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Design & Development of Tesla Turbine for Waste Pressure Recovery System

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Abstract: There are many instances and applications in process industry where the processing of a fluid stream (gas / air) requires its pressure to be reduced. This pressure reduction is usually accomplished through use of a throttling valve. In this method the energy of fluid stream is lost, currently; emphasis is being placed on more 3effective energy usage in processing industry. As a consequence, areas in which energy is wasted are being closely monitored and methods of energy recovery are being investigated. This calls for developing of effective low pressure recovery systems.

Project work includes the design development analysis of a bladeless turbine; Decrease in the weight of the energy generating mechanism is the major factor driving the global bladeless wind turbines market. The construction cost of traditional wind turbines is significantly high as high quality machinery is required to avoid structural damage. As bladeless wind turbines oscillate when responding to vortices, the risk of heavy structural damage is comparatively low.

Moreover, as bladeless wind turbines contain few parts, they emit less noise and also pose no threat to birds, eliminating two of the major complaints that consumers have from traditional wind turbines. The inclusion of fewer moving parts also makes construction of bladeless wind turbines more reliable than the conventional ones. Bladeless wind turbines are also less expensive than traditional wind turbines and are easy to install. These factors together are likely to drive the growth of the global bladeless wind turbines market.

1. Introduction

The Tesla turbine is a bladeless centripetal flow turbine patented by Nikola Tesla in 1913. It is also known as a bladeless turbine. The Tesla turbine is also known as the boundary layer turbine, cohesion-type turbine, and Prandtl layer turbine (after Ludwig Prandtl) because it uses the boundary layer effect and not a fluid impinging upon the blades as in a conventional turbine. Bioengineering researchers have referred to it as a multiple disk centrifugal pump One of Tesla's desires for implementation of this turbine was for geothermal power which was described in Our Future Motive Power

2. Literature review

1) Enhanced power and heat generation from biomass and municipal waste
Torstein Strand
Siemens Power Generation Industrial Applications, Siemens AG 2005.

2). compressed air system
Bureau of Energy Efficiency

3). Waste Energy to Power Solutions Oct 22, 2012
Solutions powering industry

4). Energy savers Improving industrial productivity through energy efficient advancements
Compressed air systems are important and necessary components of modern industry. However, these systems are costly to maintain and operate. If compressed air systems are managed so that the air is properly controlled, treated, and used, significant savings can result.

5). Heat Recovery and Compressed Air Systems
By Frank Markowitz for the Compressed Air Challenge®, 0 9 / 1 0 www.airbestpractices.com
Sustainable manufacturing features
Frank Markowitz, Draw Professional Services

6). Global Warming Countermeasures
Japanese Technologies for Energy Savings/GHG Emissions Reduction《2008 Revised Edition》
New Energy and Industrial Technology Organization (NEDO), Kyoto Mechanisms Promotion Department

7). Finding Hidden Energy Waste with Data Loggers: Cost-Saving Opportunities

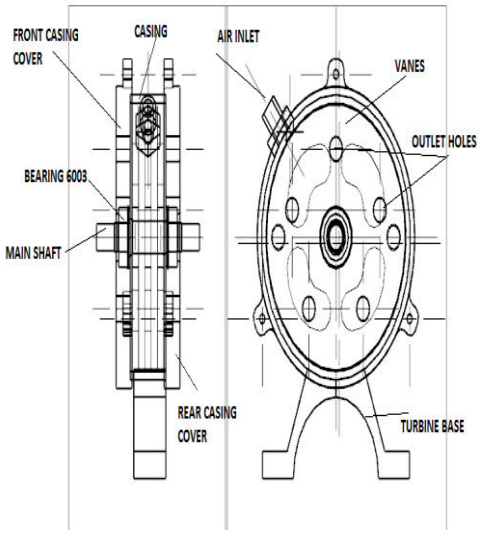
By Paul H. Stiller, Director, Energy Management
Summit Energy Services, Cleveland, Ohio
Finding Hidden Energy Waste with Data Loggers: 8 Cost-Saving Opportunities

