



FREQUENTLY ASKED QUESTIONS ON

DYNAMIC BALANCING MACHINES

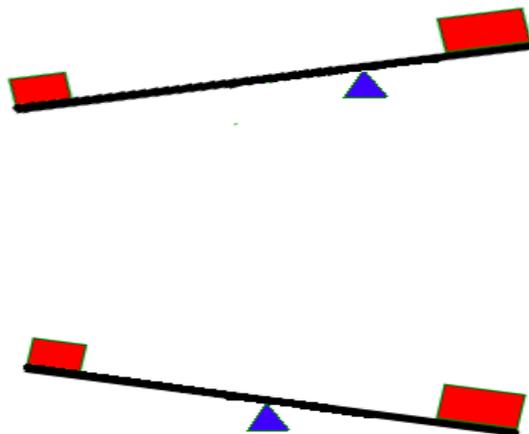
AND

ANSWERS

- Q.** In Dynamic Balancing do we need to support the component on the machine in the same location as in assembly?
- A.** Yes it is necessary to support the component being balanced at the same or near about of the bearing supports for proper results. Dynamic balancing is a force balancing and couple balancing Operation. The couple is the product of force and the distance to the point of support. So it is essential that the real life conditions are replicated on the balancing machines.



**Figure 1:- An example of couple and Force (Weight) balance is shown balanced
*The Balance is no more valid if point of support is changed.***



- Q.** In Dynamic Balancing Machine do we need to run the component being balanced to operating speed/service speed?
- A.** Using a dynamic balancing machine we measure the unbalance in the units of gram millimeter. The quality and sensitivity of balancing Machine decides the speed at which you can balance a Component. In modern hard Bearing dynamic balancing Machines Engineers are able to measure the un balance at relatively lower Speeds. The unbalance corrections effected are valid for most of The service speed requirements of rigid rotors. Refer to the ISO 1940 standards to determine the residual un balance permitted in rigid rotors.
- Q.** What are rigid rotors?
- A.** The rotors which do not change shape when speed of rotation Increases, or the ones which do not operate at resonant frequency, are classified as rigid rotors.
- Q.** What are flexible rotors?
- A.** Flexible rotors are rotors which operate near their resonant frequency. This running of motor generates very slight deformation of the rotor. Flexible rotors need to be balanced at higher speeds and also near their service speeds. Many times, in situ balancing is required to achieve desired results.



- Q.** What are soft bearing dynamic balancing machines and hard bearing dynamic balancing machines?
- A.** Few decades back, when balancing machines were introduced, the cradle on which the rollers were supported needed to be moved to measure the vibration levels due to unbalance. With the advent of technology and introduction of quartz transducers to measure force, it is no longer required for the cradles to oscillate to measure vibration.

The machines which continued to have oscillating cradles and electro dynamic pickups to measure vibration were classified as soft bearing machines.

The machines which had rigid cradles devoid of any movement and measure force using piezo or other pickups are classified as hard bearing dynamic balancing machines.

The basic design philosophy of hard bearing dynamic balancing machines is measuring force and the advancement of computational mathematics using microprocessors has enabled introduction of balancing machines whose calibrations are valid for the complete range of speeds, weights and quality requirements.

The algorithm used facilitates permanent calibration and host of other features for day to day use and extreme reliability.

Q. Why is measuring of balancing speed of the component very important in a balancing machine?

A. Balancing machine is an industrial machine. The machine is located in a factory environment along the process line. Many types of industrial noises electrical, mechanical, magnetic will exist in an industrial environment. Besides this balancing machine has drive elements like motors, pulleys, belts which also rotate along with the component. The component is mounted on rollers, and rollers also rotate along with the component. The transducers will pick up signals from all rotating elements. The electronics of the balancing machine needs a reference signal to extract the unbalance signal of the component being balanced. The speed signal of the component being balanced provides the reference for signal extraction.

In older stroboscope machines, it can be observed that the unbalance location will start shifting / oscillating over a wide angle when balancing is done. In modern machines with phase lock loop, the shift of angle is reduced to insignificant levels.

Q. Why do we need multi speed balancing machines?

A. Multi speed balancing machines are normally big size machines and machines which handle a range of jobs. In case the component is a mass produced component with predictable levels of unbalance, single speed machines can be tuned to balance the components faster and well within the tolerance. But in heavy components, the level of unbalance may not be known initially. It may be hazardous from the point of safety to directly run the component at the required balancing speed. So, heavy components are run at lower speeds, initial balancing is done. Further balancing is done at higher speeds till the desired level of accuracy is achieved.

Q. Do we need to put Dynamic Balancing Machines on a foundation?

A. Balancing machine is an industrial machine used to measure Vibration and compute the residual unbalance. Modern Hard Bearing Balancing Machines are force measuring. It is essential that the Machine do not vibrate or shake for correct measurement of unbalance amount and phase angle. For more precise results it is required to mount the machines firmly on an industrial floor.

Q. What is unbalance reduction ratio?

A. Balancing machine instrumentation indicates the level of unbalance on the component being balanced. A good machine can indicate a value and when a correction equivalent to the value shown is executed the next resultant residual unbalance should be below 90-95% of the first indicated value. For example, on the first run, if the machine has shown say 50 gram at a given location. When a 50 gram weight is added at that location and a residual unbalance reading taken, in case the machine indicates a value of 5 gram and below, then it is said that the machine is having an unbalance reduction ratio of about 90%. For more details refer to the ISO standards 1940, 2953 etc.

