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COUPLED FIELD ANALYSIS OF MICRO GAS TURBINE BLADE USING CFD

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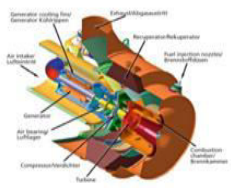
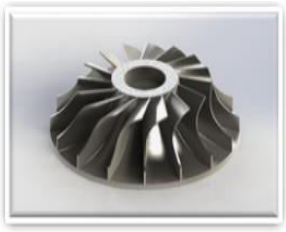
ABSTRACT: In this Micro-gas turbine blade is used to convert mechanical energy to electrical energy of power. By observing some research papers, to increase cooling effect they have designed the micro gas turbine blade. In this project the micro gas turbine blade with alloys of titanium alloy (aluminium+ vanadium), nickel alloy and chromium steel in designed and model in CREO software. Coupled field analysis (thermal and structural), CFD analysis are done both the design of existing model and the modified model cooling effect results of three materials are 4.2% 4% 3.8%. By comparing the analysis, I can say that titanium alloy is better.

Key words: Gas turbine rotor blade, Modeling, Meshing, Thermal Analysis.

1 INTRODUCTION

1.1 MICRO GAS TURBINE: Gas turbines are among the most advanced systems as they combine intense situations in phrases of rotational speed with multiplied gas temperatures (up to 2100 K for army engines). Miniaturisation of this kind of gadget poses amazing technical problems as it results in extremely excessive rotational speeds (e.G. 106 rpm). Moreover, scaling down the device unfavourably influences the waft and combustion method. Fabricating such gadgets calls for new substances to be explored (along with Si3N4 and SiC) and also requires three-dimensional micro manufacturing processes. The device essentially consists of a compressor, regenerator, combustion chamber, turbine and electrical generator. The system basically consists of a compressor, recuperator, combustion chamber, turbine and electrical generator To keep away from demagnetisation of the magnets, the generator is placed away from the recent elements and the inlet air is aspirated through cooling channels in the generator stator. Generator, compressor and turbine are established on a unmarried shaft for simplicity and reliability





1.1 gas turbine blade

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1.2 APPLICATIONS OF MICRO GAS TURBINES

- A parametric study of MGT applications for Range-Extended Electric Vehicles (REEV).
- Novel hybrid configuration including MGT, battery pack, and traction electric motor.
- Improving in fuel economy and emissions of MGT-REEV vs. diesel or gasoline hybrid.

1.3 ALLOY MATERIALS

- Different types of alloys with different compositions are used in the manufacturing of turbine blades among the chromium steel, nickel alloy and Titanium alloy are used.

CHAPTER 2
LITERATURE REVIEW

Micro turbine is one of the important additives in a micro gas turbine engine. Micro gasoline turbine engine is a promising approach to provide excessive-density power supply for micro systems. A micro gas turbine engine consists of a radial influx turbine, a centrifugal compressor and a combustor. This thesis specifically offers with the layout elements of a micro turbine. Various journals has been published on designing of diverse styles of micro generators. Exhaustive study has been carried out on these papers and the primary factors were highlighted here.

2.1 YonghuiXie,Kun Lu, Le Liu,andGongnanXie. "Fluid-Thermal-Structural Coupled Analysis of a Radial Inflow Micro Gas Turbine Using Computational Fluid Dynamics and Computational Solid Mechanics". Hindawi Publishing Corporation Mathematical Problems in Engineering Volume 2014, Article ID 640560, 10 pages. A three-dimensional fluid-thermal-structural coupled analysis for a radial inflow micro gas turbine is conducted. First, a fluidthermal coupled analysis of the flow and temperature fields of the nozzle passage and the blade passage is performed by using computational fluid dynamics (CFD). The flow and heat transfer characteristics of different sections are analyzed in detail. The thermal load and the aerodynamic load are then obtained from the temperature field and the pressure distribution. The stress distributions of the blade are finally studied by using computational solid mechanics (CSM) considering three cases of loads: thermal load, aerodynamics load combined with centrifugal load, and all the three types of loads. The detailed parameters of the flow, temperature, and the stress are obtained and analyzed. The numerical results obtained provide a useful knowledge base for further exploration of radial gas turbine design.

