Analysis of TAE by Modifying Cold and Hot Heat Exchanger Using Waste Heat Recovery

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***Abstract*---Abstract Thermoacoustic engines**, a promising technology at the intersection of thermodynamics and acoustics, offer a novel and sustainable method for recovering waste heat from various industrial processes.

This paper explores the principles of thermoacoustic engines and their potential application in waste heat recovery systems. By converting waste heat into useful mechanical work through acoustic phenomena, thermoacoustic engines contribute to energy efficiency and greenhouse gas reduction.

This abstract summarizes the key concepts, benefits, and challenges associated with thermoacoustic waste heat recovery, emphasizing its role in addressing environmental concerns and advancing sustainable energy practices.

I. INTRODUCTION

Thermoacoustic is the branch of science which deals with Thermodynamics, Fluid Dynamics and Acoustics to give interactions between heat and sound. Thermoacoustic devices are those which utilize thermoacoustic effect to convert thermal energy to acoustic energy or vice versa. When a sound wave travels through air or any other compressible fluid it creates pressure, motion and temperature oscillations in that media. In other words, if a particular gas molecule experiences a sufficiently rapid pressure increase from an acoustic wave, such that the heat doesn't have time to flow away, its temperature will rise. The work in these sound waves can then be harnessed with a linear alternator as sound. Conventional engines like internal combustion engines, gas turbines, and Stirling cycle engines need complex mechanical parts like pistons, valves and other mechanical elements to produce work. Thermoacoustic devices however, have no moving mechanical parts.
A sound wave in a gas is usually regarded as consisting of both pressure and motion oscillations, but temperature oscillations are always heat also flows to and from the channel walls. The combination of all such oscillations produces a rich variety of "Thermoacoustic" heat transfer betwe sound waves in pressurized gases, thermoacoustic can be used to produce powerful engines, pulsating combustion, heat pumps, refrigerators, and mixtu motivated by the desire to create new technology for the energy industry that is as simple and reliable as sound waves themselves. Thermoacoustic devices are an attractive alternative to current conventional system based on its simplicity, reliability and environmentally friendly mode.

II. OBJECTIVES

1. Testing of Thermoacoustic engine using air as a working fluid.
2. Using sound as alternator for extracting acoustic power to electricity.
3. Optimize heater for lower temperature operation.
4. Enhance thermoacoustic engine efficiency through modifications.

III. COMPONENTS

A. COLD HEAT EXCHANGER:---

Cold heat exchanger is used to carry away excess heat of fluid. It connected before the regenerator. For CHX, water is used as a cooling medium which is circulated at a fix discharge rate. CHX is useful to maintain the temperature range required of fluid, but it is necessary to obtain the number of passes required to maintain the required temperature. A shell and tube type heat exchanger is taken into consideration given its effectiveness to carry away the heat.

B. REGENERATOR:-

As stated earlier, TBT and Regenerator are subjected to maximum thermal stresses.

Hence it is necessary to calculate the maximum thermal stress that the material can sustain.

C. HOT HEAT EXCHANGER:-

Hot heat exchanger is used to introduce heat in surrounding fluid. The HHX is made up of steel casing in which Nichrome wires are used to heat the fluid medium. The wires are wound on ceramic rods which are not affected by the heat.

D. THERMAL BUFFER TUBE:-

From pressure vessel design, we cannot have thickness less than 2 mm of pressure vessel pipe. Therefore design is safe beyond 2 mm thickness. Thermal buffer tube is connected right below the hot heat exchanger .Thermal buffer tube is subjected to pressure. So it is necessary to estimate the pressure TBT is going to sustain.

E. O-RING :-

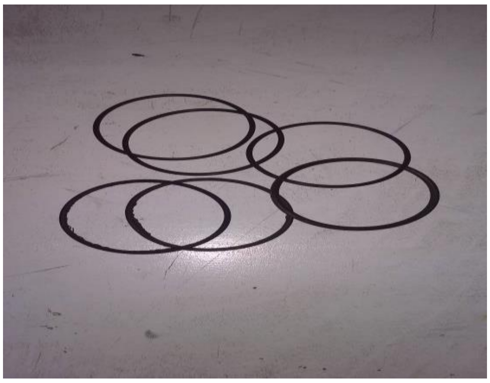
Required Specification of O-Ring:-

O-ring Should Sustain to higher temperature up to 500 ^{0}C.

O-ring should have excellent resistance to ozone, weather, oxygen, mineral oil, fuels, hydraulic fluids and many organic solvents and chemicals.

O-ring should be TBR-Totally Base Resistant compound that provide improved that provide improved performance over other polymers.

Viton V75's specifications meets the requirements of the desired O-ring. Hence we decided to go for Viton V75 O-ring. Temperature range for Viton V75 is -25^{0}C to 500^{0}C



F. SPEAKER MOUNTING:-

A stainless steel pipe is taken which is having length 300 mm and having outer diameter 220 mm and inner diameter 210 mm.. Two flanges are connected at both ends. Outer diameter of flanges connected is 310 mm and inner diameter is 50.8 mm .

G. THERMAL BUFFER TUBE:-

A stainless steel pipe is taken which is having length 160 mm and having outer diameter 60.3 mm and inner diameter 42.9 mm. A taper of 2.7° is given from inner side of the pipe upto length 80 mm from bottom face of the pipe. Two flanges are connected at both ends.

I. ACTUAL SET UP OF TEA

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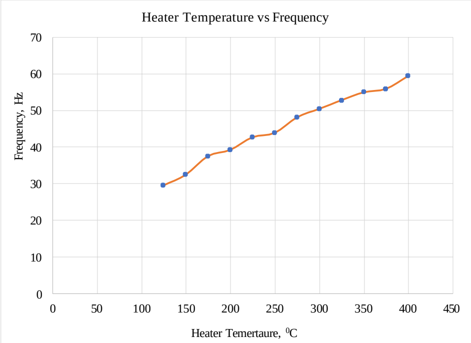
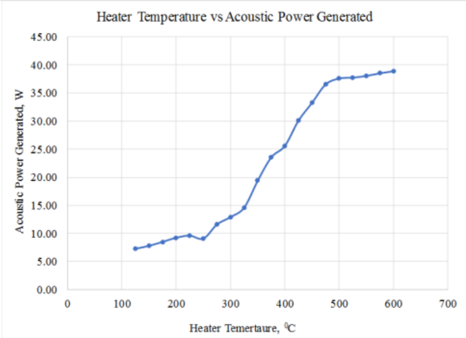
II. METHODOLOGY

1) Mathematical simulator to be developed for performance of the thermo-acoustic engine.
2) Using suitable software various parametric analyses would be carried out.
3) Parametric analysis can be carried out using experimentation.





III. CONCLUSION

1. As the temperature increases the frequency gradually increases by keeping pressure constant.
2. Enhanced electricity generation via modified thermoacoustic engine.
3. Wire mesh percentage in regenerator is about 100%, for this condition frequency obtained is about 74.68 Hz and for the regenerator temperatures of about 2170C the acoustic power generated is 38.89 W.

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