Dynamic Balancing Of a Blower Impeller for a Passenger Ship

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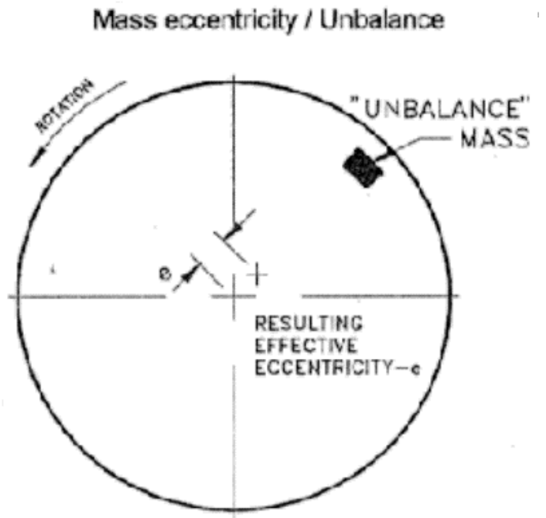
***Abstract*— *This paper deals with the "DYNAMIC BALANCING OF A BLOWER IMPELLER FOR THE PASSENGER SHIP". Dynamic balancing is the most important concept for rotating parts of marine machinery. Any rotor with an uneven distribution of mass about its axis of rotation has an unbalance. If there is any unbalance present in the parts of rotating machinery which will effect on connected bearings and connected parts. Then these rotating parts will be damaged because of its vibrations. Hence the particular rotary parts like shaft, blower, impeller and other connected rotating parts which are having unbalance of its own improper casting or machining. These unbalance to be removed by using the procedure of dynamic balancing. By using the dynamic balancing the vibration developed in rotating parts will be minimized.*

In this paper we determine the unbalance mass present in the blower impeller and we also suggested removing the extra mass where it is present or adding mass at an angle opposite to the unbalanced mass.

Keywords*— *Dynamic balancing, blower impeller, marine machinery, rotor, unbalanced mass.

I. Introduction

Excessive vibration in rotating machinery can cause unacceptable levels of noise and, more importantly, substantially reduce the life of shaft bearings. Hence, the ideal would be to remove all causes of vibration and run the unit totally "smooth". Unfortunately, in practice, the ideal cannot be achieved and, whatever one does, some inherent cause of vibration, or unbalance, will remain. The best one can do is to reduce this unbalance to a level that will not adversely affect the bearing life and will reduce noise levels to an acceptable level. The process of reducing the out-of-balance forces that cause vibration in rotating machinery is called "Balancing". The unbalance is caused by an effective displacement of the mass centre line from the true axis caused by some mass eccentricity in the unit. The process of "Balancing" is the removal or addition of weight to the unit such that this effective mass centre line approaches the true axis. Where balancing grades or levels are referred to here, and in subsequent sections, they are referenced to ISO1940.



Benefits of balancing:

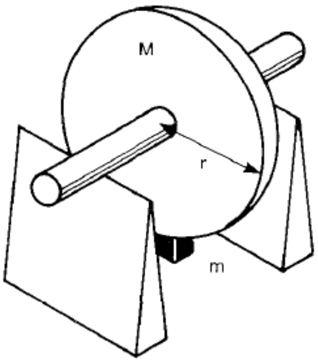
- Increase quality of operation.
- Minimize vibration.
- Minimize audible and signal noises.
- Minimize structural fatigue stresses.
- Minimize operator annoyance and fatigue.
- Increase bearing life.
- Minimize power loss

II. UNBALANCE:

Any rotor with an uneven distribution of mass about its axis of rotation has an unbalance. A rotor with an unbalance caused by an extra mass 'm'. A similar effect is created by out-center machining, non uniform winding in armature, blades of different sizes on rotors, internal flaws in casting and uneven density of material etc. when the rotor rotates the extra mass 'm' exerts a centrifugal force. This centrifugal force moves around with the rotating mass and causes deformation to the shaft and vibration to the system. Since excessive vibrations are objectionable, we try to reduce them and this is done by the unbalance.

