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Review of Recuperator used in Micro Gas Turbine

Yastuti Rao Gautam[1], Ramendra Singh Niranjan[2], Ajeet Pratap Singh[3], Shishupal Singh[4], Dr. Praveen Bhai Patel[5]
Assistant Professor, Mechanical Engineering DepartmentM U.I.E.T., C.S.J.M. University Kanpur, (INDIA)
Assistant Professor, Chemical Engineering DepartmentM U.I.E.T., C.S.J.M. University Kanpur, (INDIA)

Abstract: Micro gas turbines are an auspicious technology for power generation because of their small size, low pollution, low maintenance, high reliability and natural fuel used. Recuperator is vital requirement in micro gas turbine unit for improve the efficiency of micro turbine unit . Heat transfer and pressure drop characteristics are important for designing an efficient recuperator. Recuperators preheat compressed air by transfer heat from exhaust gas of turbines, thus reducing fuel consumption and improving the thermal efficiency of micro gas turbine unit from 16–20% to 30%. The fundamental principles for optimization design of PSR are light weight, low pressure loss and high heat-transfer between exhaust gas to compressed air. There is many type of recuperator used in micro gas turbine like Annular CWPS recuperator , recuperator with involute-profile element , honey well , swiss-Roll etc . In this review paper is doing study of Heat transfer and pressure drop characteristics of many types recuperator.
Keywords: Recuperator, Swiss roll, Micro gas turbine , PSR , cross-wavy

I. INTRODUCTION

Micro gas turbines of high performance and low emissions which use Natural fuel are about to find acceptance in large quantities in the distributed power generation .For this type of micro gas turbine generator of near 100 kW, an exhaust heat transfer recuperator is an absolutely necessary in order to get a thermal efficiency of 30% or higher [1] . The recuperator is a new type of heat exchanger concept that meets the demanding requirement for micro gas turbines. Heat recuperation is a well known mean to increase the overall cycle efficiency of a micro gas turbine unit . This recuperator has many types of shape which placed well on the turbine and combustion chamber. In this paper , based on the structure characteristics and Pressure drop and heat transfer theory of the recuperator , an optimization and simulation analysis was done on the structure geometry and performance input parameters. They have primarily evolved from automotive and aerospace applications, and have been under a lot of developments due to the needs for micro power and distributed generation.[2]. it is difficult to achieve a thermal efficiency more than 20% due to aerodynamic loss and clearance loss . Therefore, in order to achieve efficiency of 30% and higher, a recuperator becomes vital for micro gas turbines [1,3]. Current research on improving micro gas turbine efficiency mainly on improving thermal resistance of the inner micro gas turbine parts and recuperator designs with increased heat exchanger efficiency [3–5].

Since establishing a recuperator of low cost is paramount for micro gas turbine unit, the requirements must be strongly focused on this aspect. In establishing a new recuperator concept. To achieve low cost there are certain basic requirements that need to be adhered too, and indeed these have a strong impact on the heat exchanger form. One basic consideration is that in the metal forming process there should be no material wastage, that is to say absolutely zero
scrap metal. [5]

II. TYPES OF PRIMARY SURFACE RECUPERATORS USED IN MICRO GAS TURBINES UNIT

From many years gas turbines have been widely used in the power generation fields, mechanical units and aircraft propulsion, and heat exchangers have always taken important roles in thermal efficiency of system [5]. Initial exchangers that have been used in the gas turbine unit, including recuperators, were essentially designed based on boiler technology, but the applicability of these heat exchangers is limited because of their bulky size, poor reliability and high cost .[6] . Now days there are many types of recuperators are in power generated by micro gas turbine

A. Primary Surface Recuperator (PSR)

The honeycomb core of PSR is made up of many stainless steel corrugated foils and side stripes arranged in turn and in order The heat-transfer area of each foil is made up of two parts: corrugation area and diversion area .

Primary surface with different type of channel corrugation like Elliptical corrugation, Sinusoidal corrugation ,Parabolic corrugation and Rectangular corrugation these are used according micro gas turbine unit requirement [1] there are three patterns of primary-surface recuperators, i.e., cross-corrugated (CC) ,corrugated-undulated (CU) and cross-wavy (CW) as shown in Fig. 1.