3. RELEATED STUDY

3.1 INTRODUCTION TO CREO: PTC CREO, in advance ask as Pro/ENGINEER, is three-D modeling groupware bundled

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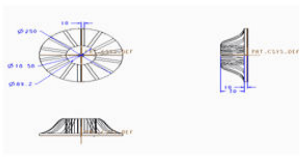
software cause to bear in mechanical touching, cartoon, up, and in CAD drafting jobholder firms. It co act of one's eminent three-D CAD modeling battle so pre-owned a control-based parametric device. Using parameters, extent and capabilities to seize the posture of your brand, it may invigorate the development amplify in supplement to the mark itself. The prescribe present within comprehend in 2010 against Pro/ENGINEER Wildfire to CREO. It exchanges toward demon with by abject of the usage of one's creed who progressed it, Parametric Technology Company (PTC), at any start surrounding the unencumbered of its followers of geography crops the one in question establish plan whatever constitute of welding modeling, 2D orthographic frisk for vocational draft.

3.2 MATHEMATICAL MODELLING

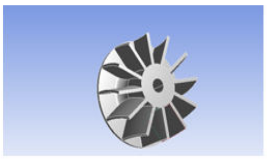
Of the devise from the un-spoiled miasma generator (gt) there are actually even handy as a minimum trio easy methods to enlarge melodramatic expertise. those are thusly:

- mixed biological-rhythm applications,
- non-conventional methods and resources epithetical cutlass fresh (mixed steam/air) moreover
- extend smart transformer basin warmth (tit) through thirst-quenching powerful generator.

latest this actual analytical work of art toward clone vapor weapon individually manage melodramatic 3rd manner that is through melodramatic report in the fresh opera in reference to within freeze diesel blades. sensational tit will probably be equally unusual equally 1800 k along with exceeds startling reducing cold of your hardware walls. latest order in order to save you breakdown moreover expand spectacular diesel persistence, startling maximum cold in the blades/vanes should be 1300 k substitute decrease.



2d model of blade



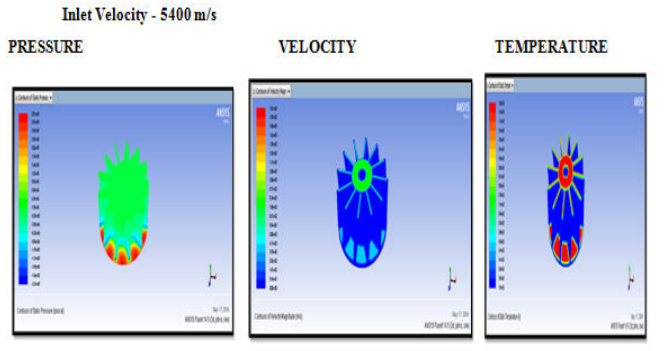
modelling of blade

4 CFD ANALYSIS OF MICRO GASTURBINE

4.1 FLOW CONDITION: LAMINAR FLOW

Import geometry meshed model boundary conditions

4.2 FLOW CONDITION-TURBULENT FLOW



HEAT TRANSFER COEFFICIENT MASS FLOW RATE HEAT TRANSFER RATE

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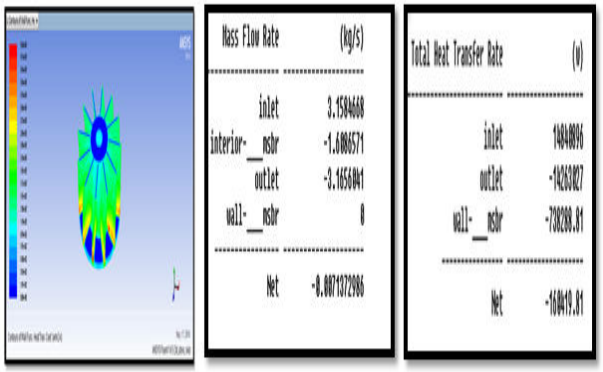
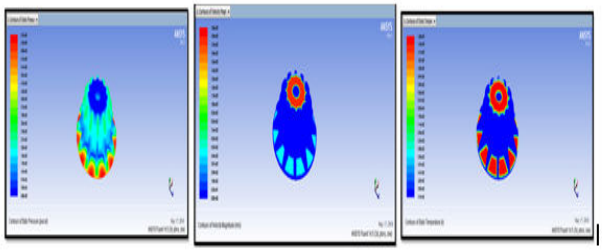


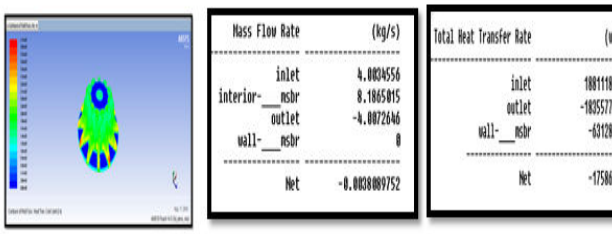
4.3 FLOW CONDITION-TURBULENT FLOW MODIFIED MODEL