Unbalance and centrifugal force:

The unbalance 'U' of the rotor of fig. is given by:



Unbalanced force on the bearing –rotor system

$U=mr$

Where,
m= unbalance mass
r= radius at which the mass is located

It should be clear that the unbalance 'U' is independent of speed and it exerts even when the rotor is stationery. When the unbalance rotor rotates, the centrifugal force given by:

$$F=mv^2/r$$
$$= mr\omega 2$$

Where,
v= linear velocity
ω= angular velocity

This clearly shows that the centrifugal force 'F' is directly proportionate to the unbalance 'U' and hence we can reduce the force by reducing unbalance.

Types of unbalance:

Unbalances are classified in to 3 types:

a. Static unbalance
b. Couple unbalance
c. Dynamic unbalance

Static balancing:

- Static balancing is a balance of forces due to action of gravity.
- A body is said to be in static balance when its centre of gravity is in the axis of rotation.
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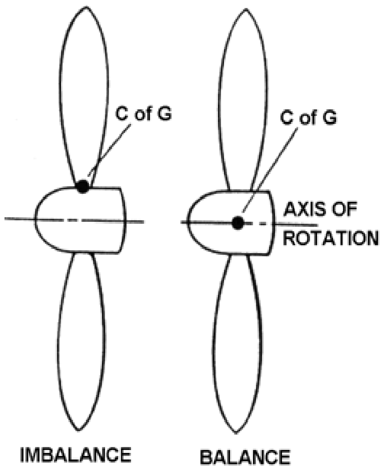
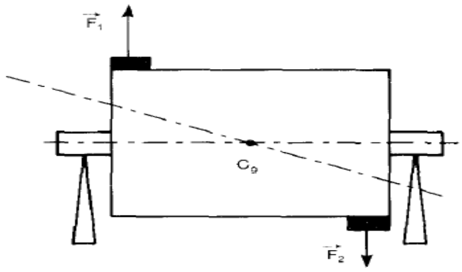


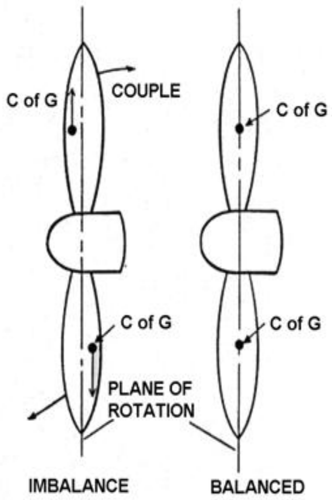
Couple unbalance:

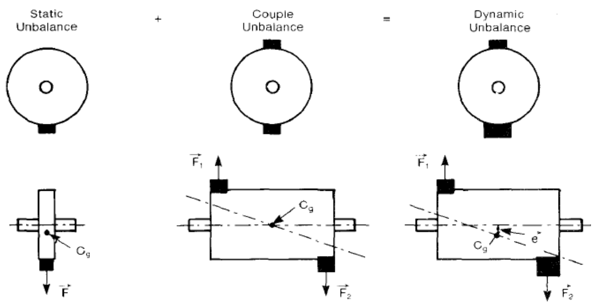
Here, two equal weights are present in two different planes (plane 'one' & plane 'two'). One weight is on the top and other is at the bottom (or 1800 from each other). This type of unbalance is also referred to as dynamic unbalance. When the rotor is rotated, two equal forces are produced which constitute a couple and give rise to vibrations. Even though these forces are equal and are opposite in direction they do not cancel each other as they are axially displaced.



Dynamic balancing:

- Dynamic balance is a balance due to the action of inertia forces.
- A body is said to be in dynamic balance when the resultant moments or couples, which involved in the acceleration of different moving parts is equal to zero.
- The conditions of dynamic balance are met, the conditions of static balance are also met.





