International Journal of
Advances in Scientific Research and Engineering (ijasre)

E-ISSN : 2454-8006

DOI: http://dx.doi.org/10.7324/IJASRE.2017.32478

Vol.3 (7) Aug - 2017

INVESTIGATION OF STRESSES IN TURBINE ENGINE DISC

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ABSTRACT

In this paper, the failure analysis of the air engine's turbine disk has been established in a certain type of aircraft. From the visual examination of the surface of the fracture, the signs of the beach could be inspected, general of fatigue failure. In operating conditions, a non-linear finite element was used to determine the stress position of the disk / blade segment. High stress areas were found in the area of lower fur-tree slots, where the failure occurred. A calculation was also done at a very rotational pace. The focus of this study is devoted to the mechanism of damage to turbine discs and significant high stress areas.Residual stresses that after removing the root cause of stress, it remains in solid content. Under residual stress engineering environmental and aircraft load challenges, increasingly important aspects of design and construction of monolithic wind farms are becoming increasingly important. Residual force does not affect structural performance only during the life cycle of the service, but they also affect the quality of the part during manufacturing and assembly. Residual stress can be desirable or undesirable, during most of the manufacturing processes related to physical deformation, heat treatment, machining or processing operation, residual stress occurs, which change the size or properties of the material. They have originated from many sources and can be present in unused raw materials produced during production or manufacture by in-service shipment.

Keywords : *Turbine disc , Failure analysis , Fatigue , Turbine engine , Residual stresses*.

1.INTRODUCTION

Turbo-Machinery Discs are heavy, highly stressed, whose main factors are the speed and components used in the gas turbine to exceed the operating temperature. Experimental burst testing is always time-consuming and overpriced. In theoretical investigations of stress in rotating solid and annular discs at high speeds, extensive attention is being received due to a large number of applications in engineering such as turbine discs, fly wheel etc. Gas turbines work in the hot flow of disc device (650^0C) and it is one of the most expensive parts. All these conditions inspire stress in excess of 100 MPa in the rim facility. Then, the disk's mechanical design includes the evaluation of centrifugal and thermal stress .Non linearities (i) objects behaviour in dissimilar temperatures, generated from (ii) geometric changes are responsible for the construction of stress. These results have been used in Ahmet, Mohammed etc al. which explains that burst occurs when the mean circle stress on a disc block becomes equivalent to determining the nominal tensile strength of the material, from an axial tensile stress. This condition of rings shows high-quality relationship with rotating experimental results, but this criterion gives a specific approximation of the maximum angular velocity for a solid or bored disk Nie and Batra surprises, and Manavi bursts into a burst the use of factor recommendation is further mentioned stress between the two.

2. LITERATURE SURVEY

Rejijon, James M. Larsen Dennis Jay. Buchanan, Noël E Asbog[1] components are used for non-destructive inspection technology to test location-specific cleft size. The crack length is believed to be based on the behavioural behaviour of crack-thermal-mechanical load conditions and materials expected to predict against the bicycle behaviour in crucial locations. Using the throwing of shot is to reduce crack growth in key locations. The introduction is tense of 150-200 micrometers. The benefits of this stress fatigue are a breakdown of growth to improve life. Bonus element of safety T-6 Al-2Sn-4Zr-6Mo components are used in Shot Paning. Kreswas set the surface length of the surface in the formation of the weight pressure intensity side length semi-oval surface.

C. AyyappanRajshekar, P. Ramesh, Rajiv Jain [2] is the forerunner of the development of the flight test rating (PERT) and the rest of the quality examination (QT) as part of the certification report. In order to increase the fatigue life of the hole in the work of expanding the automobile engine and components, it is believed that the rest of this pressure. In the case of thermal hot disks, this phenomenon becomes more complex. The only solution to the complex problem of evaluating the development of such a residual element of strategy is limited to possible. Surface and internal cracks Using the technique of ultrasound inspection, a high speed disc is tested in this test facility tests, discs are made of heavy machinery. ABAQUSTM of the disc was held to predict similar thickness finite element solutions using residual stress and deformation non-linear finite element analysis.

