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DESIGN AND ANALYSIS OF WORK HOLDING FIXTURE IN A SHAFT BEARING TEST RIG

V. Chaithanya Raam[1], M.S. Amrish[2], S. Harish Balaji[3]

[1,2,3] *Student, Department of Mechanical Engineering, Meenakshi Sundararajan Engineering College, Tamil Nadu.*

Abstract - *"DESIGN AND ANALYSIS OF A WORK HOLDING FIXTURE IN SHAFT BEARING TEST RIG" involves designing and analyzing of a fixture in the shaft bearing test rig which is being currently used. The main purpose of using a fixture in this test rig is to hold a bearing housing of various diameter ranging from 350mm to 700mm. Therefore a universal fixture is designed keeping in mind about the space constraints, load acting on the fixture, dimensional standards, diameters of different bearing housing and its physical properties. After designing, the structural and modal analysis is done to justify the reliability of the designed model under the operating conditions that prevails in the industry. Finally after justifying the reliability of the designed model the SOP (Standard Operating Procedure) is framed.*

Key Words: Shaft, Work holding fixture, Static analysis, Modal analysis, Dynamic frequency. Standard Operating Procedure.

1. INTRODUCTION

The work holding fixtures is used to securely locate and support the work, ensuring the accuracy and repeatable machining. The main use of a fixture is to improve the economy of production by allowing smooth operation and quick transition from part to part, reducing the requirement for skilled labor by simplifying how work pieces are mounted and increasing the conformity across a production run. The current work holding fixture in the test rig is designed in such a way that it contradicts with the definition of a fixture. For each bearing housing of various diameters the flange holder in the fixture has to be changed with respect to the bearing housing. It is a time consuming process which increases the labor cost and thus decreasing the efficiency of the production. So we decided to design a universal fixture. The purpose of making it universal is to reduce the time for changing the radius flange which is being used in the current process. Also it reduces the cost and material usage. Universal fixture can be used to mount all type of bearing housing irrespective of its variant that is the diameter, length and weight.

2. EXISTING DESIGN

EXISTING PROCEDURE

- The housing is lifted and placed on the holder using a crane.
- The size of flange holder to be mounted on the fixture is predetermined according to size of housing.
- After placing the assembly, it is clamped to the support using nut and bolts.
- Axial and radial load are given to the assembly to create a virtual working environment.
- The shaft is made to rotate at a required rpm after loading.
- Oil is pumped into the housing at a controlled rate with the help of oil controller.
- Oil controller also maintains a constant inlet temperature of oil to the housing. It consists of cooling and regulating unit.
- The shaft is made to rotate for 4 hour and every 15 minutes bearing temperature is recorded.
- The bearing temperature is not to exceed 80^{o}C.
- The testing is stopped at end of 4th hour and certified fit to use.

EXISTING METHOD

Existing method consist of a bed, support, flange holder and bearing housing of various size.

Bed

Bed consist of guide ways on which the fixture is mounted. It enables to change the distance between the fixtures.

Fixture

The fixture is used to hold flange housing. Depending on the length of shaft the distance between fixtures can be changed.

Flange holder

Flange holder holds the shaft with bearing assembly and clamps the assembly to control the vibration caused during testing. Various flanges are used depending on the diameter of the bearing housing.

Disadvantage

The existing method is time consuming because the flange has to be changed every time when a bearing housing of different diameter is to be tested.