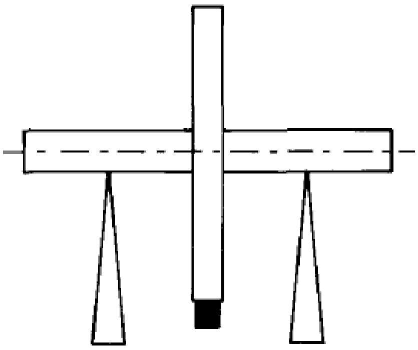
III. BALANCING

Balancing is the technique of correcting or eliminating unwanted inertia forces or moments in rotating or reciprocating masses and is achieved by changing the location of the mass centres. The objectives of balancing an engine are to ensure:

- ✓ That the centre of gravity of the system remains stationery during a complete revolution of the crank shaft and
- ✓ That the couples involved in acceleration of the different moving parts balance each other.

Principle of balancing:

The rotor to be balanced is placed on the two work supporting carriages of the balancing machine and rotated. The centrifugal forces created due to the unbalances act on the carriages and are measured. These two forces give us the total unbalance of the rotor in these two planes (planes in which we have two carriages). While measuring the unbalances, we have to ensure that the rotor is rotated about any other axis; spurious unbalance shall be created by the displaced mass of the rotor. The simple method of achieving above mentioned objectives is to rotate the rotor while supporting on its balancing surface.



Working speed and balancing speed:

Here we must distinguish between the operating speed of the rotor and the balance speed. Whereas the operating speed of rotor is the speed at which it is ultimately doing to work, the balancing speed is the speed at which the balancing machine works in order to sense the unbalance of rotor. The balancing speed need not be the same as the operating speed. A rigid rotor when balance at one speed shall be balanced at all speeds. The unbalance 'U' is independent of speed.

IV. PROCEDURE FOR DYNAMIC BALANCING

1. First identify the work piece which is to be balanced.
2. Measure the weight of the work piece.
3. Determine the grading of the balance in which work piece is falling from grading levels table.
4. Determine the residual allowable unbalance of the work piece from the graph.

Locate the original speed of the work piece and locate intersection point of speed and grading line. Corresponding line on y-axis shows the value of residual unbalance of work piece (X).

5. Determine the allowable unbalance in the work piece

$$Allowable\ unbalance = \frac{(X) \text{ x Weight of the work piece}}{2 \text{ x Radius of the work piece}}$$

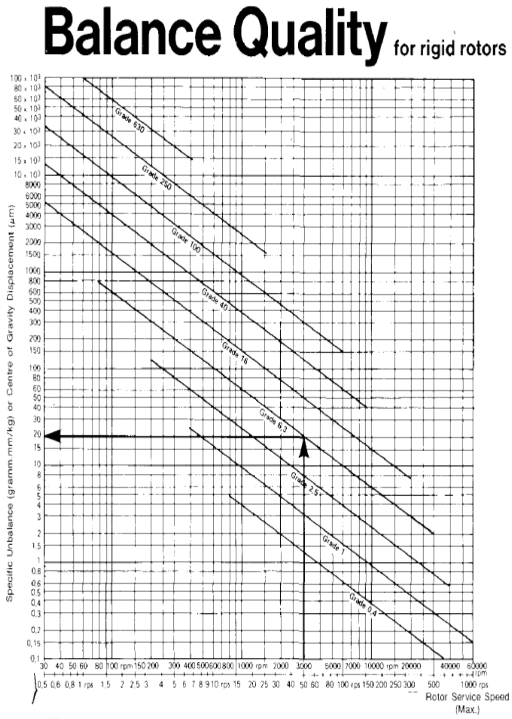
Where,
X=Residual unbalance.

