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Modal Analysis of Turbocharing Blades

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ABSTRACT: Turbocharging blades can get vibration damages during the working process ,because of the high rotating speed,and changing exhausted conditions.And the damaged turbocharing blades can not only cause the ineffiency of the turbine ,but also can cause the damage to the engines.So the modal analysis of the turbine blades can be very important for us to avoid the vibration damages .And this ariticle will focus on the characteristics of the turbocharging blades and try to find the characteristic frequency of the turbocharing blades .And we will explore the characteristics of the turbocharging blades together.

Keyword： modal analysis turbochargin blades frequency

I. INTRODUCTION

Turbochaging blades are the nessessary components of the turbochargers,which plays an indispensible role in transforming the exghausted air’s energy into the kenetic power of the turbochargers.As the turbocharging blade is the key point in maintaining the turbochargers’ effiency,safety and acoustic features,a lot of reasearches had been done to improve its quantity.[1]And I still had a strong interest to do the reasearch on the turbocharing blades,And I had done a modal analysis of turbocharging blades recently.And believe it or not,it is still important for us to have a modal analysis of turbocharging analysis ,if we want to make our turbochargers to show better vibration characteristics.

And modal analysis is mainly focused on the characteristics frequency of the objects we studied,and It was firstly used to improve the aircrafts characteristics.And this is because a lot of aircrafts’ accidents are due to their virbration charactertics.And the modal analysis hadn’t just being used for the aircrafts.It became popular very soon.A lot of technicians and engineers used modal analysis to improve the quanlities of the engines,ships and bridges.So we can see that modal analysis is used in almost every mechanical products[2].

There are mainly three benefits we can get from modal analysis.Firstly,avoid resonance and make the products vibrates in the frequency requested.Secondly,know the responses of the products to the different dynamic loads.Thirdly,estimate the control parameters in other dynamic analysis ,such like time step.[3]

Theory

Finite element method(FEM)is an effect method to solve the partial differential equations .And it is widely used engineering structure,heat transfer analysis,electromagnetic analysis,fluid analysis,and so on.To be simple.any field that partial differential equations can describe is suitable for the finite element method to solve.And this method is a numerical method to solve the engineering problems.

The existence of the finite element method,make it possible for people to apply the scientific theory to techonologies and engineering.As large as airspaceships , marine machineries ,big bridges,geotechnical structures,pressure vessels or hydraulic turbines the objects could be,and as small as toys,cell-phone shells,precision devices in the CP or tiny machines the objects could be,they all can be designed by the engineers using the finite element method.

The main technical method road of the finite element method is to turn the continually field we studied into limited separate small elements.And we use the joint points of the small element to estimate the value of the point inside the small element.And the element adjoined to the other share the same the joint point,and by calutating one element of the object,we can get the value of the joints of the element adjoined the other. And there are three steps for us to use the finite element method to solve the problem.The first step is to build up the model.The second is to set up the conditions.The third is to use the calculator to get the results.

And according to theory of the vibration ,the equation of the multi-degree freedom dynamic equations of the mechanism system is

$[M]\{\ddot{\delta}\}+[C]\{\dot{\delta}\}+[K]\{\delta\}=\{F\}$

In this equation $[M]$-mass matrix of the system

$[C]$-damping matrix of the system

$[K]$-stiffness matraix of the system

$\{\ddot{\delta}\}$-the points' acceleration vectors of the system

$\{\dot{\delta}\}$-the points' velocity vectors of the system

$\{\delta\}$-the points' displacement vectors of the system

$\{F\}$ −the load vector of the system

If $\{F\}=0$,then the vibration of the system was called the free vibration And we can get

$$[M]\{\ddot{\delta}\}+[C]\{\dot{\delta}\}+[K]\{\delta\}=0.$$

If we neglect the effect of the damping,we can get

$$[M]\{\ddot{\delta}\}+[K]\{\delta\}=0$$

Then we can get $\{\delta\}=\{X\}\sin(\boldsymbol{\omega}t+\alpha)$

It means that if the system is vibrating freely,all the point of the system were vibrating with the same frequency and same phase[4].

if we put $\{\delta\}=\{X\}\sin(\boldsymbol{\omega}t+\alpha)$ to $[M]\{\ddot{\delta}\}+[K]\{\delta\}=0$

We can finally get $([K]-\omega^2[M])\{X\}=0$.

II. MATERIAL AND METHOD

The material of the turbocharig blade is High nickel heat resistant steel,and the main characteristics of the material[7] are listed in the chart.

density（kg m^-3）	8000	Melting point（℃）	1295-1395
Young's modulus（Gpa）	144-211	Coefficient of thermal conductivity（W/(m℃)	10.15
coefficient of thermal expansion	20-100℃	Poisson radio	0.31

The steps of the ansys workbench we used are as follows:

(1) open the software and ,open the “modal” program,the right click the geometry and put the CAD model into the program.

