Volume : 5 | Issue : 3 | March 2016 • ISSN No 2277 - 8179 | IF : 3.508 | IC Value : 69.48

Research Paper

Multidisciplinary Performance Analysis Optimization of Subsonic Flow on Turbine in a Diffuser Duct with New experimental Göttingen 535 Airfoil Strut and Present Usual NACA 4421Airfoil Strut

Engineering

KEYWORDS : Flow over göttingen 535 airfoil strut, pressure recovery, CATIAV5 &ANSYS CFX Solver analysis.

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ABSTRACT

A comprehensive analysis investigation on the subsonic compressible flow performance to diffuser duct with the help of usual(NACA 4421) airfoil strut data as compared to new experimental design and analysis performance data with help of göttingen 535 airfoil strut on gas turbine afterburner diffuser. We try to obtain the optimum system performance during combustion processes with the help this experiment's. The engine performance parameters such as total pressure loss, flow properties such Mach number, flow velocity, statics pressure, swirl are compared for both the cases. In this paper we concentration on With the help of new design and flow analysis on göttingen 535 airfoil strut with diffuser duct can provided better performance and pressure loss improvement as compared to current using NACA 4421 airfoil strut present experimental data on afterburner diffuser duct at combustion chamber .

NOMENCLATURE

Alphabet

Cp	pressure recovery coefficient
ΔCp	change in recovery
A/R	air ratio
P	pressure
O	total
Y+ or X+	known dimension wall distance
A/Rr	pressure recovery to pressure loss ratio
ζ	total pressure loss coefficient
L	length of afterburner diffuser duct
H	height of afterburner diffuser duct
Cp0	initial pressure
Cp01	second stage pressure
Cp02	final stage pressure

1. Introduction

The diffuser designs of most important component of subsonic transport type airplanes engine, which have converged to configuration manly characterized by airfoil strut. So such an duffer design has successfully proven itself over last decades. The airfoil strut on diffuser designers face numerous challenges

to meet high efficiency fluid flow performance demands for improvements in pressure loss or recovery , flow velocity . To developed enough pressure for afterburner to build proper combustion as in combustion chamber at where combustion chamber will received abnormal enough pressure,

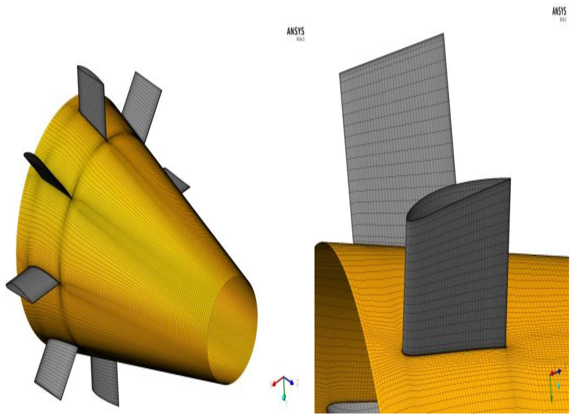


Fig-1 Grid generated around the göttingen 535 Aerofoil Struts

For its combustion process. Krishnamurthy, et al. [1].says that as the pressure increases in the flow with the limited number of struts is beneficial as it developed tremendous mixing of air and fuel in afterburner diffuser chamber.

Static numeric numbers arifoil strut on diffuser are Guides the vanes for the static flow direction and improve the pressure recovery is given by Sovran, G., Klomp, E.D. [5].

Afterburner diffuser with NACA 4421 airfoil improved and holding the flame at the same time it's improved the total pressure loss also in diffuser mixture chamber . So how to minimize the total pressure loss from the method of different struts in the diffuser mixture as try to find out present study.

2. Design Of Diffuser Ducts With The Airfoil Strut

The afterburner diffuser duct design with Airfoil is based on efficient diffuser improvement performance maps. The Sovran and Klomp diagram which base on afterburner diffuser duct length L with height h and number of airfoil strut areas to duct inlet area ratio AR. the static pressure coefficient C p:

$$\frac{P - P1}{P01 - P1} \qquad (1)$$

And at C p =(1) fluid flow around afterburner diffuser duct is constant

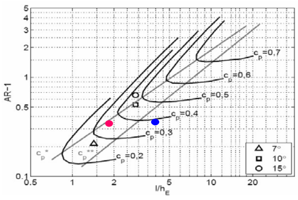


Fig.2. Sovran and Klomp afterburner diffuser design performance map

Maximum pressure recovery is limited when ideal static pressure coefficient increases which base on static non-swirling flow around the airfoil strut duct which is function of AR:

$$Cpi = 1 - (AR)^{-2} \qquad (2)$$

However strut flow losses and afterburner diffuser inlet swirl are not taken for above two equation equation.