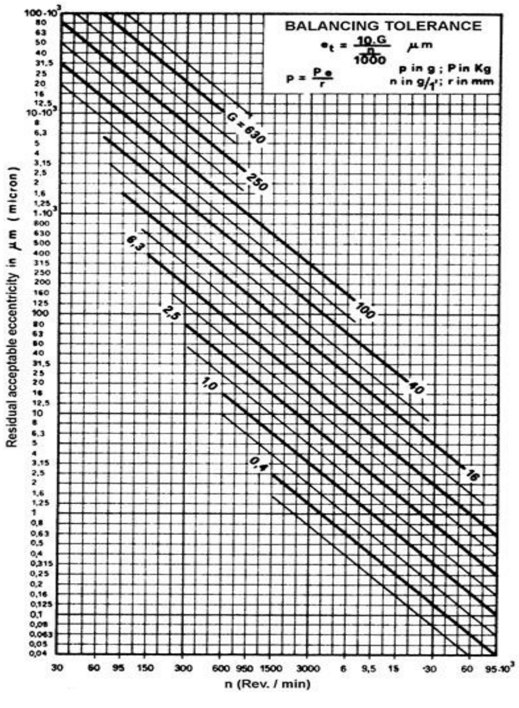
6. After determine the allowable unbalance set the work piece on the machine and set the left plane radius, right plane radius and distance a, b, c on electronic panel.
7. Run the machine up to original speed of work piece.
8. Then tabulate the values from the display panel.
9. By knowing the value of unbalancing mass from machine remove the unbalance mass on the particular angle or add the mass on the opposite side of the plane.
10. Continue the process till the work piece should be balanced.

Determining Balance Quality:

Ideal machine would show no unbalance at all. In practice however, due to machining tolerances, perfect balance can never be achieved. For different types and sizes of machines, the level of vibration regarded as excessive varies considerably. It is important therefore to classify the rotor to be balanced according to the level of vibration that is acceptable. Table shows an Unbalance grade list, based on ISO Standard 1940. The Quality Grades list and some typical examples of each grade. Once the grade has been decided, the maximum allowable residual unbalance can be determined, if the rotor service speed is known. The value obtained is the maximum allowable level of specific unbalance (in g mm/kg) after balancing.

Typical quality grade requirement	
Grade	***Type of rotor.***
G 630	Large slowly operating engine crank shaft assembles.
G 250	Fast four cylinder diesel engine crank shaft assembles.
G 100	Fast 6-or-more cylinder diesel engine crank shaft assembles.
G 40	Vehicles wheels, vehicle engine crank shaft assembles.
G 16	General non-critical drive shaft rotors.
G 6.3	Blower & fan rotor, flywheels, general machine parts, electric motor and generator armatures.
G 2.5	Turbine rotors, machine tool drive components, small electric motor armatures.
G 1	Gramophone and tape-deck drives, grinding machine drive parts.
G 0.4	High precision grinder rotors, gyroscopes.





V. RESULT AND CALCULATIONS:

For the blower impeller
Weight of the blower impeller = 38 kgs
Grade of the balancing = G 6.3
Residual allowable unbalance= 40 mmg/kg
No of planes= 2
Correction plane radius: Left= 280 mm
Right= 280 mm
Radius will be measured by measuring instrument

For left plane= $= \frac{40 \times 38}{2 \times 280} = 2.71 \text{ gms}$

For right plane= $\frac{40 \times 38}{2 \times 280} = 2.71 \text{ gms}$

Working speed of the blower impeller = 1500 rpm
Balancing speed= 400 rpm

UNBALANCE READINGS:

No of checks	Left plane		Right plane	
	Angle (^{0})	Weight (gms)	Angle (^{0})	Weight (gms)
1-RUN	280	60	130	30
1-RUN	240	25	120	12
1-RUN	140	10	120	8
FINAL RUN	140	2.5	50	2.5

Correction:
Material has been removed
Result:
The allowable unbalance will be determined as:
Allowable residual unbalance fr the blower impeller is
In left plane=2.71 gms
In right plane= 2.71 gms
After determining allowable unbalance the decision had been taken to remove the unbalancing mass from the blower impeller.

VI. CONCLUSION:

After dynamic balancing of rotating parts in marine machinery vibrations of the connected parts (i.e bearings, shafts and impellers) will be minimized to the acceptable limits. Damaging to the machinery parts and disturbance in alignment of concerned shaft, impeller or blower will be avoided after completion of dynamic balancing.
Finally the machines or equipment in the vessel will be working smoothly and safely without noice and vibration.

VII. REFERENCES

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