Kwai, S. Chan, Michael P. Eryit, Patrick J. Goulden, Sameer Naboli, Ramesh Chandra, Alan C. Pentages [3] They say that high cycle fatigue is the argument that the most expensive source of in-service damage in the army is the aircraft engine can cause the turbine blade and the risk of the HCF engine of the disc because fatigue failure is less than resonant vibratory stress Can be continuous in time. Tired fatigue is due to the loading of the HCF gas turbine engine component at the fracture risk. This data shows that fatigue can contribute to the construction of tiredness turbine discs before time of fatigue cracks in the exhaustion. In order to simplify the aerodynamic loading model was provided by NAVAIR, in particular, the structural analysis of the disk assembly was done by FEM method to calculate the stable and dynamic contact stresses. In the LCF and HCF load history, the combination of LCF and HCF in the engine disk was used in the life prediction method to assess fatigue crack increase.

3. OBJECTIVES AND METHODOLOGY

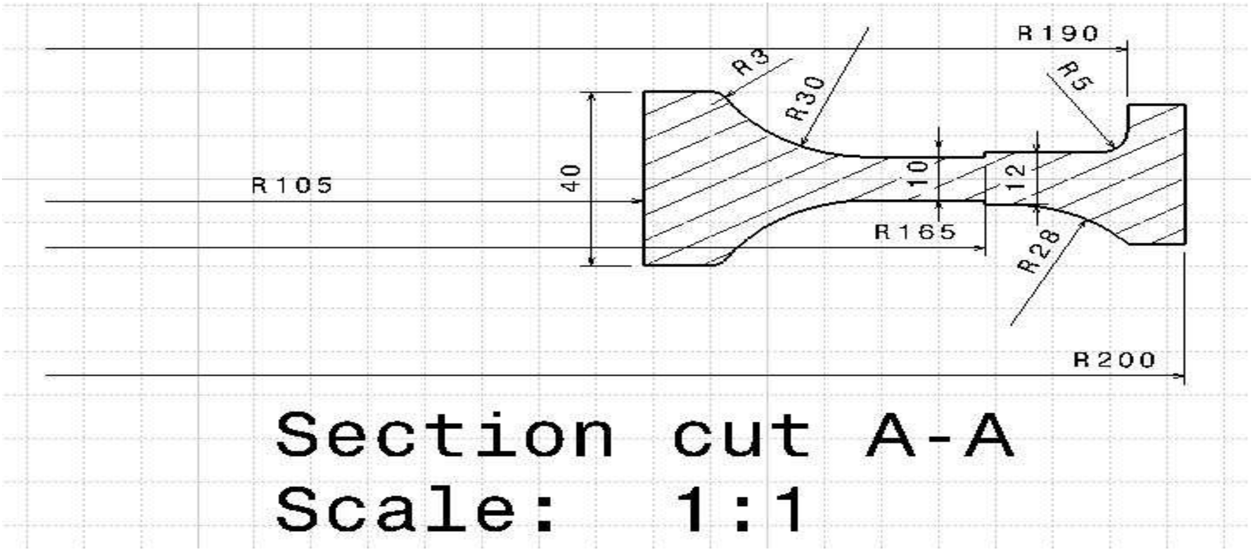
The current goal of the job

- Identify disc-critical zones in blended, and optimize the disk.
- The disc program of the disc is insistent on the disc, which is subject to the uniform disk and spin loading.
- Diagnostic equations and disc spin weight recognition flourished with the help of limited element technologies.
- Through the linear analysis of techniques not by line analysis to test disk efficiency.
- Fast evaluation and burst margin range gas turbine disk macro development under spin loading.
- Due to the high speed of device drive fatigue study of life.
- Inspired burst marine investigate the effect of residual stress.

4. MODELLING AND SIMULATION

4.1 Geometry

CATIA is multiplatform for CAD/CAM/CAE, which is developed by a popular French company called Dassult system. The user friendly tool helps easily to generate model of the car hood accurately with ease . Initially the dimensions of the car hood are collected as per that dimensions a 3D model is created.