Now total pressure loss of the afterburner diffuser duct:

$$\frac{P02 - P02}{P01 - P1} \qquad (3)$$

The pressure loss increases as we increases the airfoil strut in the diffuser duct.

3. Introduction to Catiav5

CATIAv5 is one of more useable of industrial software which provided long range of design tools variation to carry the build the of a full digital representation of product design and parametric solid modelling program. It has ability to generate all kind of integrated design such as industrial engine. In this tools drafting process shows views of a part are created in the processing to describe the geometry. In this feature based modelling, every feature is individually described then integrated into the part. In this study we dealing with the diffuser duct with struts design parts are involved in below steps...

i.Part design

ii Drawing (drafting)

3.1. Design Of Afterburner Diffuser Duct With Göttingen 535 Airfoil Strut.

2.1.1. 2-D Design

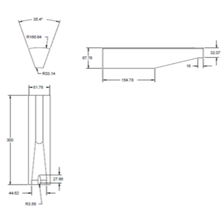
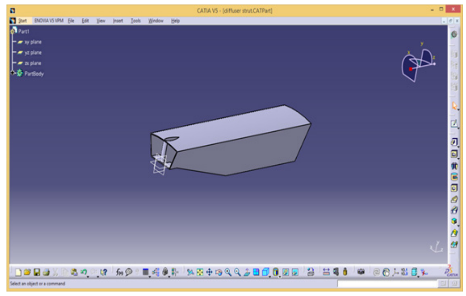
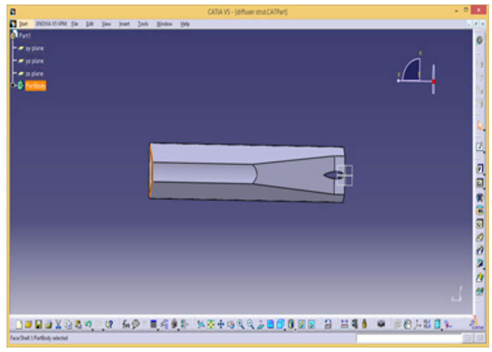


Fig.2. 3-D Afterburner Diffuser Duct with Strut

3.1.2. 3-D Design





3.1.2. 3-D Design

Fig.3. 3-D Afterburner Diffuser Duct with Strut

4. Mesh Generation

In order to visualised fluid flow, The governing equations to solved inside each of these sub domains. The meshed area around the diffuser duct and strut aerofoil section is shown in figure 1.

4.1. Grid independence studies

Afterburner diffuser duct with both airfoil strut Göttingen 535 and NACA 4421.

S L No	Grid size, Number of elements	Y-plus	Total pressure (absolute) at section 6.1,Pascals Experimental & CFD	Remarks
1	259521	82	Not available&511036	Y-plus value is high
2	271361	31	Not Available&489223	Y-plus value is acceptable
4	267024	33	Not Available&478812	Mesh finalized for CFD analysis

Table.4. Grid Independence Values for both airfoil strut.