Primary-surface recuperators have been developed at Caterpillar Tractor Co. since the 1970s
Honeywell Corporation developed a primary-surface counter-flow recuperator, as shown in Fig. 2(a),(b) &(c) [6]. In recuperator, CC plates that are used in the main heat transfer region are welded at the periphery. [7]

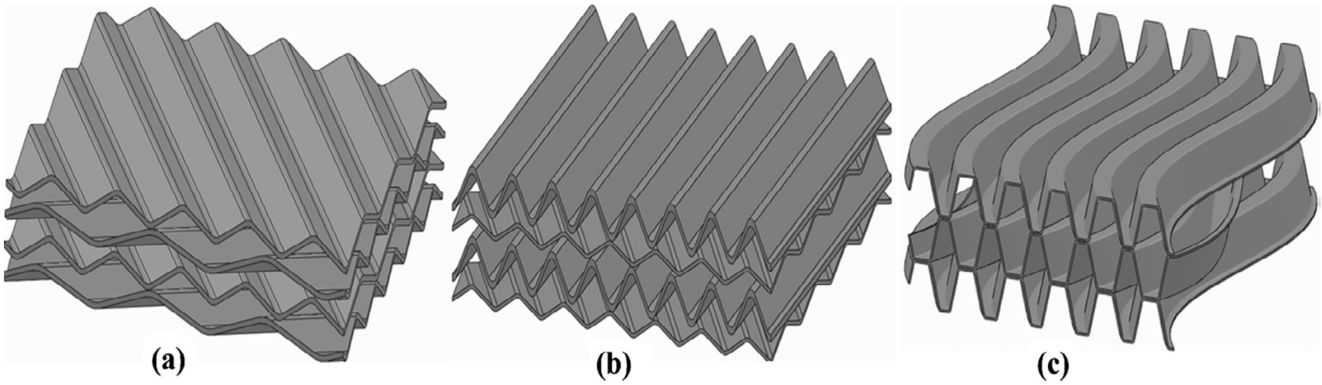

Fig. 1 Schematics of a cross-corrugated (CC) surface (a), corrugated-undulated (CU) surface (b) and cross-wavy (CW) surface (c). [6]

The proposed Swiss-roll recuperator is the primary-surface type. It is possessed of two flat plates that are wrapped around. The combustor is wrapped inside the recuperator which is designed as a Swiss-roll type. As the recuperated cycle is applied, the thermal efficiency of micro gas turbine is increased and the fuel consumption rate is really decreased [6].

There are another type of recuperator that is annular involute-profile cross wavy primary surface (CWPS) recuperator in micro gas turbine. The annular CWPS recuperator can be circumstantially installed around the combustion chamber of micro gas turbine. This is the more compact merit in comparison to the cuboid-shape CWPS recuperator. In addition, heat exchange element (called air cell) with involute profile is designed to fully utilize the space for a larger heat transfer area[8].

III. HEAT TRANSFER AND PRESSURE DROP [6]

Heat transfer performance, which is also known as thermal effectiveness

$$\varepsilon = \frac{T_{air\ out} - T_{air\ in}}{T_{gas\ in} - T_{air\ in}} \qquad (1)$$

where $T_{air\ in}$, $T_{air\ out}$ and $T_{gas\ in}$ are the temperatures of the recuperator inlet air, outlet air and inlet exhaust gas, respectively.

Total relative pressure drop is [6]

$$\delta P = \frac{\Delta P_{air}}{P_{air}} + \frac{\Delta P_{gas}}{P_{gas}} \qquad (2)$$

where . ΔP_{air} and ΔP_{gas} are the pressure drops of the air side and gas side, respectively, and P_{air} and P_{gas} are the inlet pressure of the air side and gas side, respectively.