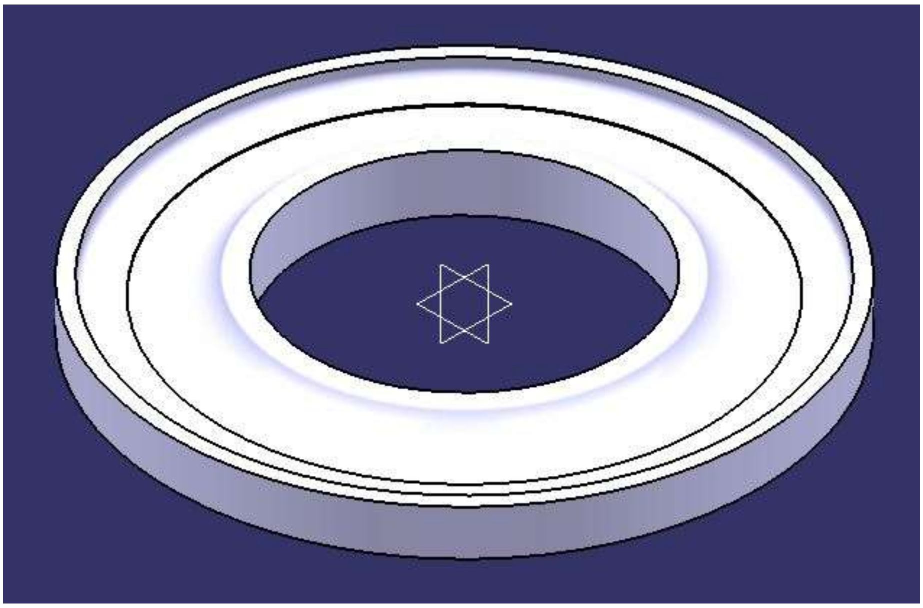


Fig.no.1.1Catia model of INCONEL 718 turbine engine disc.

4.2 Meshing

The main goal of the meshing software is to provide robust, user friendly and easy handling tools simplify the mesh generation process. For the ease of work initially model is divided into number of small pieces called finite elements. Hypermesh tool is the software used to mesh the turbine engine disc

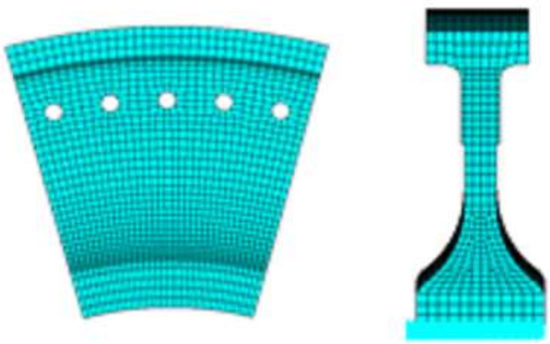


Figure. 4.1. Disc FE Model

4.3 Material Properties

Material and its properties play a vital role for the analysis of any component . Material properties are the specifications of the material .

Table 6.1 : Mechanical and Thermal Properties of INCONEL 718 considered for FE formation for prediction over speed and burst margin

Property	20°C	100 °C	400 °C	500 °C	600 °C	700 °C
Young's Modulus N/mm^2	20900	19600	183100	178400	170300	157300
Coefficient of Linear expansion (10^{-6}/°C)	12.2	12.8	13.9	14.0	14.5	15.0
Thermal Conductivity (10^3 W/mm °C)	11.11	12.41	17.95	19.48	21.21	23.09

Material	Young's modulus E	Poisson's ratio	Density (lb/in^3)
INCONEL 718	200GPa	0.294	0.297

5.ANALYTICAL MODEL FOR BURST ENGINE

1. Consideration of centrifugal reaction
2. Thermal correction
3. Speed correction
4. Modification of burst margin equation
5. Bursting speed computed by analytical method

