10/26/2017

Advanced Undergraduate Project including mechanical design, thermal analysis and manufacturing of prototype

Subject: “Mechanical, hydraulic and thermal design & manufacturing of gas turbine combustor casing and liner providing even distribution of cooling air”.

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A team of three students is required for the project

The project will be given as part of the course “New Project Design” of the Design teaching track.

Background: Gas turbine combustor shown on figure 1 is normally designed to operate on natural gas fuel (and oil # 2 as an emergency back-up fuel). When this combustor is adjusted to operate on synthesis gaseous fuel with high content of hydrogen (44% - 53%), the synthesis gas requires higher air flow (both primary combustion air and cooling air) than the natural gas. With a higher air flow and a larger diameter of modified combustion chamber casing, uneven air flow distribution results inside each individual “can type” combustion chamber of the gas turbine combustor. In the annular space between the casing and liner uneven distribution of air was detected in circumferential direction, inside the liner the flow stratification was detected in both circumferential and radial direction. Air flow stratification resulted in uneven heating of combustor liner and increased NOx emissions.

Project goal:
1. Design of combustor casing and liner having high flowrate and even air flow distribution.

2. Manufacturing a scaled down version of the combustor casing & liner using 3D printer and appropriate materials.

3. Hydraulic and thermal testing the manufactured scaled-down prototype in the laboratory by measuring air flow velocities and temperatures at different locations inside the casing and liner.

Description of components targeted for design and manufacturing

Liner is a cylindrical perforated shell having special thermal coating on its inner surface (TBC). Liner serves as an inner lining of cylindrical combustion chamber (see figure 1). Liner is usually made of temperature resistant alloys (like Hastelloy-X or Inconnel 718) or sometimes stainless steel 347.

At the front edge liner is connected to a rigid steel holder of burners and fuel/air delivery set up. At the rear end liner is connected to transition piece which allows circular exit of combustion chamber to be smoothly “blended” into more complex and irregular shape entrance of combustion turbine (see figure 2).

Liner is surrounded by another co-axial cylindrical shell of larger diameter called **casing**.

Liner and casing form the annular space intended for flow of cooling air. Cooling air enters the annular space through the special inlets and flows in axial directions simultaneously entering the combustor space through the liner openings and array of smaller diameter holes.

Cooling (or tertiary) air is used for temperature and NOx control. Primary air is used for partial premix with fuel and secondary (tangential) air is used for flame stabilization and reaching complete mixing between fuel and air.

In the framework of the project it is required to design and build a scaled-down version of the actual combustion chamber.

After manufacturing of liner is completed the latter must be tested for performance verification. The testing stand will include air compressor, flowmeter, piping, air ducts, Pitot tubes, manometers, support structure etc. Parameters to be checked are air flow rate and air velocities at different locations of the casing-liner set up.

Requirements for students:

1. Sound knowledge of mechanical design fundamentals
2. Familiarity with manufacturing methods and practices including ability to use 3D printer for producing prototype model
3 Knowledge of fluid mechanics, heat transfer and hydraulic calculations