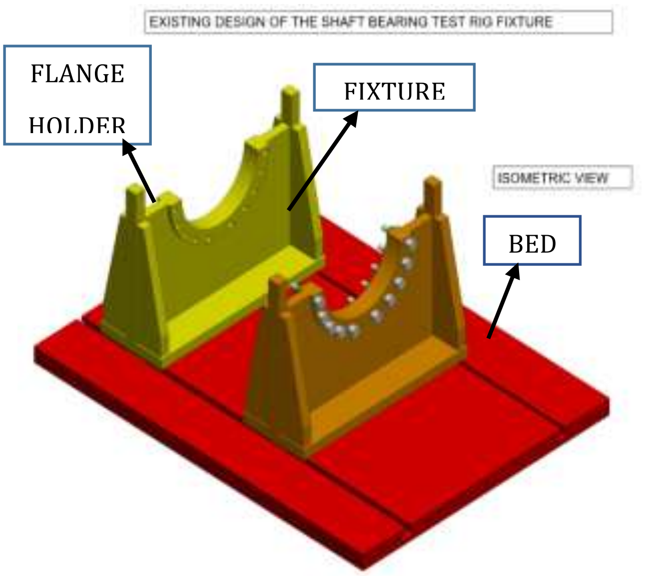

Figure 1: Existing method isometric design

3. PROBLEM STATEMENT AND SOLUTION

The main purpose of using a fixture in this test shaft bearing test rig is to hold a bearing housing of various diameter ranging from 350mm to 700mm. The current work holding fixture in the test rig is designed in such a way that it contradicts with the definition of a fixture. For each bearing housing of various diameters the flange holder in the fixture has to be changed with respect to the bearing housing. It is a time consuming process which increases the labor cost and thus decreasing the efficiency of the production.

A universal fixture can be designed.

- The purpose of making it universal is to reduce the time for changing the flange holder which is being used in the current process. Also it will reduce the cost and material usage.
- Universal fixture can be used to mount all type of bearing housing irrespective of its variant that is the diameter, length and weight.
- The universal fixture should be designed keeping in mind about the space constraints, load acting on the fixture, dimensional standards, diameters of different bearing housing and its physical properties.
- After designing, the structural and modal analysis should be done to justify the reliability of the designed model under the operating conditions that prevails in the industry.

4. FIXTURE DESIGN

The objective of the design is to maintain a constant center distance for various diameter of Shaft with bearing housing assembly. The distance between the V block can be adjusted by using a compound screw. The compound screw is square threaded and has opposite threading on either side. V block is free to move along the axis of the compound screw. A vertical screw is provided to make fine adjustment if needed to achieve the center distance. Clamping is done to eliminate vibration arising due to the rotation of shaft at a very high rpm. Square thread was chosen because it has a greater efficiency when compared to other types.

According to the need the fixture is being designed and assembled.

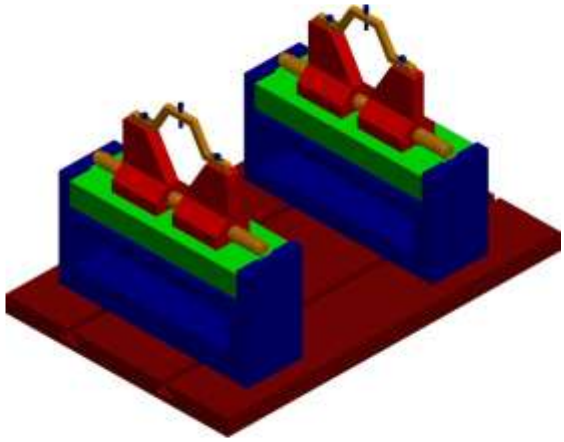

Figure 2: Final assembly isometric view

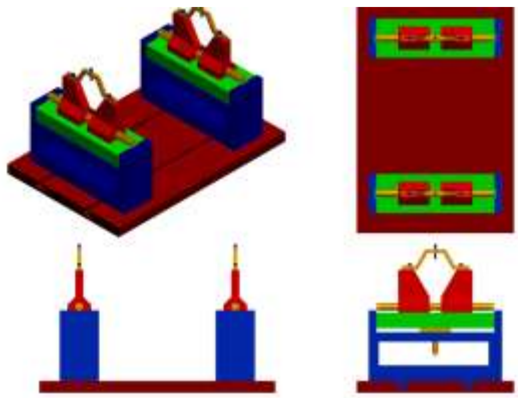

Figure 3: Final assembly

5. ANALYSIS

To validate the design both the static and modal analysis is done.