4.2.1. Meshing Of Sub-Sonic Flow In Afterburner Diffuser Duct with Göttingen 535 airfoil Strut.

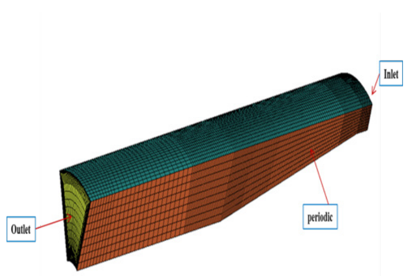


Fig.5. Grid Generation on Afterburner Diffuser Duct without Strut

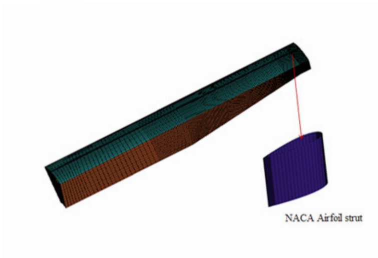


Fig.6. Grid Generation on Afterburner Diffuser Duct with Strut

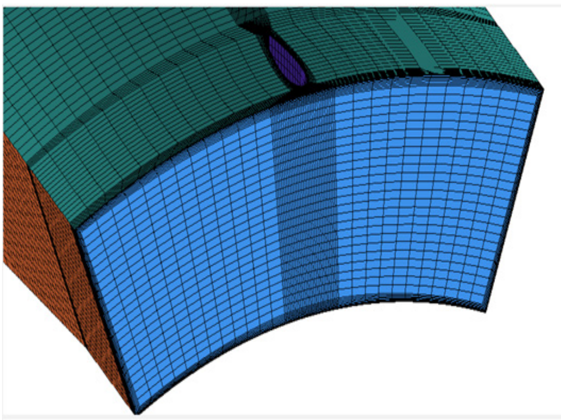


Fig.7. Grid Generation on Inlet Section of Afterburner Diffuser Duct with Strut

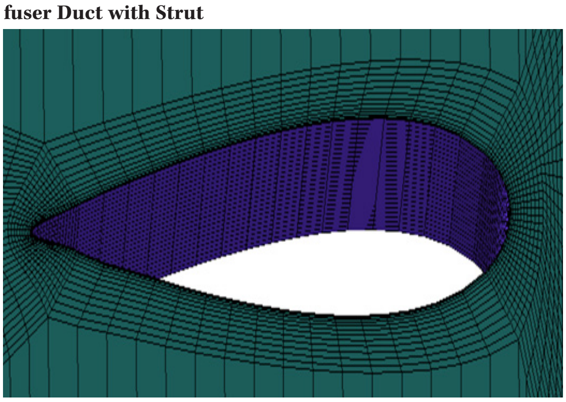


Fig.8. Grid Generation on Göttingen 535 Airfoil Strut.

5. Cfx Solver

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The basic physical models of ANSYS CFX Solver:

- Domains of objects
- Physical Models of objects
- Requirements of Sources
- Material Properties of objects
- Mixture variable (Fixed, Variable, Reacting)
- Mathematic Efficiency Calculation

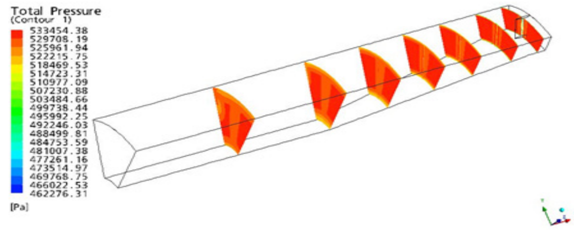


Fig.9. Analysis of Total Pressure over Afterburner Diffuser Duct with Strut

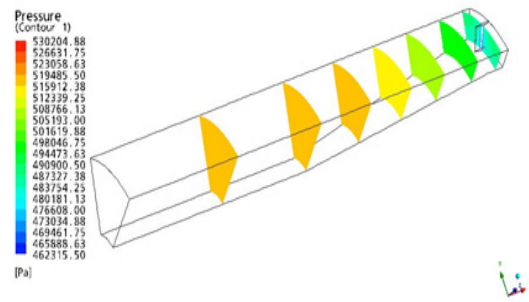


Fig.10. Analysis of Static Pressure over Afterburner Diffuser Duct with Strut

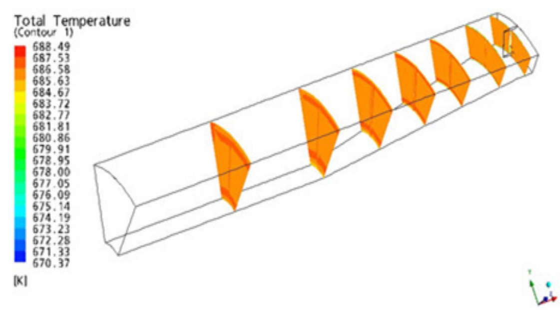
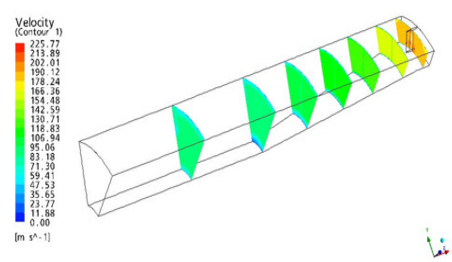


Fig.11. Analysis of Total Temperature over Afterburner Diffuser Duct with Strut



Volume : 5 | Issue : 3 | March 2016 • ISSN No 2277 - 8179 | IF : 3.508 | IC Value : 69.48

Fig.12.Analysis of Velocity over Afterburner Diffuser Duct

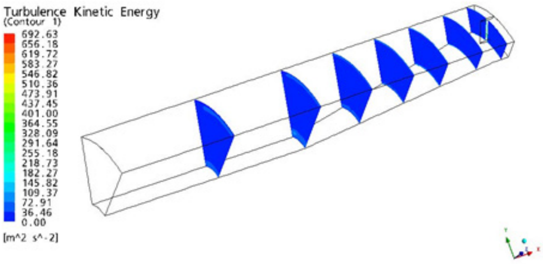


Fig.13. Analysis of Turbulence Kinetic Energy over Afterburner Diffuser Duct with Strut

