Implementation and Thermal Analysis of Transition Duct in Industrial Gas Turbine

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Abstract: Gasoline turbine development is normally pushing forward and forlarger talent extra gas turbine inlet temperatureis needed. The project turns out to be to develop and associate new opportunity cooling andmounting principles for a transition duct inside the trendy gas turbine. Transitionduct is a warm element and has the venture to the manual the new gasoline from the combustionchamber to the turbine inlet in a gas turbine.The transition duct of currently is cooled with the assistance of a surprisingly massive amount ofcompressor air which needs to be reduced in case of apower upgrade. Themodern mounting solution requires three combustion chambers to be eliminatedfor one transition duct preservation, which is time- ingesting. The concept became then generatedfrom feature/means tree together with morphology matrixes. This changed intodivided into two branches, one for cooling and one for mounting and sealing.The transition duct turned into modeled in CATIA and evaluated with thermalanalysis has been performed in ANSYS software.

Keywords-Transition duct in SGT-750, Can type combustion chamber,temperature and heat flux.

I. INTRODUCTION

The efficiency of fuel generators becomes increasingly more vital simultaneously asthe pollutants demands get more difficult. Therefore it is crucial to hold the flametemperature within the area of effective combustion to avoid pollutions. To preserve theoverall performance high, the turbine inlet temperature should be as high as viable.Due to this, cooling of the hot elements has to be extra efficient and cooling air leakage tothe combustion chamber ought to be reduced.Today the transition duct in SGT-750, that's a hot combustion aspect, iscooled with impingement cooling, a verified method for cooling of hot parts. Todaythis cooling method is allowed to consume a beneficial amount of compressor air tohold the transition duct fabric at an excellent temperature. Due to the interest ofpersevered improvements, different cooling techniques are the hobby to decrease theintake of air and still preserve a good temperature in the transition ductcloth.

Due to this continued work with enhancements, mounting of the transition duct additionallyis of interest. It needs to be investigated to discover even more sturdy mounting techniqueswith decrease vibrations and the slighter chance for low cycle fatigue.Today the transition duct mounting includes many parts that ought to be held in the area even as becoming and tighten the bolts. To attain all bolts to eliminate or mount atransition duct, three of the combustion casings needs to be removed, the only in which theactual duct is positioned and also the adjacent casings. To decrease the preservation timefor service, it's far from a relaxation to trade this design.Different cooling methods will be investigated to lessen the air intake used forthe transition duct cooling.Concepts for new approaches to mounting the transition duct with fewer parts and with simply onecombustor casing eliminated may also be investigated. Seals which might be suitable for themounting principles can also be chosen..

The SGT-750 is a twin-shaft gas turbine (figure 1) whichis suitable for either mechanical commute or force era.The high-productivity, fast, 6100 rpm power turbine isappropriate for mechanical commute. In force era the freepower turbine empowers the SGT-750 to adapt to changesin the framework's recurrence, and licenses bothcontinuous and fast begins, coming to full load in under10 minutes. The complete gas turbine unit is mounted ona solitary base edge into which the lube oil tank iscoordinated. All the assistant frameworks, for example,begin engine and electrically determined move downframeworks are mounted on the base casing.

Figure 1: SGT-750 gas turbine

The innovation in the SGT-750 is in light of the generalSiemens gas turbine armada, both the mechanical and theutility reaches. Advancement concentrated basically onthe center motor keeping in mind the end goal to enhanceexecution and discharges further, while the configurationof assistant frameworks was to an expansive degree inlight of the SGT-600/700 bundle.Since natural execution, for example, restricting NOx,CO, CO_2 and commotion outflows, is turning out to beprogressively imperative, the high-effectiveness SGT-750has a low carbon foot shaped impression, the Dry LowEmissions (DLE) combustor being standard for lownitrogen oxide discharges.

