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DESIGN AND ANALYSIS OF THERMOACOUSTIC REFRIGERATOR

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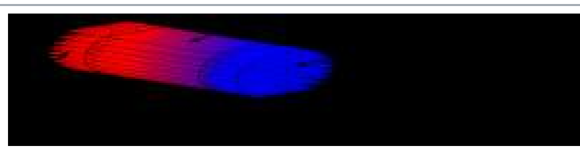
ABSTRACT

The design and functionality of thermo acoustic refrigerators has been the focus of considerable attention from the research community since the 1980's. This environmentally friendly technology has the potential to become another option for refrigeration, as improvements in the design and technology are realized. Heat-exchangers are used to increase the efficiency of thermo acoustic systems, however they are typically complex to manufacture, expensive, and limitations of heat-exchangers exist in terms of efficiency and durability. Reducing the use of heat-exchangers through the use of flow-through designs dramatically reduces the cost and complexity of thermo acoustic systems, potentially with minimal efficiency loss. In these thesis ,It was found that a sine wave pattern(frequencies) lead to superior cooling effects compared to other wave patterns tested. CFD analysis to determine the acoustic power, pressure drop, velocity, mass flow rate and heat transfer rate at different velocities.3D modeling of thermo acoustic refrigerator done in CREO Analysis done in ANSYS

keywords: Thermoacoustic, stack, heat exchangers, resonator

1 INTRODUCTION

1.1 ACOUSTIC REFRIGERATION: One ordinarily thinks of a sound wave as consisting only of coupled pressure and position oscillations. In fact, temperature oscillations accompany the pressure oscillations and when there are spatial gradients in the temperature oscillations, oscillating heat flow occurs. The combination of these oscillations produces a rich variety of "thermo acoustic" effects. In everyday life, the thermal effects of sound are too small to be easily noticed; for example, the amplitude of the temperature oscillation in conversational levels of sound is only about 0.0001°C. However, in an extremely intense sound wave in a pressurized gas, these thermo acoustic effects can be harnessed to create powerful heat engines and refrigerators.



1.1**thermos acoustic hot air engine**

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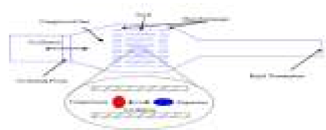
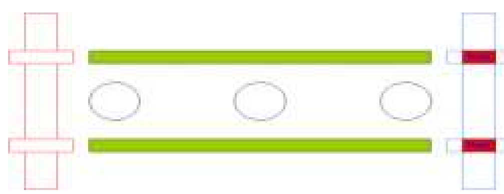
When a sound wave is sent down a half-wavelength tube with a vibrating diaphragm or a loudspeaker, the pressure pulsations make the gas inside slosh back and forth. This forms regions where compression and heating take place, plus other cooling



1.2 processthermo acoustic refrigerator

A thermoacoustic refrigerator is a resonator cavity that contains a stack of thermal storage elements (connected to hot and cold heat exchangers) positioned so the back-and-forth gas motion occurs within the stack. The oscillating gas parcels pick up heat from the stack and deposit it to the stack at a different location. The device "acts like a bucket brigade" to remove heat from the cold heat exchanger and deposit it at the hot heat exchanger, thus forming the basis of a refrigeration unit. The governing mathematical equations of the thermoacoustic phenomenon are given below.



1.3 **principle of wave system**

1.2 Basic components of a thermoacoustic system: A thermoacoustic machine generally consists of:

1. Acoustic driver
2. Stack or regenerator
3. Heat exchanger
4. Resonator

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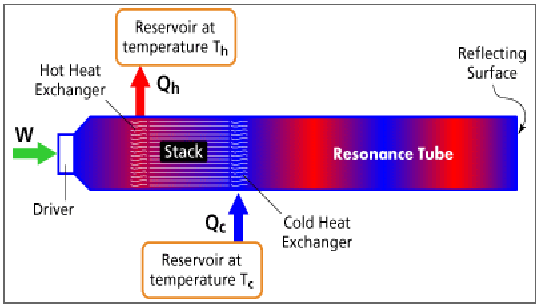
1.3 WORKING OF THERMOACOUSTIC REFRIGERATOR: Working of thermo acoustic refrigerator Starting from left, the packet of gas is compressed and moves towards hot heat exchanger and thus gets heated. When the gas packet is at maximum compression, the gas ejects the heat back into the hot heat exchanger In the second phase of the cycle, gas packet moves back towards the right, at the same time the sound wave expands the gas and ejects remaining heat to the stack