6.RESULTS

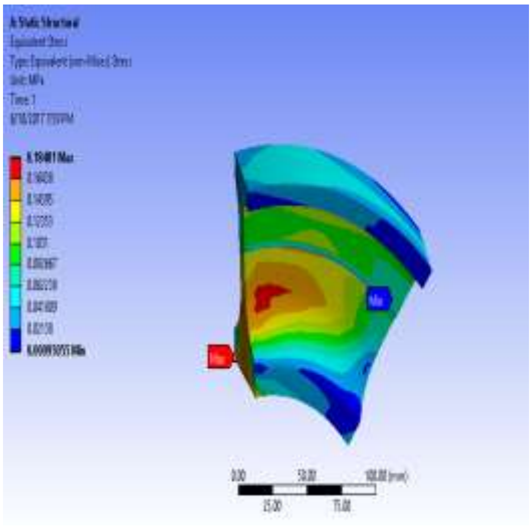


Fig.6.1 Equivalent von-mise stress

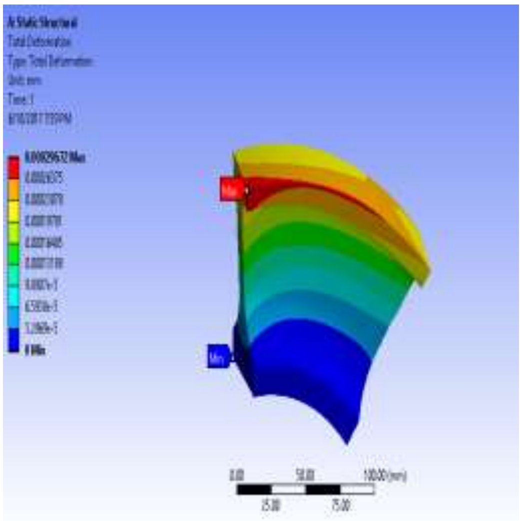


Fig.6.2 Total deformation

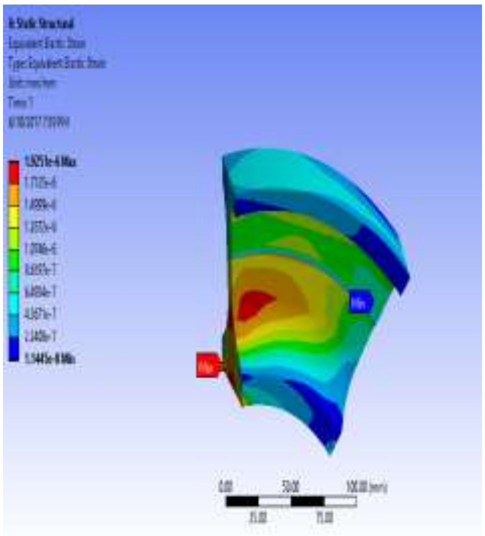


Fig.6.3 Equivalent elastic strain

Table 6.1 Life prediction results of blades for fatigue interface at different speeds and loads

Speed (rpm)	Force (kN)	Hoop stress (MPa)	Radial Stress (MPa)	von-Misses Stress (MPa)	Deflection(mm)	EPTOEQ*	EPELEQV **	LCF
10000	90.13	675.76	505.77	854.69	1.84	0.007372	0.0047582	5780
11000	190.05	754.75	478.58	859.77	1.92	0.007487	0.0047792	5450
12000	129.78	821.06	483.60	868.68	2.00	0.007705	0.0048195	4865
13000	152.31	881.81	541.79	881.84	2.11	0.008086	0.0048817	4050
14000	176.65	935.90	600.53	896.63	2.24	0.008649	0.0049535	3200
15000	202.79	953.95	649.98	919.98	2.44	0.009600	0.005074	2300
16000	230.73	997.84	692.22	943.92	2.74	0.011212	0.0052027	1500
17000	260.47	1106.13	746.58	946.66	3.65	0.016347	0.0053392	570

Table 6.2 Life prediction results of blades for fatigue interaction at different temperature range at constant centrifugal load.

