Modeling of Micro Turbine for Rapid Prototyping

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ABSTRACT

A micro turbine is for harnessing energy from an airflow, which is generated by body motion. The energy is transformed into usable electrical energy and thus providing power for portable electrical devices. The turbine is flown axial and rotates in the same direction independent of the incoming airflow. This paper presents an overview of work performed to date on modeling of micro turbine for rapid prototyping that can automatically take solid models from computer Aided Design data in the form of stl, iges files.

KEYWORDS: *Micro turbine, CAD model, turbine, nozzle, and rotor.*

I. Introduction

Micro turbines are small components of modern electricity generators that burn gaseous and liquid fuels creating high-speed rotation which in turn operates the generators. Working in small stationary and automotive gas turbine has very much benefited from recent developments in the micro turbine process [1]. Micro turbine is a recent development. The vast majority of gas turbines today are jet engines, turboprops or turbo shaft engines. Renowned for their high power to weight ratio, extreme reliability and low maintenance, these engines dominate the aircraft industry. Derivatives of these turbines drive electric utility generators, power pipeline compressors and propel ships. A separate class of industrial gas turbine is used in power generation and other heavy-duty applications [2].From a historical perspective, micro turbines could be traced back to 1988 in North America, where a Co-generation was owned by a person named Herb Retch who also knew someone called Robin MacKay and Jim No e, two engineers who had left Garrett Corporation after it had merged with allied Signal. Robin and Jim had then decided to form a company to develop a small gas turbine that might be useful in the automotive market. [2]. However, the history of the micro turbine through 2003 includes only a scant 5 years of field and production experience. With all manufactures contributions less than 3000 units are presently operating around the world [2]. Consequently, micro turbine could be considered as a new generation of using gas turbine. Many applications and advantages of micro turbines help create a rapidly increasing market for them. To mention a handful of these advantages, first, the environmental performance of the micro turbine is very impressive thanks to decades of intensive research, In fact, micro turbine can now operate with fuels which produce much lower NOx emission than previously possible, surprisingly with even higher reliability and energy efficiency. Therefore, micro turbine can be considered as an environmentally friendly alternative, given that it produce substantially less polluting materials than other forms of power generating devices. The environmental dimension is especially important when it comes to the current environmental legislation. Second, another yet very important factor is the availability of gas as a fuel of choice for smaller scale industrial. The inherent deficiency in these methods is the absence of innovative design models to propagate more efficiency and cop. A.K.Matta [10] the first stage rotor blade of a two stage gas turbine has been analyzed for structural, thermal and modal analysis using ANSYS 9.0 Finite Element Analysis software. The gas turbine rotor blade model is meshed in HYPERMESH 7.0, meshing software. The thermal boundary conditions such as convection and operating temperatures on the rotor blade are obtained by theoretical modeling. Analytical approach is used to estimate the tangential, radial and centrifugal forces. A.K.Matta [11] the blade with material INCONEL 718 performed well, which improved the life and efficiency of future generation of engines. A.K.Matta [12] the analysis of Stress values that are produced while the turbine is running are the key factors of study while designing the steam turbines. Hot section blades typically fail because of creep, oxidation, low cycle fatigue and High cycle fatigue. A.K.Matta [13] development of a test bench which can be used to test the behavior of rotor during a braking cycle under dry conditions is described.

Caused by the progressive development of new technologies, humankind gets more reliant on energy supply for wearable electric devices. From the review conducted by A.K.Matta etal [14] new technologies and concepts to rapid prototyping systems reduce the cycle and cost of product development. A.K.Matta etal [15] presented the results achieved in the development of a 3D model and error compensation in the STL files.

II. Design Principle of Micro Turbine

The turbine consists of turbine inlet, Storage, Nozzle, Rotor, Coupling with shaft, Outlet, Housing /cover disposed like shown in Figure2.1 to 2.8. Due to its simple design, unlike other turbines with rotor blades, the turbine can be miniaturized to very small sizes. The prototype of the turbine has a diameter of 20 mm.

2.1 Design Criteria

2.1.1 Turbine Inlet:

Inlet hollow cylinder = 12 mm dia.
Length = 10.265 mm.
Outlet Diameter = 13.8 mm
Length = 6.4 mm
Octagonal diameter = 18.3 mm
Length = 4.42 mm.

2.1.2 Storage:

This is basically a hollow cylinder which used as a temporary storage of hot gases .It lies between the Inlet and the nozzle.
Its Outer diameter = 14 mm
Inlet diameter = 12 mm
Length = 7 mm

2.1.3 Nozzle:

No. of nozzles = 10
It has two phases first 1.263 mm has a diameter of 13.66 mm and second 7.1 mm has a diameter of 12.4mm.

2.1.4 Rotor:

Diameter = 12 mm.
Length = 3.474 mm.

2.1.5 Coupling with shaft:

It has basically 2 parts one is the rod and the other is the coupling which is in turn attached to the counter part of the Generator.
Rod diameter = 2.6 mm
Length = 25 mm.
Coupling main shoe diameter = 8 mm
Individual coupling hole diameter = 1.5 mm.

2.1.6 Outlet:

Main solid diameter = 12.42 mm
Central hole diameter = 2.6 mm
4 holes of diameter = 1.56 mm
Width is = 3.6 mm

2.1.7 Housing/Cover:

Outer diameter = 17 mm
Diameter for diff. parts to be fixed is different.
Total Length = 32 mm (Which is turbine length indirectly).