(2) Right click the “engineering data”,click edit and then set all the parameters as the chart required before

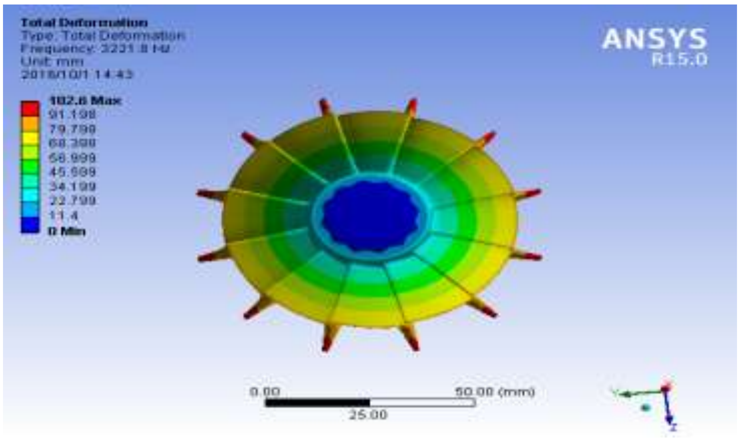
(3) Double click modal.click “size”,then click “insert method”,then select all for the geometry option,then right click “mesh”,then”insert sizing”,and then select the turbine,and make the size 5mm.

(4) Set the vibrate deformation and conditions.make the surface of the nut fixed,and limt the axis displacement of the turbine .then set the “max modes to find”to 6.