This establishment (Figure.2) meets stringent necessitiesfor smallness, short establishment and dispatching timesand simplicity of upkeep. The gas turbine is slip mounted,with the assistants gathered in independent modules set inthe helper room. The format is in view of the samestandard for all applications, whether mechanicalcommute or force era, inland or seaward establishment.

The gas turbine driver slide is constructed from steel bars,supporting the gas turbine, assistant frameworks andstarter engine and, if material, speed-diminishment gear.The helpers are situated before the gas turbine airadmission in the assistant room. The gas turbine driverslip is associated with the determined hardware which canbe on establishment or slide mounted. The entire bundlein this way frames a solitary lift unit, whose advantage isquicker establishment on location with less work at site.The air admission and fumes stack are bolstered byindependent outer pillar structures. A two-stage static airchannel is supplied as standard, yet different choices areadditionally accessible, for example, plane heartbeatthree-stage and so on, contingent upon clientprerequisites. In the standard form, the electrical andcontrol module containing Motor Drive System (MDS),batteries and unit control work spaces remains all alonebolster adjoining the gas turbine/generator slip reportingin real time admission side.

Figure 2: Package layout

Gas turbine technical description

The gas turbine comprises of a pivotal stream gasgenerator with a 13-stage compressor, combustor and atwo stage air-cooled compressor turbine. The two-stageuncooled force turbine is counter-pivoting with respect tothe gas generator for higher effectiveness. The higherproficiency originates from more proficient utilization ofthe outlet twirl from the gas generator.

Performance

This is designed to meet the very high expectations ofperformance with over 40% efficiency at 37 MW andmarket leading emissions. For different ambienttemperatures there is an opportunity to select differentmatching on the power turbine in order to optimizeperformance for example the hot ambient matching gainstwo MW at 50deg C compared to normal matching.Another important performance aspect is the ability toburn different types of fuels, to be fuel-flexible. In theSGT-750 Siemens has used the experience of fuelflexibility from the rest of the Siemens fleet. The SGT-750 is able to cope with large amounts of inert gases,pentane and varying wobbe index, all with maintainedcombustion stability.

Compressor

The compressor (figure 3) has 13 stages with a pressureratio 24:1. Two variable guide vane rows and threecompressor bleeds located after stages 3, 6 and 9 are useddduring start-up and part-load operation. This is a morerobust design compared to multiple variable guide vanes.The configuration was chosen for maximum reliability,with highest possible compressor performance.The compressor rotor disks and shafts are welded togetherby Electron-Beam (EB) welding, the same technology asused on other Siemens gas turbines. EB-welding has theadvantage of low heat release to maintain the accuracy ofthe disk alignment. Field-balancing possibilities areprovided for, as well as access from the outside to thestandard instrumentation at the bearings, which facilitateseasy exchange of vibration probes if necessary. Allmaterials have been selected to suit hot and cold ambientconditions. Protective anticorrosion coating is alsoavailable if required, for example in offshore applications,where salt from the sea can lead to corrosion issues.

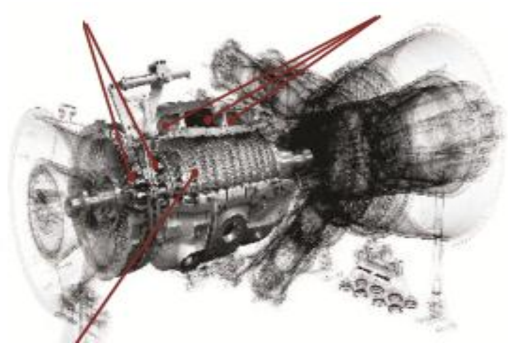

Figure 3: Compressor section

II. METHODOLOGY

The SGT-750, see Figure.4 is intended to be used for both power generation andmechanical drive with a high efficiency. The main feature of this turbine is the shortmaintenance time and low emissions. The power output in power generation setup is36 MW with an electric efficiency of 39%. With the mechanical setup, the output is37 MW, 50’000 bhp with 40% efficiency. To boost the efficiency even more at powergeneration, the SGT-750 can be used in a combined cycle due to the high exhausttemperature.