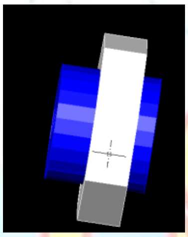

Fig2.1.Turbine Inlet

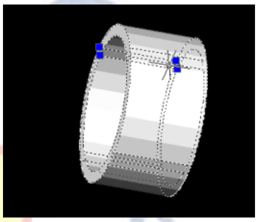

Fig2.2. Storage

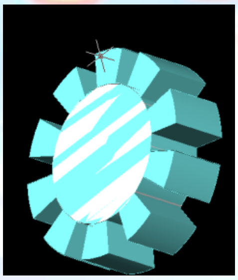

Fig2.3. Nozzle

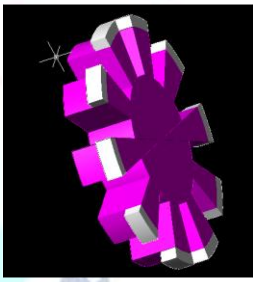

Fig2.4. Rotor

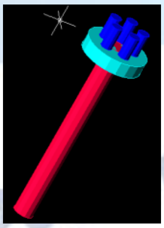

Fig2.5.Coupling with shaft

Fig2.6.Clip

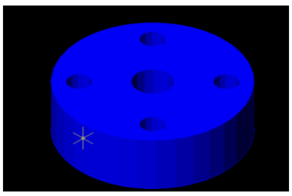

Fig2.7.outlet

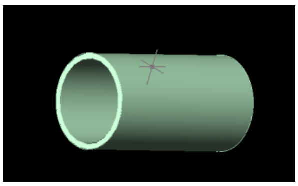

Fig2.8.Housing with cover

III. Production of Micro Turbine

The two main parts of Micro turbine are the rotor and the nozzle. Rest of the parts like inlet storage, coupling, clip and housing can be made by easy machining like Turning in lathe, milling, drilling etc. The two main intrinsic parts like rotor and nozzle out structure can be done by turning in lathe. Rest the slotting and all can be done by using die sinking of EDM. For machining they are clamped in the rotary head of the EDM. A prismatic copper electrode having a cross section of Air channels is used as the electrode. The electrode as described is produced by wire cut EDM. The major problem of the electrode is the wear the wear rate is not same in all direction and in particular time so at a fixed we have to cut the electrode by a small amount to increase the accuracy

IV. Creation of CAD MODEL [7]

First, the object to be built is modeled using a Computer-Aided Design (CAD) software. Solid models, such as Auto desk Inventor tend to represent 3-D objects. A pre-existing CAD file or a newly created CAD file for prototyping purpose can also be used. This process is identical for all of the RP build techniques.

V. Rapid Prototyping [6]

Rapid prototyping refers to a class of technologies that can automatically produce solid models from Computer-Aided Design (CAD) data. It is a freeform fabrication technique in which the object of prescribed shape, size, dimension and finish can be directly constructed from the CAD based geometrical model stored in a computer, with little human intervention. The fabrication processes in a rapid prototyping can basically be divided into three Categories which are additive, subtractive and formative. In the additive or incremental processes, the object is divided into thin layer s with distinct shape and then they are stacked one upon other to produce the model. The shaping method of each layer varies for different processes. Most of the commercial Rapid Prototyping systems belong to this category. Such processes can also be called layered manufacturing (LM) or solid freeform fabrication (SFF). Layer by layer construction method in LM greatly simplifies the processes and enables their automation. An important feature in LM is the raw material, which can be either one-dimensional (e.g. liquid and particles) or two- dimensional (e.g. paper sheet) stocks. Whereas in case of subtractive RP processes three-dimensional raw material stocks are used. Stereo-lithography apparatus (SLA), three dimensional printing, selective laser sintering (SLS), contour crafting (CC), fused deposition modeling (FDM), etc. are few examples of LM. Subtractive or material removal (MR) processes uses the method of cutting of excessive material from the raw material stocks. There are not as many subtractive prototyping processes as that of additive processes. A commercially available system is Desk Proto, which is a three-dimensional computer aided manufacture (CAM) software package for Rapid Prototyping and manufacturing. As in case of pure subtractive RP processes the model is made from a single stock, fully compact parts of the same material as per actually required for end use is possible. The other advantages like accuracy of the part dimensions and better surface quality can be achieved by the subtractive machining approach. However if we compare geometric complexity the MR processes are limited than the LM processes. Different types of cutting methods used are computer numerical control (CNC) milling, water-jet cutting, laser cutting etc. In formative or deforming processes, a part is shaped by the deforming ability of materials.

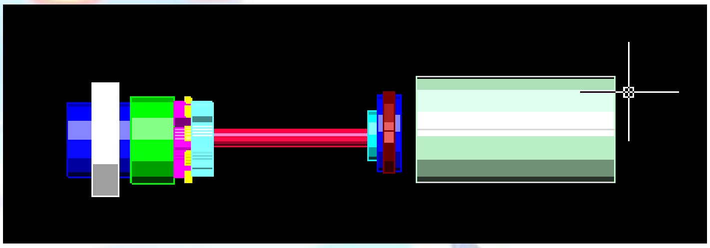

Fig5.1.Assembled model for Rapid Prototyping

VI. Conclusions and Future scope

A novel design of a turbine is presented, which can be scaled down to micron sizes because of its simple design. As the turbine consists of 2D-layers, it can easily manufactured by laser-cutting techniques. The required area is lower than the one which is necessary to generate the same power from Gas and Steam Turbines. A model was developed to relate the micro requirements for assembly. It provides the designer to visualize and analyze the model for Rapid prototyping.

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