure ration are instrumental to the achievement of a half and half FCGT control plant. A warmth exchanger with low viability will largy affect framework cost with just negligible effect on framework yield, and comparably, a warmth exchanger with high adequacy will have a vast size so it will be excessively costly, making it impossible to have the best general effect, Untrained and Sunder (2001a) Three distinctive warmth exchanger process conditions were broke down for the mixture FCGT application, to be specific a Fuel Preheat Exchanger, a Low Temperature.

II. OBJECTIVE

- Study various compact heat exchanger (CHEX) technologies pertinent to gas-gas recuperative**.**
- Prepared a model for the transient thermal simulation of counter flow heat exchanger partition plates and calculate thermal stress various partition plate steady state and transient modes of operation.

III. METHODOLOGY

3.1 Materials use in present study

As per writing audit, in particular the Fine Filter show and the Transient Thermal Simulation display, gave adequate premise to figure warm worry in warm exchanger segment plates. This investigation was performed utilizing the limited component examination programming ANSYS. The general component definition utilized by ANSYS depends on the rule of virtual work (PVW). Low Temperature Heat Exchanger (LTHE) Thermal Stress demonstrate and the High Temperature Heat Exchanger (HTHE) Thermal Stress display. The principle contrasts between these two models were the material of development and working temperature. The LTHE segment plates were taken as stainless steel 304 and the HTHE segment plates were taken as arrangement treated Inconel 625. Both warm pressure models comprised of a solitary warmth exchanger segment plate having no balance associations or braze material,. As opposed to the two dimensional Transient Thermal Simulation display, the warm pressure models were completed in three measurements.

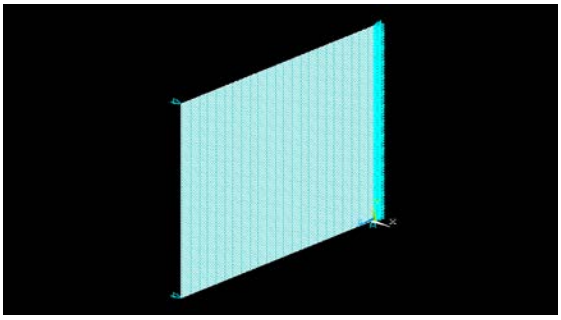

Fig. 1Heat exchanger partition plate setup for thermal stress and creep calculation

Table Tensile Stress Grid Sensitivity

Stress Description	124800 nodes	104000 nodes	87000 nodes	71500 nodes
	Max Stress (MPa)	%Error	%Error	%Error
X Component	4.369	2.650	18.206	26.284
Y Component	69.182	0.046	0.035	0.166
Z Component	95.615	0.047	0.183	0.728
XY Shear	0.357	2.775	14.832	21.523
XZ Shear	19.112	0.010	0.073	0.246
YZ Shear	0.519	1.779	8.784	24.962

This was allowed on the grounds that stream misdistribution was disregarded, which stipulates that temperature is uniform along the width measurement Average material properties utilized as a part of this examination including versatile modulus (E), Poisson's proportion (n), coefficient of warm development (an), and thickness (r) are classified in Table 2. Both stainless steel 304 and arrangement treated Inconel 625 parcel plate materials were thought to be isotropic, however E, u, and a were modified to incorporate the impacts of temperature reliance. Accordingly, it will be known whether plastic harm happens when the warm pressure comes about are acquired. It will be accepted for the two materials that the 0.2% counterbalance yield qualities arranged in Table 2 apply to both pliable and compressive burdens.

Table Compressive Stress Grid Sensitivity

Stress Description	124800 nodes	104000 nodes	87000 nodes	71500 nodes
	Max Stress (MPa)	%Error	%Error	%Error
X Component	-1.900	2.111	16.689	25.066
Y Component	-12.760	0.071	0.133	0.714
Z Component	-46.158	0.097	0.245	0.100
XY Shear	-0.142	24.458	24.486	24.902
XZ Shear	-17.602	0.011	0.074	0.227
YZ Shear	-0.445	1.177	42.645	36.293

IV. RESULT AND DISCUSSION

Warm Stress Simulation

The accompanying segments incorporate warm pressure comes about computed utilizing ANSYS programming for the LTHE and HTHE issue plans. For the LTHE setup, warm pressure increase state, after increase state or consistent state, and no more serious transient state for the 30.0 °K/s incline rate case. For the HTHE setup, warm pressure was ascertained for the variable width parcel plate geometries HTHECA and HTHECB, at two distinct states to be specific before activity (before crawl) and following 300 hours of task (after crawl). The subjective idea of the pressure shape plots for the LTHE when increase states, and in addition the HTHE before crawl states, were about indistinguishable with special case to the greatness of the burdens. Along these lines, a point by point clarification of the warm pressure inferred in the warmth exchanger segment plates was made for the LTHE after increase state just, since it will be liable to dialog firs .