Static Analysis

The shaft bearing housing is placed over the face of the split V Block. The weight of the shaft bearing housing is 2.5 tons but we pushed its limit to 3 tons. 3 tons is equivalent to 30 KN and this is divided by 4 to get 7500 N, why it is divided by 4 is we want to apply equal force on the 4 faces of the split V blocks. So the static analysis is done. We did 4 iterations it is because the point of contact between the shaft bearing housing and the face of the split V block.

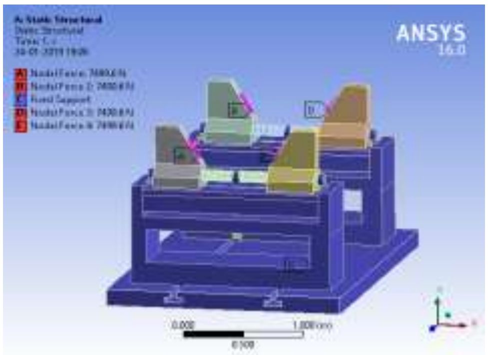

Figure 4: Iteration 1

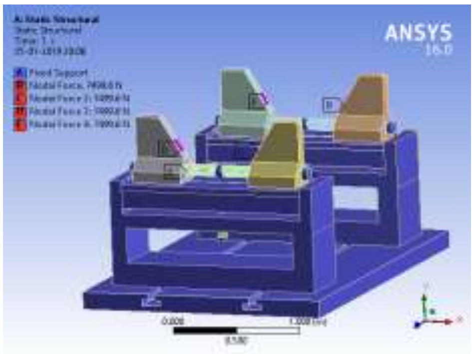

Figure 5: Iteration 2

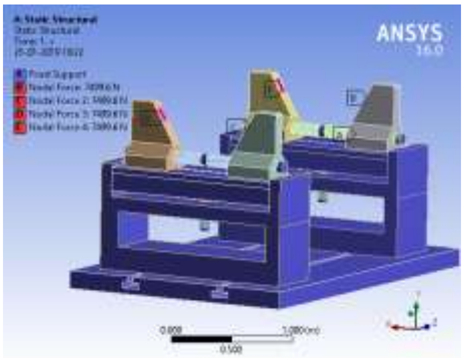

Figure 6: Iteration 3

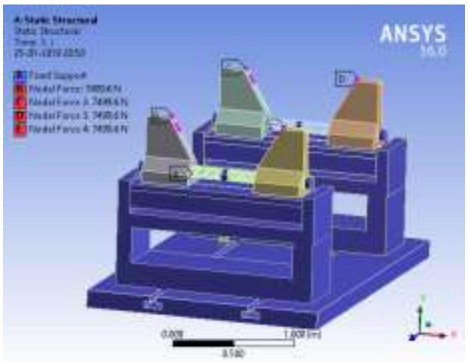

Figure 7: Iteration 4

The result of the static analysis:

ITERATION	Total Deformation (Maximum)	Equivalent Elastic Strain (Maximum)	Equivalent (von-Misses) Stress (Maximum)
1	6.8522e-007	2.2311e-005 m	4.4353e+006 Pa
2.	1.2622e-006	3.4522e-005 m	6.8613e+006 Pa
3.	1.0385e-006	2.7324e-005 m	4.2817e+006 Pa
4.	2.1052e-006	4.0461e-005 m	8.0405e+006 Pa

Figure 8: Static analysis result

From the analysis results we can infer that the total deformation is too less and negligible. Stress is far low than the yield stress which concludes that the design is safe in static condition.

MODAL ANALYSIS

The shaft shown in **Figure.9** with highest diameter and length is taken as reference and to it different rpms in which the shafts tend to rotate is applied using the ANSYS WORKBENCH software to find the frequency generated by the shaft.