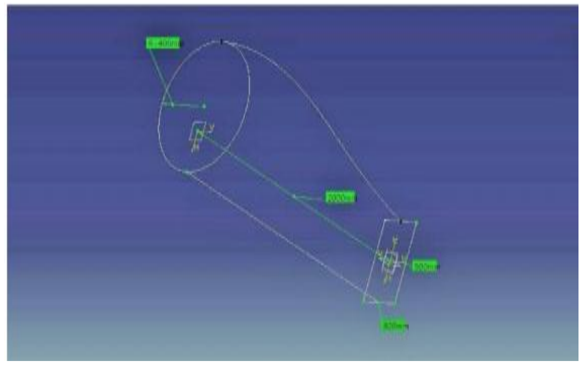

Fig.4 the dimensions of Transition duct

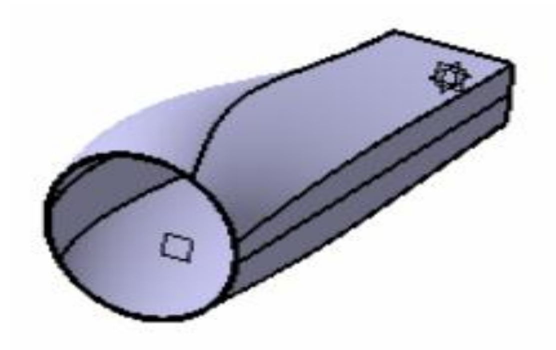

Fig. 5 3D model of transition duct

Conduction: Conduction refers to when heat flows from one high- temperature stage in one part ofa medium to another part in a lower temperature stage until equilibrium is reached.The rate of heat transfer can be written as Equation 1 referring to Fourier conductionlaw.

Q is the rate of heat transfer through a specific length,DT/dx is the temperature gradient, $\Delta T = 1173$ K

Thermal conductivity, k

The heat transfer area, $A = \pi\ (r1 - r2)2 = 0.000314\ m^2$

(1) For Aluminum,k = 205 W/m K

Q = 205 x 0.000314 x 1173

= 75.506 Watts

(2) For E- Glass Epoxy,

k = 1.35 W/m K

Q = 1.35 x 0.000314 x 1173

= 0.4972 Watts

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(3) For Aluminum,
k = 0.4 W/m K
Q = 0.4 x 0.000314 x 1173 = 0.1473 Watts

Convection: The heat transfer is described by Newton's law of cooling, Equation 2. The heattransfer coefficient, α is written as Equation 3 and dependent of the fluidsconductivity, k, Nusselt number, N_u and a characteristic length, L. Both the Nusseltnumber and the characteristic length are dependent on the applied situation.

Nu = h L / k

- Air - h = 10 to 100 W/ (m2K)
- k = 0.024 W/mK
- L= 0.2 m

Nu = h L / k = (50 x 0.2) / 0.024 = 416.66
A = 0.434 m2
QConv = h A ΔT
= 50 x 0.434 x 1173
= 25454 W/m2 K

III. RESULTS AND DISCUSSIONS

This part presents the strongest concept combination from the evaluation. Alternative concepts and combination of concepts that can be of interest for SIT AB are also presented. All of the cooling solution contains calculation results of the material temperature and air consumption. In this cooling calculation a new way of calculating the heat transfer coefficient at the hot side have been used to get more reliable results. The duct is divided in five parts, like and the heat transfer coefficient is gained with a factor from SIT AB's earlier CFD calculations.

According to the thermal analysis and comparing with different materials, BoronEpoxy can be considered for fabricating the transition duct for better cooling of the airflowing towards the turbine.