IV. DESIGN AND OPTIMIZATION METHODS

The main objective of recuperator design for micro gas turbine is to determine the geometry of recuperators to determine a compromise among the heat transfer effectiveness, pressure drop, compact recuperator size ,low-cost requirements and higher efficiency [9]
the optimization of recuperator is done by Genetic Algorithm in Matlab. The principle GA is survival of the fittest, and successively produces an approximate optimal scheme in the potential solutions.[8]
optimization design analysis is done on PSR by optimum theory in order to determine the optimum structure and flow parameters of PSR, and then to make the structure and flow and heat-transfer combination performance of PSR achieve the best result. The basic objective for optimization design of PSR are
light weight, low pressure loss and high heat-transfer coefficient. Main objective is that weight and pressure loss are minimization and heat-transfer coefficient is maximization for higher efficiency [6]

V. ANALYSIS METHOD

The design of Swiss-roll recuperatore is then modeled and analyzed by using STAR-CD, the general CFD software A two-dimensional, steady, compressible k-e turbulent model with heat transfer is used, and the Navier–Stokes equations consisting of mass, momentum, and the energy conservations are solved with SIMPLE algorithm [10]. The Swiss-roll combustors or the heat recirculating burners were employed as heaters for thermoelectric power systems [11] . Analysis of this recuperator is done by CFD model

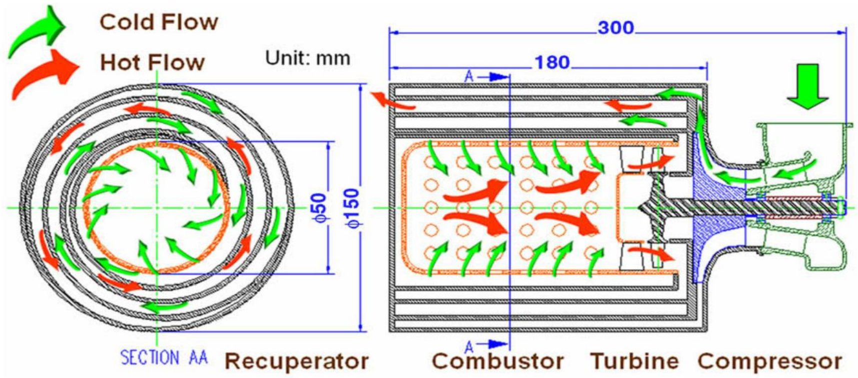

Fig. [2] Swiss-roll recuperature [13]

VI. LITERATURE REVIEW

S. No.	Types of recuperator	Conclusion & Result	Ref. No.
1.	Primary surface recuperator (Elliptical corrugation)	The linear weighting method is often employed in the optimization design of the recuperator. the multi-objective optimization theory is applied to the design of PSR. The optimum corrugated foil parameters and flow parameters are obtained by solving the optimization model and obtain best result for heat transfer rate and pressure loss.	[6]
2.	CWPS recuperator	Optimal design of the CWPS recuperator in micro turbine, which depends on the choice of calculation correlations for Nusselt number and friction coefficient. Based on the flow and heat transfer characteristics of air in micro rectangular channels presented.	[8-11-12]
3.	Swiss-roll recuperator	The designs of the recuperator explore to advanced performance with high effectiveness, low pressure loss and small size . The performance increase because to five various parameters is shown using pressure loss and effectiveness as the coordinates. The thermal design of the Swiss-roll recuperator was carried out by theoretical analysis, which gives the thermal characteristics of the recuperator .	[13]
4.	Plate-fin recuperators	A detailed multi-objective optimization was carried out for four plate-fin recuperators applied in a very 200 kW micro gas turbine unit using rectangular, triangular, offset strip and louver fins for heat transfer enhancement. Recuperator effectiveness and energy efficiency were taken as the objective functions. NTU method was selected to calculate the recuperator effectiveness and pressure drop. Consistent with the numerical and optimization results, maximum cycle thermal and energy efficiencies and NPV occurred within the counter-flow recuperator using offset strip fin and also the values were found to be 39.1275%, 36.7431%	[14]

VII. CONCLUSION

This paper provides a broad review of various types of recuperators , heat transfer rate pressure drop and design parameters . In additionally, versatile and malleable design of recuperators is another challenge for micro gas turbines utilized in distributed and green energy systems. There are lots of efforts to develop better recuperator for micro gas turbines with high heat transfer and reduce pressure drop. Heat transfer coefficient basically depends on the geometry of primary surface recuperator .