4. Ability to use “Solidworks” or equivalent CAD/CAM software for design and manufacturing purposes

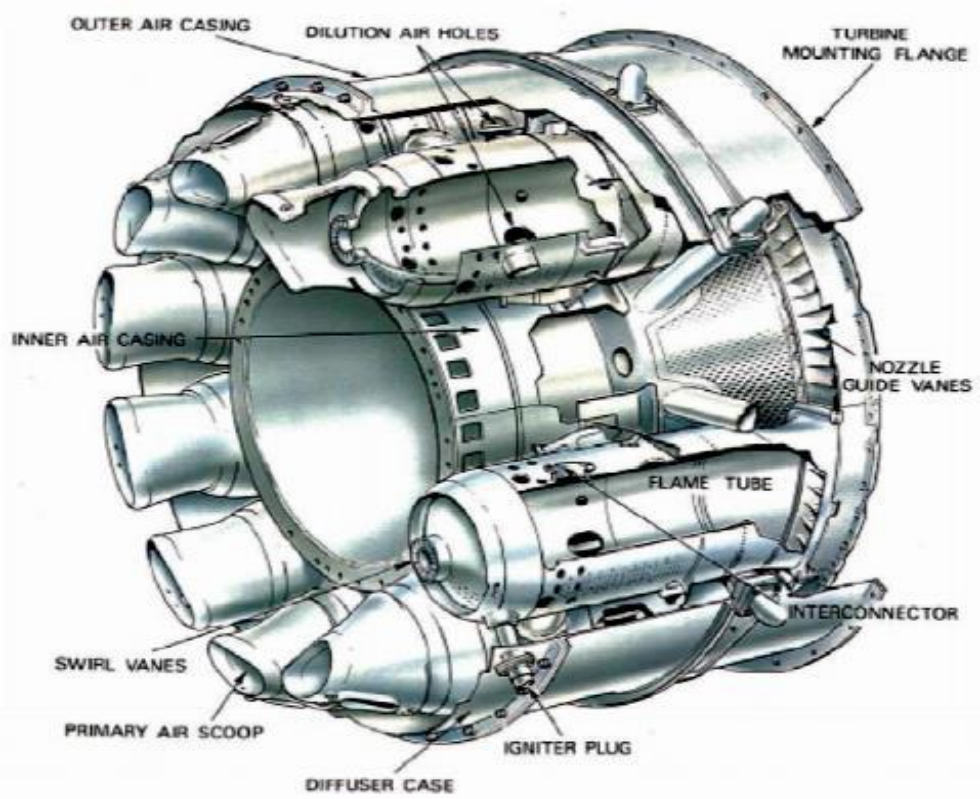

Figure 1: Can annular combustor.

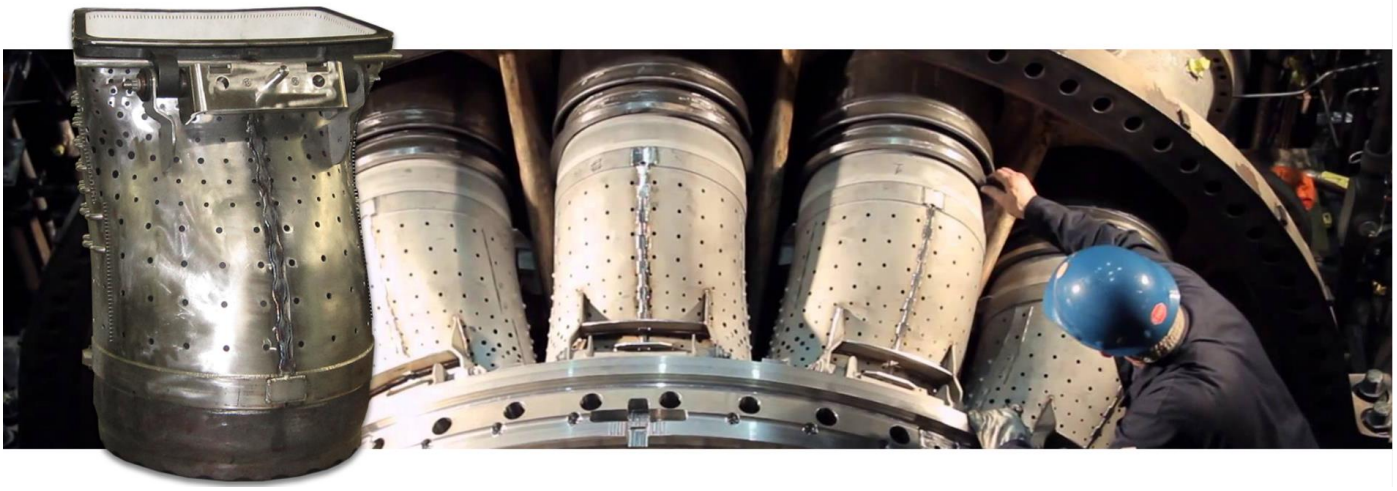

Figure 2: Transition pieces connecting combustion chambers to the entrance of gas turbine.