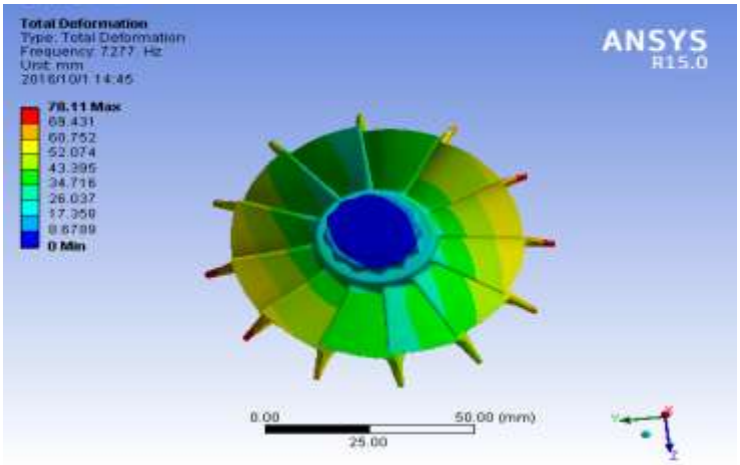
(5) Solve

IV. ANALYSIS

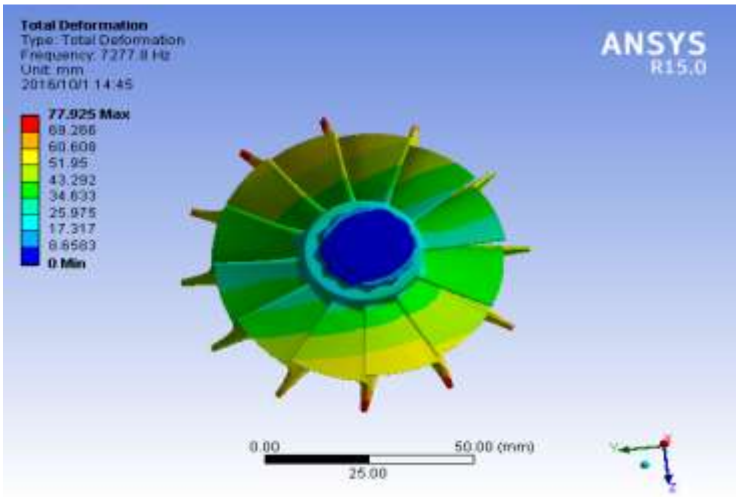
First order result



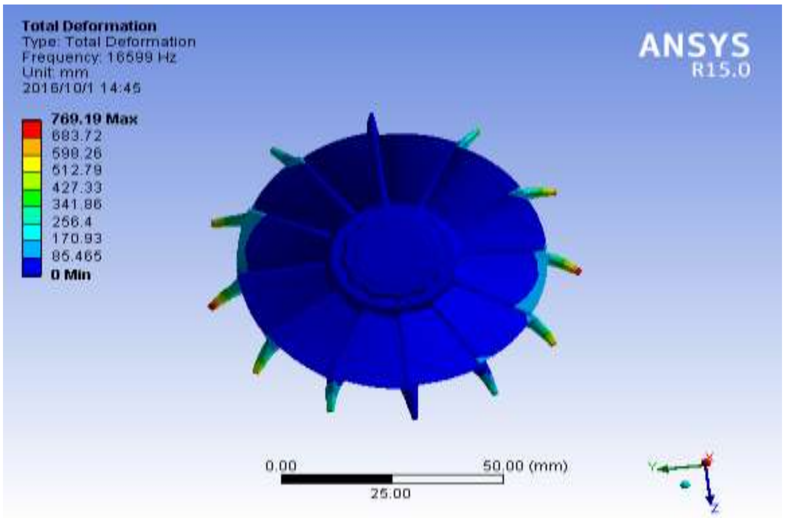
Secondorder



Thirdorder



Fourth order



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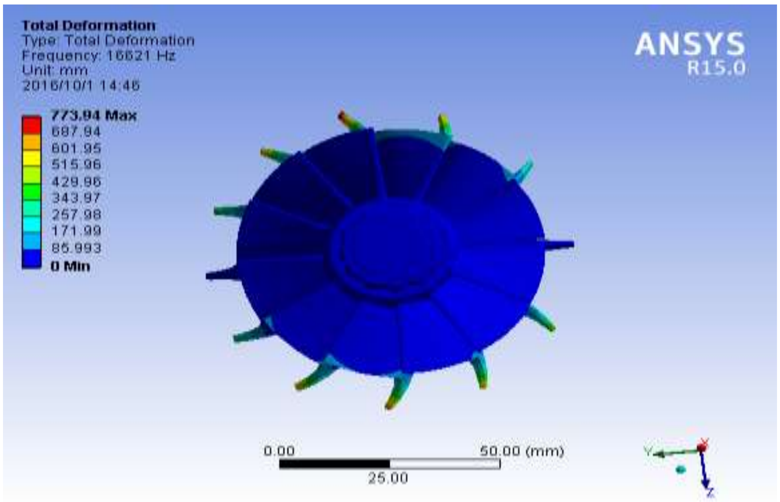
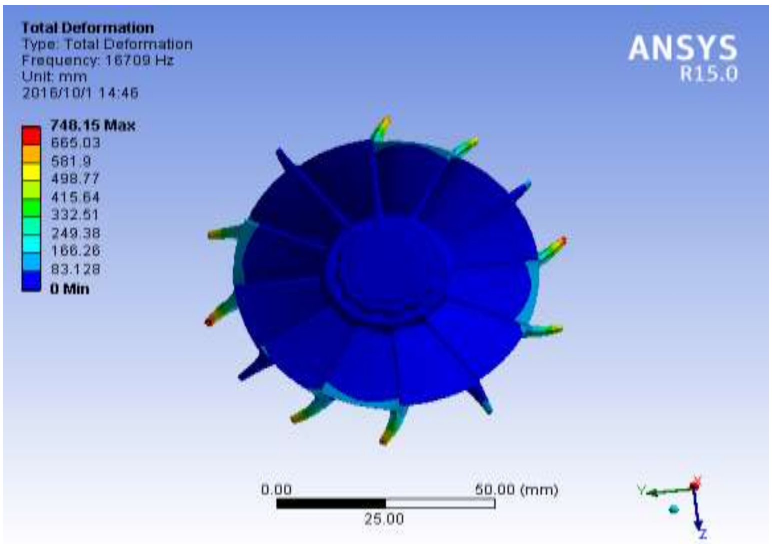


Sixth order



We can see from the pictures that the part of the turbocharging baldes which is far form the axis go through a large deformation ,while the part of the turbocharing blades which is close to the axis of the turbine go through smaller deformation.And we can infer from the result that the further the blades were from the axis of the turbine ,the easier the blades to get deformed.And so the further the baldes get from the axis of turbine,its ability to resist the vibration get weaker,and it is easier for it to get damaged.

V. CONCLUSIONS

The turbine which rotates in a high speed during the working process had to face up with a lot of problems,and one of them is that the turbocharing blades could be broken because of its high rotation speed,and the load of high temperature exhausted air.And it happens especially to those blades which had to go through changing loads which could be the rotation speed,the exhausted gas,or the nonlinear forces from the axis.Because ,in those conditions,the blades could vibrate a lot and ,if the frequency of the vibration equal to characteristic frequency of the blade,or the integral multible of the the characteristic frequency,then the turbocharing blades would go through resonance,and cause the turbocharing blades to broke finally.So,modal analysis is very important to the turbocharing blades,if we want to avoid the resonance.And we can tell from my experimental results that the further part of the blades away from the axis of the turbine are easier to deform because the load.And the further parts of the blades away from the axis are weak in resist vibration.

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