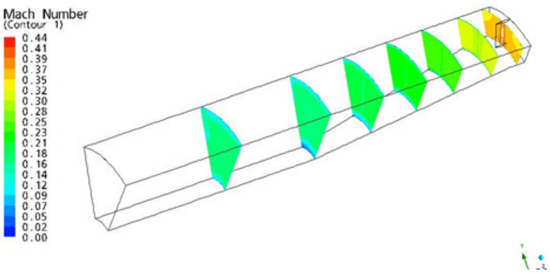


Fig.14. Analysis of Mach number over Afterburner Diffuser Duct with Strut

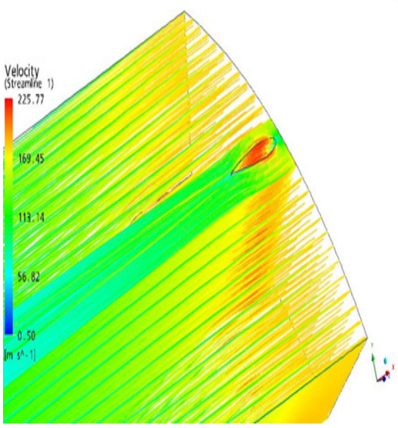


Fig.15. Analysis of Velocity over Afterburner Diffuser Duct Inlet with Strut

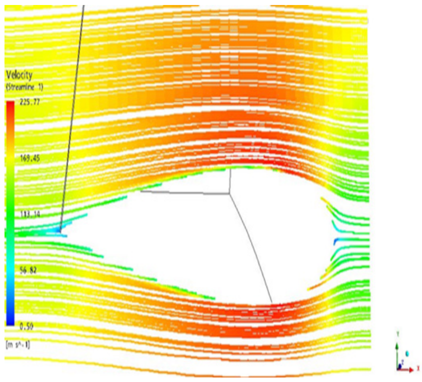


Fig.16. Analysis of Velocity over Afterburner Diffuser Duct's Strut

6. Result

By applying present NACA airfoil strut improvement data and our Göttingen 535 airfoil new experimental data on afterburner diffuser duct we got more improvement pressure recovery to pressure loss ratio, total pressure improvement at subsonic condition by using Göttingen 535 airfoil strut as compared to NACA airfoil strut at 0 swirls condition on afterburner diffuser duct.

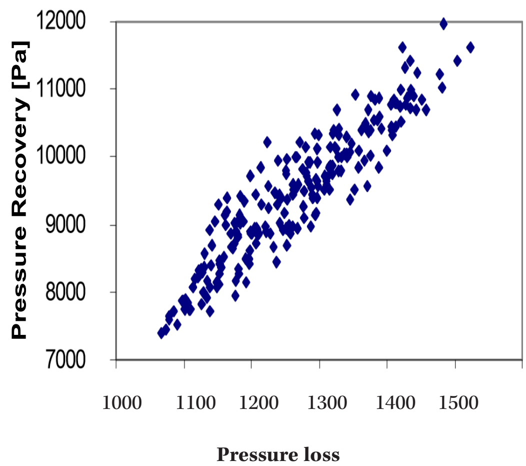
Table 5: CFX analysis results for the afterburner diffuser mixer with NACA 4421 aero foil and cylindrical struts for O0 swirls.

SL No	Description	Unit	Values at station 6.1
	Mass flow rate	Kg/sec	12.96
	Absolute total pressure	pascals	532665
	Absolut static pressure	pascals	449723
	Total temperature	K	525.728
	Mach Number		0.159521

Table 6: CFX analysis results for the afterburner diffuser mixer with göttingen 535 aero foil and cylindrical struts for O0 swirls.

SL NO	Description	Unit	Values at Station 6.1
1	Mass flow rate	Kg/sec	14.0314
2	Absolute Total pressure	Pascals	536386
3	Absolute static pressure	Pascals	513743
4	Total temperature K		586.497
5	Mach Number		0.153218

7. Ratio Of Pressure Recovery To Pressure Loss (ARr) Using new Göttingen 535 Airfoil Strut on Duct.



8. Conclusion

On the basis of experimental analysis and outcome results, we come up with following conclusion:

- The total static pressure recovery or pressure loss increases for comprisable swirl flow at inlet flow variation is 22% more in gottenger 589 as compared to NACA4421 airfoil strut data . The loss coefficient also increases for variation of different direction swirl flow.
- The mass flow distribution are more uniform
- The secondary flow are on diffuser more uniform flow so pair vertex not formed.

- as the less vertex so pressure loss are become less

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