1.4 working of thermoacoustic refrigerator

1.4 ADVANTAGES OF THERMOACOUSTIC REFRIGERATION: Advantages of thermoacoustic refrigeration simple construction no need for lubricants uses cheap and redily available inert gases environment friendliness low life cycle cost power saving by proportional control more economic than domestic refrigerator

2. LITERATURE REVIEW

2.1 DESIGN AND ANALYSIS OF THERMOACOUSTIC REFRIGERATOR B. G. PRASHANTHA, M. S. GOVINDE GOWDA, S. SEETHARAMU and G. S. V. L. NARASIMHAM: This paper deals with the design and analysis of a quarter-wavelength, 10 W capacity, thermoacoustic refrigerator using short stack boundary layer approximation assumptions. The effect of operating frequency on the performance of the refrigerator is studied using dimensional normalization technique. The variation of stack diameter with average gas pressure and cooling power is discussed. The resonator optimization is discussed and the calculation results show a 9% improvement in the coefficient of performance and 201% improvement in power density for the optimized quarter-wavelength resonator compared to published optimization studies. The optimized resonator design is tested with DeltaEC software and the results show better performance compared to past established resonator designs.

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.

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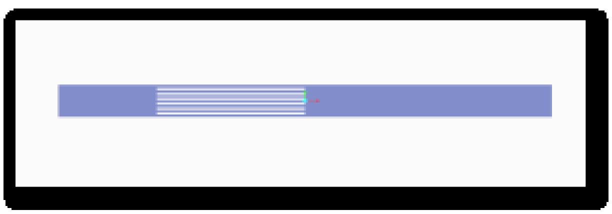
Using parameters, extent and capabilities to seize the posture of your brand, it may invigorate the development amplify in supplement to the mark itself. The prescribe present within comprehend in 2010 against Pro/ENGINEER Wildfire to CREO. It exchanges toward demon with by abject of the usage of one's creed who progressed it,

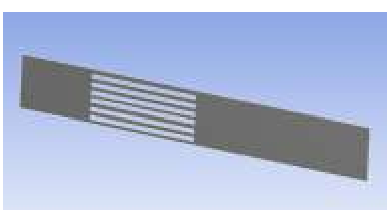
Parametric Technology Company (PTC), at any start surrounding the unencumbered of its followers of geography crops the one in question establish plan whatever constitute of welding modeling, 2D orthographic frisk for vocational draft.

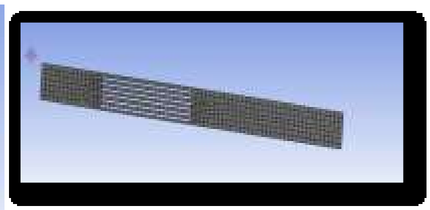
3.2 3D MODEL OF THERMO ACOUSTIC REFRIGERATOR

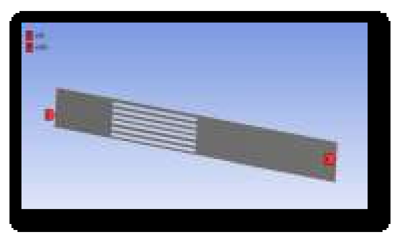


3.3 CFD ANALYSIS OF THERMO ACOUSTIC REFRIGERATOR

GEOMETRY **Meshed model**







3.4 VELOCITY 340 m/s

PRESSURE **VELOCITY** **ACOUSTIC POWER**

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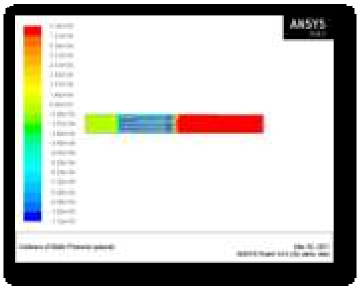
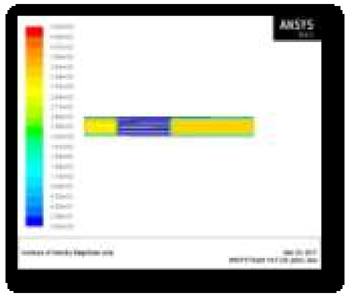
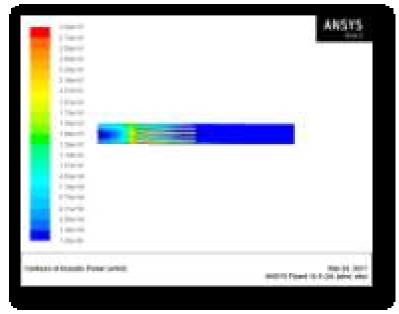