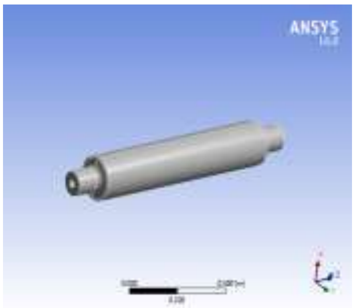

Figure 9: Model shaft

S. No	RPM	Damped Frequency [Hz]
1.	1000	378.26
2.	2000	378.36
3.	3000	378.26

Figure 10: Model shaft dynamic frequency

We all know about resonance, when the natural frequency of the object coincides with the frequency of the force acting on the object the magnitude of the vibration is higher. So we want to know whether that resonance acts on the designed model. So the natural frequency of the fixture model is found by using the ANSYS SOFTWARE.

	Mode 1	Mode 2	Mode 3	Mode 4	Mode 5	Mode 6
Natural Frequency	1122.9 Hz	1183.4 Hz	1185.9 Hz	1189.5 Hz	1192.9 Hz	1275.9 Hz

Figure 11: Natural frequency of the fixture

If we infer this result we come to know that none of the natural frequencies of the fixture as shown in the **Figure.11** matches with dynamic frequency of the shaft. So it concludes that even in dynamic condition the design of the fixture is safe.

6. STANDARD OPERATING PROCEDURE

S.NO.	SHAFT SIZE	HOUSE FLANGE DIAMETER (mm)	DISTANCE BETWEEN THE SPLIT V BLOCK AND CENTRE LINE (mm)	LENGTH OF THE SHAFT (mm)	CLAMP NUMBER
1.	11 SIZE	370	40	540	1
2.	12 SIZE	522	128	630	2
3.	16 SIZE	575	159	800	2
4.	250 FD	350	29	630	1
5.	250 PA	395	49	800	1
6.	500 FD	425	72	540	1
7.	500 PA	425	72	540	1
8.	600 FD	425	72	800	1
9.	600 PA	535	136	890	2
10.	600 ID	620	185	890	3
11.	800 FD	650	202	1080	3
12.	800 PA	700	231	1080	3
13.	800 ID	700	231	1080	3

Figure 12: Standard Operating procedure table

The standard way of operation is done by using this table in **Figure.12**

- The V block 1 is fixed
- The V block 2 is moveable so according to the different shaft lengths the V block 2 is moved by using the crane.
- For different shafts the length varies the required shaft length is adjusted referring the CHART.
- After fixing the length of the impeller shaft casing the house flange diameter is fixed by rotating the screw rod which is fixed to the split V blocks.
- When the screw rod is rotated with the use of rotating handle, the split block moves in or moves out according to the movement of the handle (Clockwise – moving in, Anti Clockwise-moving out) in a guide way.
- So according to the required shaft the split V block distance from the center line is adjusted referring the CHART
- Place the shaft casing on the fixture and check the center.
- Adjust the center if it's not meeting the center line using the vertical screw with the handle
- Now the required shaft upper clamp is chosen referring the CHART.
- Now the chosen clamp is placed over the flange and screwed with the V blocks 1 and 2.

7. CONCLUSIONS

The adjustable V block is an alternative of radius flange in the shaft bearing assembly running test machine. It is designed by using Creo and analysed by using ANSYS software. The total deformation and the equivalent stress obtained from the result are within the permissible limit. So, we can conclude that the design is safe. The method which is currently adopted requires the fixture to be changed every time a different sized shaft is being tested. This requires huge workforce and crane operator to lift and place the fixture at the right position.

By employing the adjustable V block method, the lead time and labour can be reduced considerably. Moreover, it is easy to maintain and requires very little time to change the setting for a different diameter of the shaft. Also, with help of the power screw the height can also be varied so the centre can be maintained constant.

8. REFERENCE

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