It is concluded that the genetic algorithm also can provide a strong ability of optimization design of recuperator compared to the traditional designs in which a trial-and error process may be involved.

All types of recuperator are very useful and these are used according their application . Analysis and optimization gives better result.

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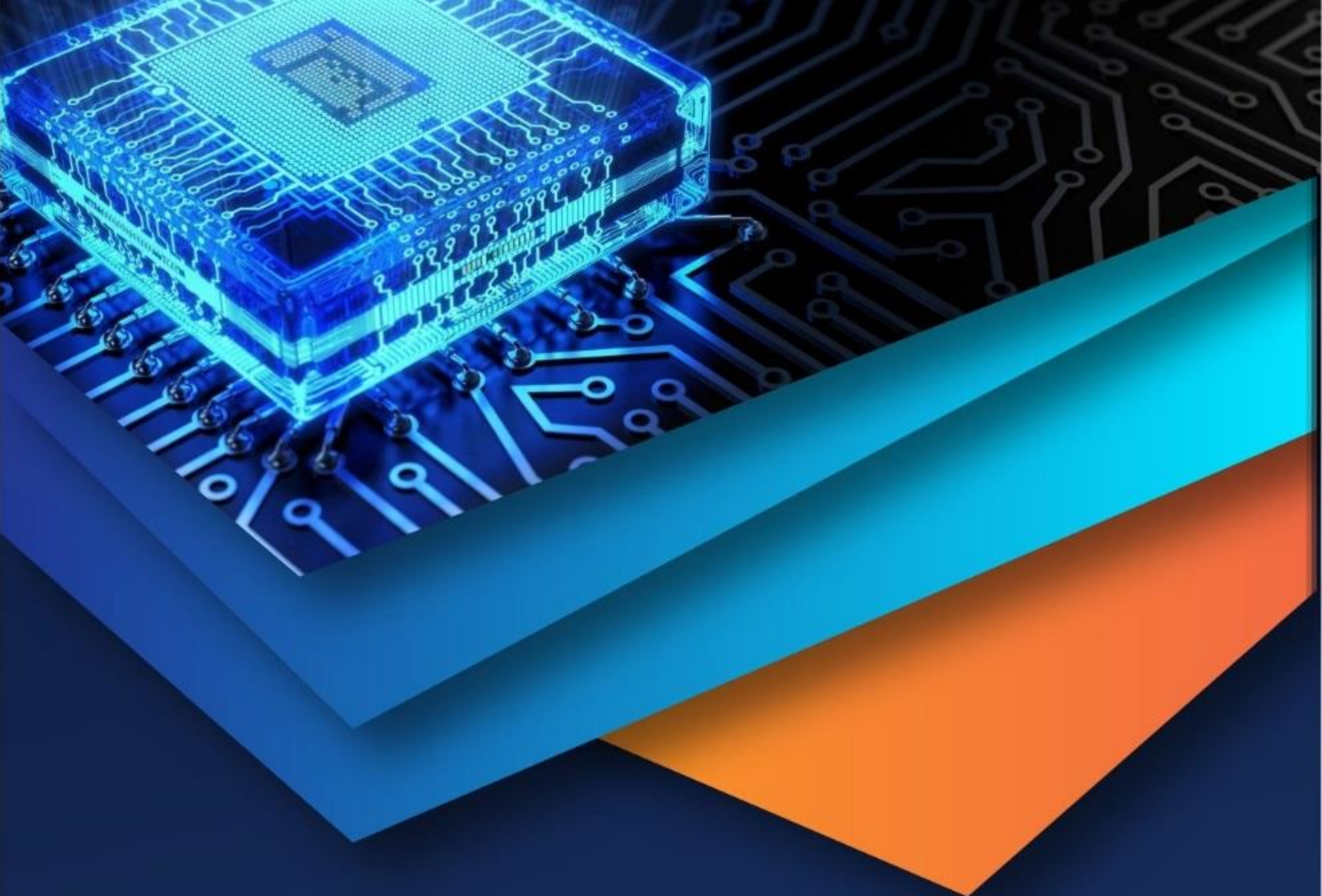

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