Low Temperature Heat Exchanger Static Thermal Stress

To help envision how warm pressure can be made in warm exchanger parcel plates, a slanted view shape plot of temperature for the enduring state LTHE is appeared in Figure. 5.1, alongside its relating warm strain which was amplified by 100X. It can be seen from this assume the hot liquid delta end (the best) of the plate extends substantially more than the chilly liquid gulf end (the base) of the plate, actuating non-uniform warm development. This event of non-uniform temperature inside a solitary strong body will make warm pressure.

Fig. 2Von Mises Equivalent Stress in HTHECB After Creep, (Pa)

V. CONCLUSION

To play out this undertaking, one must start with a warm model to decide the temperature conveyances amid enduring state and transient activity. At the point when the temperature disseminations are acquired for the different warmth exchanger segments, stretch examinations might be performed, trailed by crawl investigations, which can at last prompt a honest to goodness warm exchanger benefit life count.

- A transient thermal model of a counter flow heat exchanger partition plate and its Working fluids was developed using an alternating direction implicit finite difference scheme. Four different temperature ramping rates were tested with this numerical model for a specified temperature ramp up schedule.
- It was shown that all different temperature ramping rates yield noticeable transient thermal behavior, which was quantified through a parameter defined as heat lag. Intuitively, it was found that the faster the ramping rate, the larger heat lag becomes, which is known to be coincident with excessive thermal stress. Thus, to better understand why excessive thermal transients create severe levels of stress, the 30.0 °K/s ramping rate case was evaluated in the LTHE Thermal Stress model.
- The transient thermal model produced temperature data for candidate heat exchanger partition plates, for steady state and transient thermal stress calculations.
- During steady stat a ra e, it was found that the partition plate develops tensile stress along its peripheries, and compressive stress in its inner region.
- In contrast, it was found that during a temperature ramp up procedure the partition plate can develop rather large compressive stress at its edges near the hot fluid inlet end of the plate, and tensile stresses near its inner region.
- Thus, as mentioned previously, portions of the partition plate can endure a complete shift in stress from tensile to compressive and then back to tensile stress again during a temperature ramp up procedure. Thermo-mechanical fatigue is of great concern when this type of loading is present.
- However, it was found that a heat exchanger that experiences temperature ramping consistent with high temperature fuel cells, or at about a rate of 0.03 °K/s, endures very little transient behavior and is not subject to this thermal stress undulation.
- Therefore, it was concluded that transient thermal stress can be ignored when determining max stresses/strains for calculating life in FCGT system heat exchangers that employ this slow of a ramping rate. It was also found that there is only a slight correlation between the timing of maximum heat lag and the most severe stress state in heat exchanger partition plates.
- To find the most severe stresses during a thermal transient, one simply has to test several snapshots in time to ultimately produce a sketch of the transient thermal stress profile.
- It was confirmed however that concentrations of temperature contours can be used to coarsely identify severe stress times and locations.

It was found that the centers of the partition plate edges represented the locations of the most severe stress in the partition plates analyzed herein, which may well hold true for more complex heat exchanger partition plate designs. The validity of the thermal stress distributions were established through the use of two, four bar linkage idealizations. It was learned that the aspect ratio (Width/Length) of a heat exchanger partition plate has a major effect on the magnitude of thermal stress produced within the plate, where the larger the aspect ratio the larger the thermal stress will be. This finding is perhaps the most important since it is fundamental to partition plate design. In all likelihood, this conclusion will hold true for more complex heat exchanger partition plate geometries.

VI. FUTURE SCOPE

The accompanying rundown condenses a few purposes of intrigue that would be assessed if this work was proceeded. There are two primary territories that are examined, in particular preparatory displaying and demonstrating.. In the end, models having point by point warm exchanger structures and less rearrangements will inevitably be important to precisely anticipate warm exchanger benefit life. The proposals recorded underneath identify with the regions of

- Future work contemplations relating to warm and auxiliary displaying .
- Future work contemplations relating to material determination .

- Future work considerations pertaining to overall heat exchanger development.

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