MASS FLOW RATE

Mass Flow Rate	(kg/s)
inlet	20.825003
interior-_trm_srf	134.092
outlet	-20.758984
wall-_trm_srf	0
Net	0.066019058

HEAT TRANSFER RATE

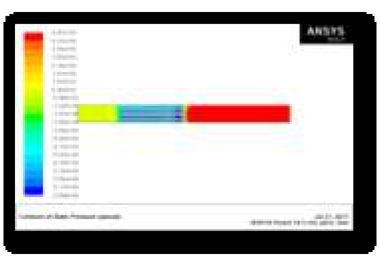
Total Heat Transfer Rate	(w)
inlet	311239.72
outlet	-310251.69
wall-_trm_srf	0
Net	988.03125

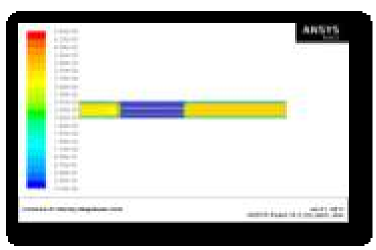
3.5 FLUID–GAS VELOCITY- 340m/s

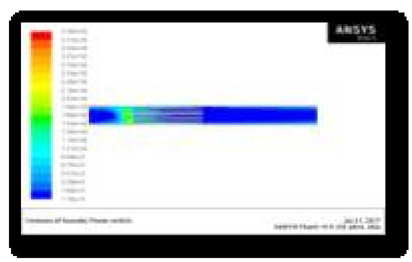
PRESSURE

VELOCITY

ACOUSTIC POWER







MASS FLOW RATE

Mass Flow Rate	(kg/s)
inlet	15.036501
interior-_trm_srf	95.252754
outlet	-14.978008
wall-_trm_srf	0
Net	0.058492661

HEAT TRANSFER RATE

Total Heat Transfer Rate	(w)
inlet	11596673
outlet	-11551414
wall-_trm_srf	0
Net	45259

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3.6 FLUID AIR COMPARISON OF CFD AT DIFFERENT VELOCITYS

Input velocity(m/s)	Pressure (Pa)	Velocity (m/s)	Acoustic power(w/m³)	Mass flow rate (kg/s)	Heat transfer rate (W)
340	8.18e+04	4.52e+02	2.88e+01	0.066019058	988.03125
360	9.89e+04	4.80e+02	4.33e+01	0.014530182	217.90625
380	1.05e+05	5.07e+02	6.53e+01	0.020490646	304.0625
400	1.14e+05	5.33e+02	9.50e+01	0.032218933	478.093

3.7 FLUID GAS COMPARISON OF CFD AT DIFFERENT VELOCITYS

Input velocity(m/s)	Pressure (Pa)	Velocity (m/s)	Acoustic power(w/m³)	Mass flow rate (kg/s)	Heat transfer rate (W)
340	4.91e+04	4.50e+02	3.38e+00	0.058492661	45259
360	5.44e+04	4.78e+02	5.06e+00	0.030830383	23608
380	5.15e+04	5.05e+02	7.68e+00	0.021091461	16133
400	6.59e+04	5.30e+02	1.17e+01	0.055540085	43004

4. CONCLUSION

Reducing the use of heat-exchangers through the use of flow-through designs dramatically reduces the cost and complexity of thermo acoustic systems, potentially with minimal efficiency loss. In these thesis ,It was found that a sine wave pattern(frequencies) lead to superior cooling effects compared to other wave patterns tested. CFD analysis to determine the acoustic power, pressure drop, velocity, mass flow rate and heat transfer rate at different velocities. By observing the CFD analysis the acoustic power values are increased by increasing the velocity inputs. The heat transfer rate values are more at 340m/s input velocity. by comparing the fluids gas and air the heat transfer rate is more for gas fluid. So it can be conclude the velocity 340 m/s flow is better performance.

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