8. Energy Recovery from Natural Gas Letdown Stations

Langston Energy's Total Flow Gas Letdown Generator™ or GLG™ is an economically viable solution to energy recovery applicable to natural gas pressure reduction stations and city-gates. This truly revolutionary engine for waste energy recovery will dramatically improve the economics of green energy. The Langston Gas Letdown Generator™ has significantly lower capital costs than other green alternatives. By integrating LEI technology with off-the-shelf components that have a proven history of reliable, robust, low-maintenance performance, Langston has solved the challenges of expensive turbine solutions to generating green power from wasted gas pressure. Traditional turbines (a.k.a. turbo expanders) have been the accepted method for generating power from pressure for many years. . However, their high capital costs and difficulty in handling fluctuations in flow rates and pressure have proven to be significant hurdles to their widespread adoption. Langston's Gas Letdown Generator™ is an economically viable solution to generating base-load, green energy from gas pressure.

3. Description

The Tesla turbine consists of a set of smooth disks, with nozzles applying a moving fluid to the edge of the disk. The fluid drags on the disk by means of viscosity and the adhesion of the surface layer of the fluid. As the fluid slows and adds energy to the disks, it spirals into the center exhaust. Since the rotor has no projections, it is very sturdy.Tesla wrote, "This turbine is an efficient self-starting prime mover which may be operated as a steam or mixed fluid turbine at will, without changes in construction and is on this account very convenient. Minor departures from the turbine, as may be dictated by the circumstances in each case, will obviously suggest themselves but if it is carried out on these general lines it will be found highly profitable to the owners of the steam plant while permitting the use of their old installation. However, the best economic results in the development of power from steam by the Tesla turbine will be obtained in plants especially adapted for the purpose

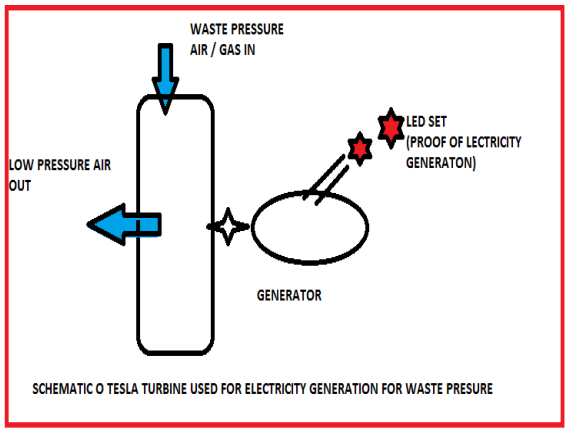


This turbine can also be successfully applied to condensing plants operating with high vacuum. In such a case, owing to the very great expansion ratio, the exhaust mixture will be at a relatively low temperature and suitable for admission to the condenser. Better fuel has to be used and special pumping facilities provided but the economic results attained will fully justify the increased outlay.

4. Construction and working

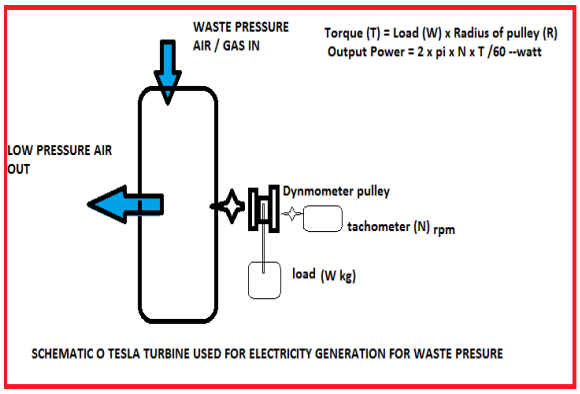
The Tesla turbine consists of a number of discs mounted parallel to each other on a shaft. Nozzles are located at the periphery of cylindrical casing and tangential to the shaft, pointing toward the inside. The discs are separated by thin gaps for the fluid to pass through it. Exhaust ports are located near the center of the turbine. Fluid enters tangentially into the turbine from the periphery. It is made to enter the gap between the discs. The moving fluid drags the discs in the direction of the flow. Due to this there is a transfer of kinetic energy from the fluid to the discs. This transferred energy causes the discs to rotate with the shaft. The fluid thus slows down as it moves towards the center in a spiral path exiting from the exhaust ports.

