Energy harvesting by Tesla Turbine

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Abstract : *In recent years, energy harvesting from natural sources and waste heat has been attracting more attention from researchers in response to ever-growing energy demands, high energy prices, and climate-change-mitigation purposes. It is also an important step towards future sustainable energy usages. In thermal dynamic cycles, expanders are playing as the most important equipment for waste heat recovery and energy harvesting as well. As a kind of expander, the bladeless turbine has a promising future and more widely using owning its advantages on relatively long life, good off-design performance, easy operation cleaning and maintenance, a simple structure, no blade corrosion, and low manufacturing costs. There are numerous studies about using the Tesla Turbine as a key technology for energy harvesting in a wide range of applications and conditions. They are presented to help identify technologies that have sufficient potential for applicating to our life and marine industrial engineering. This review paper, initially, presents an overview of current studies both theoretical and experimental of Tesla Turbine usage for waste heat recovery alongside its challenges and investigation on the effect of its configuration, working fluid selection as well. To conclude, future perspectives besides possible ways of transforming waste heat energy to electricity or work, which leads to circular energy, are discussed. The ambition of this paper is to act as a first-hand reference, through the well-defined possible directions, to the young researchers and senior scientists.*

Key words : *Tesla Turbine, waste heat recovery, energy harvesting, ORC*

1. Introduction

The Tesla Turbine is known as friction, viscous, or bladeless centripetal flow turbine and was patented in 1913 by Nikola Tesla. Unlike almost kinds of turbines, the Tesla Turbine has limited and specific applications. It can be considered as a versatile turbine owing to its design and structure and commonly used as a steam turbine to generate electricity. The high energy working fluids such as high-pressure working fluids and high velocity working fluid can be useful if it is able to convert to electrical energy. It works on the principle of boundary layer effect, where due to airflow, the turbine rotates and can be used not only in power plant operations but also for general applications such as expanders. Recently, there has been an increasing interest in Tesla turbine since it can allow a low-cost, reliable design and simple structure to generate power at small or micro scales and acts as a mover that drives generators for applications of varying sizes. The basic waste heat recovering system using Tesla Turbine can be explained as in Fig. 01.

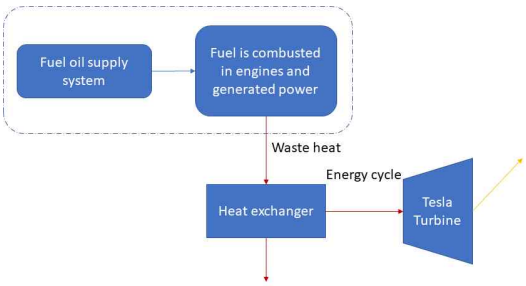

Fig. 1 Typical waste heat recovery system

2. Basic theory and application areas

2.1 Basic theory of Tesla Turbine

Tesla turbine formed by a series of discs parallelly mounted to each other on the shaft, which is closely gap and fitted with rotating shaft. These disks are multiple flat in parallel, thin and spaced along the shaft with thin gaps. The Turbine is mainly structured by three main components: discs, shaft, casing and accessories (valves and nozzles). The nozzles of the turbine are designed on the cylindrical casing and tangential to the shaft. The discharge holds are designed on the center of turbine. So that, the diameter of the disk and the inter-disc gap is mainly affected to the working performance of the Turbine.

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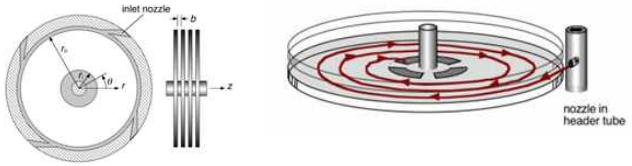

Fig. 2 Configuration of a typical Tesla Turbine

2.2 Application areas

The Tesla Turbine can be used in working fluids and multiphase without damage. The mains areas of Tesla Turbine applications include waste heat recovery, renewable energy resource, distributed generation system, irrigation channels and hybrid electric vehicles as well. As the world trends moving towards renewable sources, Tesla Turbine perfectly fits future vision in using renewable fuel at multiple locations and competitive cost as well. However, its major drawback is limited applications over conventional turbines because of their compact and small size.

3. Typical research on Tesla Turbine

3.1 Tesla Turbine as an expander on Organic Rankine Cycle (ORC)

An experiment with R245ca as working fluid for ORC system under different working conditions shown that Tesla Turbine can increase 4% ORC cycle efficiency, with 1.25 kW power output. The efficiency of the Tesla Turbine down at lower evaporation temperature and then increases with the increment of the evaporation temperature

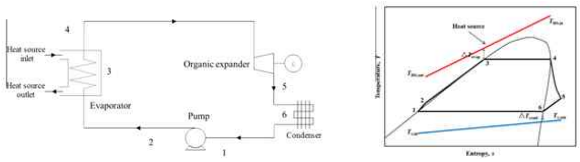

Fig. 3 Schematic diagram of Tesla Turbine as an expander on ORC system

3.2 Tesla Turbine in refrigeration cycle

Tesla Turbine can be acted as throttle valves for a refrigeration system. Sheikhnejad et al. [1] introduced the tesla turbine to substitute the wasting devices of the refrigeration system proved that the Tesla Turbine can be able to produce up to 2 kW (1440 kWh per month) in low angular velocity with R150B1 configuration. Those energies have been already wasted in expanders of the conventional refrigeration systems.

3.3 Tesla Turbine in Micro combined heat and power system

Kim et al. showed that the Tesla Turbine for micro combined heat and power system can archived 1.5 kW electric power and 6.3% of turbine efficiency at 4 of pressure ratio and 19.6% isentropic efficiency, 6.3% turbine efficiency. Tesla Turbine will be more efficient performance than conventional micro-turbines in using low-grade heat sources areas.

4. Summary, future directions and concluding remarks

Various studies have pointed potential outcomes for the future of Tesla Turbines. As large losses occurring in small scale system of conventional turbines, the Tesla turbine running with loss inducing forces to convert and generate useful work and power. Tesla turbine is a promising alternative where conventional turbines prove impractical. The properly selected Tesla Turbine may improve overall system efficiency, reduce the investment and operations cost and enhance the eco-friendly performance.

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References

[1] Y. Sheikhnejad, J. Simões, and N. Martins, “Introducing Tesla turbine to enhance energy efficiency of refrigeration cycle,” Energy Reports, vol. 6, pp. 358–363, 2020, doi: 10.1016/j.egyr.2019.08.073.