Temperature in °C	Speed rpm	Force kN	Hoop stress MPa	Radial stress MPa	Von-Mises stress Mpa	Deformation mm	EPELEQV	LCF
350-500	10000	90.13	650.6	406.82	806.02	1.52	0.005589	18600
400-550	10000	90.13	664.5	460.88	832.08	1.68	0.006444	9840
450-600	10000	90.13	675.7	505.77	854.69	1.84	0.007372	5780
500-650	10000	90.13	690.0	542.63	875.04	2.02	0.008363	3685
550-700	10000	90.13	708.1	594.44	900.52	2.20	0.009725	2260

For the b1ade, LCF simu1ation material emp1oys a centrifugal weight wave similar to samples, whose peak value is the rated weight and the valleys are almost zero. Shipment occurrence is 300 cycles per 100 hrs. The temperature of the calculation is distinct as 350-500 ° c in different sections, so that the consequences of predicting life can be safe. Centrifugal stress is always positive and is very large due to other loads, which suggests that tissue stress is present near hysteresis loops. In the reference, the result shows that the steam turbine represents the centrifugal stress-stress response feature of the blade, in which the wave of loading is similar to the previous research work.

6.1 Induced residual stress due to over speed

Residual stress can vary in the internal radius, to know that the outer radius on the line between the thickness of the disk is considered. Table 8.1(A) shows the results of elastic plastic analysis at 18,000 rpm with the inner radius, along the path of the outer radius. Speed 18,000 rpm is chosen because it is plasticization start and plasticization and velocity. Table 8.1 (B) shows the results of pure elastic analysis at 18,000 rpm, with the inner radius in the centre of the thickness of the disk along the path of the outer radius. Both elastic and elastic plastic analysis were done with angular velocity ω and blade load.

Table 6.3 Hoop stress, Radial stress, Von-Mises stress components of stress at 18000 rpm

	a. Elastic-plastic analysis			b. Pure elastic analysis			c. Residual stresses		
Radial Distance (mm)	Hoop Stress (MPa)	Radial Stress (MPa)	Von mises Stress (MPa)	Hoop Stress (MPa)	Radial Stress (MPa)	Von-Mises Stress (MPa)	Hoop Stress (MPa)	Radial Stress (MPa)	Von-Mises Stress (MPa)
105	1120	10	1181	1267	9	1344	-146.1	0.6974	-163.1
110	1153	48	1172	1229	55	1247	-74.7	-7.055	-74.9
115	1191	112	1163	1200	123	1165	-8.9	-11.45	-1.8
119	1207	173	1136	1175	191	1093	32.7	-17.67	43.6
124	1196	259	1066	1162	274	1027	33.7	-15.36	38.8
129	1187	354	1010	1155	369	976	31.9	-14.86	34.58
134	1168	434	988	1139	448	957	29.6	-14.25	30.67
138	1140	480	984	1112	494	957	28	-13.99	26.73
143	1110	486	965	1083	499	941	26.6	-12.95	24.3
148	1084	484	941	1059	495	918	25.5	-11.44	23.19
153	1060	482	920	1036	492	898	24.4	-10.27	21.95
157	1037	477	897	1014	486	876	23.3	-9.19	20.91
162	1016	454	861	994	461	840	22.32	-7.88	20.93
167	979	430	856	958	437	836	21.87	-7.19	19.66
172	945	392	837	925	397	818	21.11	-5.51	19.28
176	927	376	809	907	380	790	20.41	-4.81	19.02
181	911	355	773	892	359	754	19.69	-3.9	19.09
186	894	283	718	875	285	698	19.05	-2.6	20.08
191	841	199	712	823	201	692	18.82	-1.67	19.46
195	762	139	755	743	139	737	18.82	-0.64	17.8
200	697	116	848	678	116	833	18.79	-0.16	15.14

7. CONCLUSION

On the basis of this study, a method is obtained analytically to calculate the amount of explosion margin, fatigue life and residual stress of specific aerial engine disk blade. Some important findings from this analysis is work has been done to exhibit that revised mathematical models and FE allows automated analysis which can enable mass simulation on large scale. The hoop strain component is considered to be the maximum on the internal surface, but the lowest on the outer surface. Radial is initially emphasized to grow with radial section, so it decreases with radial distance. Increasing rotating disk with increasing speed of rotating disk

8.REFERENCES

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