TESLA TURBINE EXPERIMENTL SET UP FOR ELECTRICITY GENERATION :



Here the experimental setup will be used to determine and prove the electricity generation form waste pressure
Here input parameter will be Pressure of inlet air and output parameter will be
a. Voltage (V)
b. Current (I)
c. Output Power (P) = V x I

TESLA TURBINE SETUP FOR BRAKE DYNAMOMETER TESTING



Here input parameter will be Pressure of inlet air and output parameter will be
a .Load (kg)
b. Turbine speed (N)
c. Torque (T) N-mm
d. Output Power (P) watt

MINIMAL INPUT CONDITIONS
In our case the **minimum pressure and flow conditions are**:
Pressure (min) = 2 bar
Flow min = 1.2 cfm = 0.034 m3/min
Power (min) ((kW) =Pressure (bar) * Flow (m3/min) * 1.70 = 2 * 0.034 * 1.70 =0.115 Kw = 115 watt.
Hence minimum power output from engine for given input conditions = 115watt

MAXIMUM INPUT CONDITIONS

In our case the **maximum pressure and flow conditions are**:
Pressure (min) = 5bar
Flow min = 1.8 cfm = 0.050 m3/min
Power (min) ((kW) = Pressure (bar) * Flow (m3/min) * 1.70 = 5* 0.05 * 1.70 =0.425 Kw = 425 watt.
Hence minimum power output from engine for given input conditions = 425 watt

TORQUE ANALYSIS:-

Torque at spindle is given by;

$$Ts = \frac{975\ N}{n}$$

Where;
Ts = Torque at spindle (kg-.m)
N = POWER (Kw)
n = Speed (rpm)
Maximum power output = 425 watt at 8000 rpm

$$\Rightarrow Ts = \frac{975 \times 0.425}{8000}$$

$$Ts = 0.0517 \text{ kg .m}$$

$$\Rightarrow Ts = 0.508 \text{ N-.m}$$

Considering 100 % overload;
Tdesign = 2 Ts
= 1.016 N-m
= 1.016 N-.m
$\Rightarrow$ Tdesign = 1.016 N-.m

5. RESULT

MAXIMUM NO LOAD SPEED @ 6 BAR PRESSURE = 7500 RPM
MAXIMUM VOLTAGE AT 6 BAR PRESSURE = 12 VOLT
MAXIMUM CURRENT AT 6 BAR PRESSURE = 0.6 AMPERE
MAXIMUM POWER @ 6 BAR PRESSURE= 7 WATT

6. Applications

1. **Gas Pipeline Pressure Energy Recovery –**

   It has applications where lot of pressure is wasted such as gas power plants.in this case tesla turbine can be used to generate electricity by using this waste pressure.

2. **Low Pressure Modulated Power Station**

   It can be used where pressure energy is very low.in this case tesla turbine will be helpful.

3. **Hybrid air cars**

The quasi turbine is a pure expansion engine is well suitable as compressed fluid engine – Air engine or air motor suitably to be used in hybrid cars.

4. **Tools**

Impact wrenches, drills, firearms, die grinders, dental drills and other pneumatic tools; it can be used for where tools are operated pneumatically

7. Conclusion

Tesla turbine is a very effective turbine as compared to other conventional turbines.as it is a bladeless turbine efficiency of this turbine is more than other turbines.it can be used for generating electricity using waste pressure from industries which is must needed in today's world where electricity generation has become so costly as all the sources such as coal is depleting at a faster rate.
So it will be very helpful to protect our world from energy crisis by choosing such turbines in industries.

8. Acknowledgements

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