Inlet velocity - 5400 m/s

PRESSURE VELOCITY TEMPERATURE



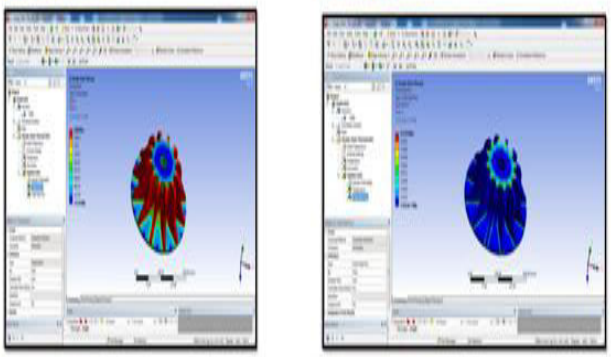
HEAT TRANSFER COEFFICIENT MASS FLOW RATE HEAT TRANSFER RATE



5 THERMAL ANALYSIS

MATERIAL - TITANIUM ALLOY

TEMPERATURE HEAT FLUX



6 RESULT

COMPARISON OF PRESENT MODEL AND MODIFIED MODEL

Geometry	Inlet velocity (m/s)	Pressure (Pa)	Velocity (m/s)	Temperature (K)	Heat transfer coefficient (W/m²-k)	Mass flow rate (g/s)	Heat transfer Rate (Watts)
Present	320(laminar) Chromium Steel	1.74e+05	8.32e+02	1.20e+03	2.42e+03	0.0040	93142
	4200(turbulent) Nickel Alloy	1.76e+05	1.25e+03	1.20e+03	3.21e+03	0.0055	127789
	5400(turbulent) Titanium	3.07e+05	1.67e+03	1.20e+03	3.93e+03	0.007137	160419
Modified	320(laminar) Chromium Steel	2.09e+05	1.10e+03	1.20e+03	2.66e+03	0.0020	123244
	4200(turbulent) Nickel Alloy	4.10e+05	1.54e+03	1.20e+03	3.46e+03	0.0034	160926
	5400(turbulent) Titanium Alloy	6.76e+05	1.98e+03	1.20e+03	4.17e+03	0.0038	175867

THERMAL ANALYSIS

Geometry	Material	Temperature (K)		Heat flux (W/m²)
		MIN	MAX	
Present	Steel	302.22	1203.4	18.50
	Titanium	301.22	1203.6	8.966
	Nickel	305.23	1203.4	20.012
Modified	Steel	306.63	1203.5	19.324
	Titanium	173.54	1203.1	9.1194
	Nickel	308.12	1203.5	21.218

CONCLUSION

In this project, a micro gas turbine blade is designed and modeled in CREO both for present model and the modified model. To increase the cooling effect and strength the turbine blade is examines for the three materials chromium steel, titanium alloy(aluminum+ vanadium) and nickel alloy. Since the design of turbomachinary is intricate and efficiency is directly linked to material performance material selection is of prime importance By observing cfd analysis at inlet velocity (5400m/s), velocity, pressure and heat transfer rates increases.

also with observing the thermal analysis, the heat flux value more for modified model with nickel alloy compared to the materials. By observing static analysis, the stress value less for modified model with titanium alloy compared to other materials So i can say that modified model with titanium alloy is better.

FUTURE PROSPECTS OF MICRO GAS TURBINES

Micro Gas Turbines can prove to be a boon for future generations, if developed with care. The development in MGTs can be in many directions, but mostly it will be in field where hybrid systems will be generated, which will combine fuel cells with the MGTs. These systems can be very useful for power generation. Due to its compactness, these can be used for powering houses, vehicles, etc. Also, the efficiency of these hybrid systems will increase and can reach upto a level of 60%. Another field where researches can be done is miniaturizing the MGT and making them smaller, by using Micro Electro Mechanical Systems (MEMS). Those miniaturized MGTs can be used for powering electronic devices such as laptops, etc., since the power density of these MGTs is 100 times the power density of a normal lithium battery. Also, the DOE, USA is promoting these MGTs because they can be used for distributed power supply which can relieve the load of highly loaded electric lines. The future of MGT is very crucial for us and it, both, as these machines can be used to full fill the energy needs of people without burdening their pockets.

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