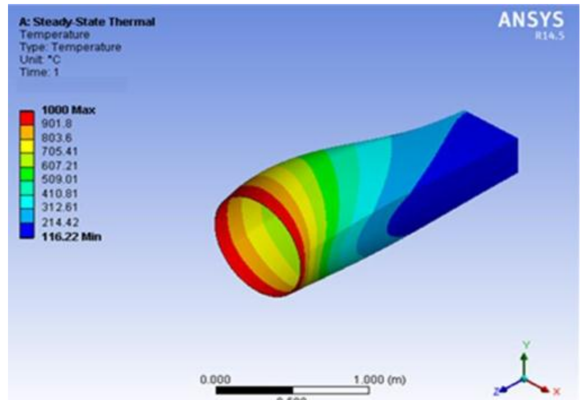

Fig.6.Temperature distribution of Transition Duct (aluminum)

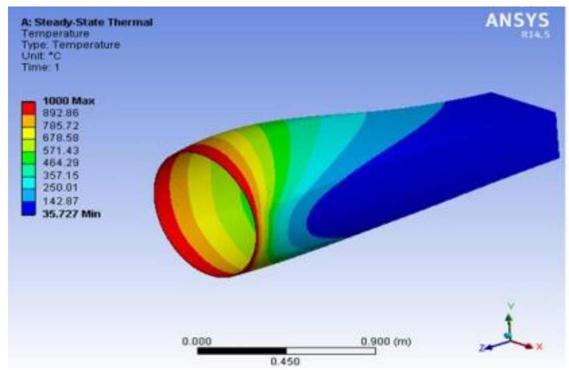

Fig. 7. Temperature distribution of Transition Duct (E-Glass Epoxy)

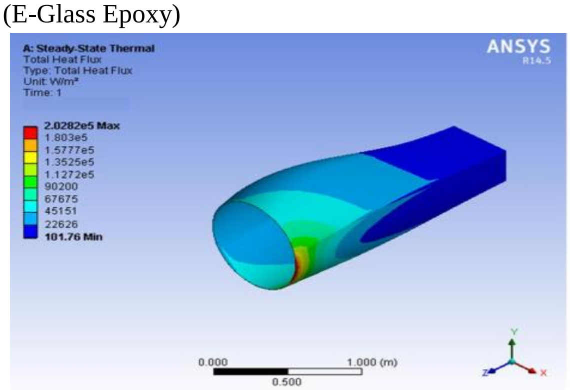

Fig.8. Heat flux of Transition Duct (Aluminum)

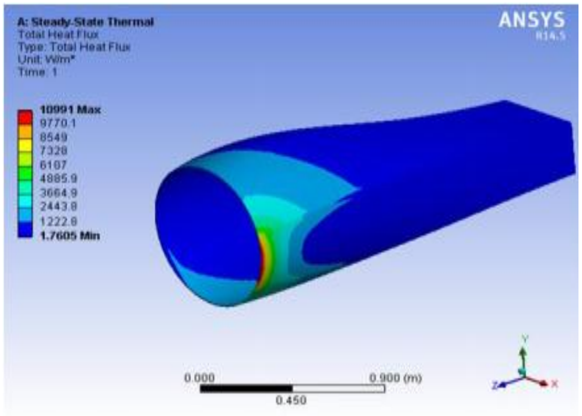

Fig.9 Heat flux of Transition Duct (E-Glass Epoxy)

IV. CONCLUSION

The SGT-750 is competent to fulfill the oil & gas enterprise's needs for effective and clean energy based on fuelturbines contribution an excessive stage of performance withoutforfeiting reliability. The assignment was to expand and evaluate new alternative cooling and mounting ideasfor a transition duct within the modern fuel turbine. The transition duct of today is cooled viaa highly massive amount of compressor air which needs to be decreased in case of anpower improve. The current mounting solution requires three combustion chambers tobe eliminated for one transition duct renovation, that's time- ingesting.The idea changed into modeled in CATIA and evaluated with thermal analysis, achievedin ANSYS software program.

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