Q. What is plane separation, cross effect, influence?

A. In two plane dynamic balancing machines, the results are indicated in two correction planes. When a correction is made on one plane, the effect of the unbalance compensation on the second plane, is defined as plane separation or cross effect or influence.

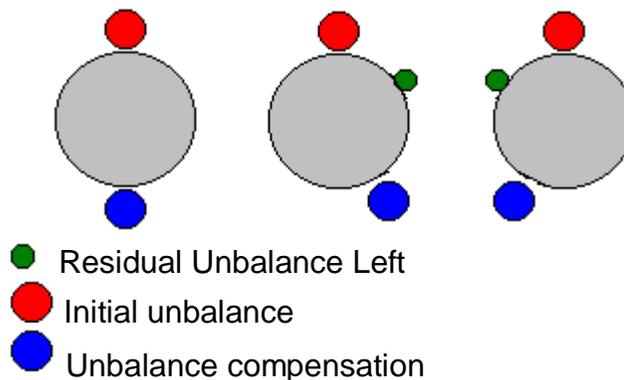
Normally, the plane separation will be well below 3 %. In computer based hard bearing dynamic balancing machines, the plane separation is achieved mathematically. So users tend to get better levels of plane separation on computerized hard bearing dynamic balancing machines and that is not the case with soft bearing machines wherein unbalance signals are electronically mixed and modulated for indicating the results.

Q. Does different balancing speed indicate different unbalance values?

A. Unbalance is a vector and a physical quantity related to the geometry of the component being balanced. It remains the same at all speeds as long as the component does not deform and remains rigid. In, good hard bearing dynamic balancing machines, the unbalance value and the angle will remain the same within permitted variations when checked at different balancing speeds. Since, the electronics operates at low voltages (say +/- 15 V), older machines have switches and markers to take care of variations in the results. A variation within +/- 5 % of the values indicated in different speed ranges is acceptable, and the machine can be classified as a very good machine.

Q. We have added an amount of unbalance as indicated by the machine. Still the machine shows substantial unbalance and the angle also got shifted.

A. Unbalance is a vector. To compensate that you need to compensate at the exact location. In case, you have compensated the right quantity, but at a different place (Angle), you will get the resultant of the residual unbalance and its location.



The above three figures indicate for the same unbalance value and compensation values, the residual unbalance is indicated. So, in essence, both amount of unbalance and location of unbalance determines the effect of balancing.



Q. We have a critical job and we want to ensure correct balancing before we proceed further. We do not know calibration or any complex theory. What do we do?

A. In this given situation, user should realize all digital electronics works between ± 5 V. It is an interpretation of the results that matter. A simple method is to balance to half the accepted values. Say for a tolerance of 50 mmg you balance the component to a residual unbalance of 25 mmg as indicated by the machine.

Now without disturbing the mounting, drive, you change the reference position. This can be done by indexing the universal shaft by 180(Any given angle) degree in end driven machines or by shifting the reference sticker by 180(Any given angle) degree in belt driven machines. Now measure the residual unbalance amount of the component. If, the residual unbalance indicated is within 10% of the first value, you can be sure that all the errors like drive errors, drift in the electronics etc have been accounted and the component is well within the residual unbalance permitted.

Q. We have balanced the component well within the tolerance. Still at assembly, our vibration levels are not satisfactory.

A. Dynamic balancing is an operation of making the center of gravity of the rotary mass in line with the axis of rotation to reduce the centrifugal force and resultant couple which are the main causes of the vibration. In case, you have used an adopter with a bore clearance of 20 micro meters and balance the assembly to G 6.3 grade, in effect your assembly when reassembled may have a balance quality of G 15 or G 20 grade. So you will not be achieving the quality grade of balancing in assembly, what was apparently achieved on the balancing machine.

Similarly, the quality of bearings also plays a part. Both balancing machine and tooling is important for good results.

- Q.** How to determine the residual unbalance permitted or balancing tolerance for a given component?
- A.** The residual unbalance permitted, is the requirement based on the design criteria and application of the specific component. The designer of the component or the end user of the component is the best judge. In the absence of such information, the user can refer to ISO 2953. The users can also use the software utility supplied to compute the residual unbalance.
- Q.** What is the best method of making unbalance compensation?
- A.** The unbalance is compensated first in design, then either by addition of weight or removal of weight. The design requirement of the component is the best guide to carry out the compensation. The weight can be removed for balancing by drilling, milling, grinding etc if the amount of unbalance compensation is less and there is a provision in the design. In case of heavy unbalance, the compensation weight is welded or bolted to the component, since removal of heavy unbalance may weaken the component and render it useless. From the safety point of view also, it may not be advisable to remove too much material.
- Q.** In how many places, do we need to do compensation?
- A.** In a dynamic balancing operation, you need minimum two planes and two places for proper balancing. In many, situations, the compensation will not be sufficient at two places. So, the compensation weight is spread out in more places along the same plane or at more planes at fixed points as in crank shafts. The users are advised to refer to the component drawing or the end user for more details. In components like fans, having segmented rotors, the unbalance compensation will be resolved into vectors where in there is an availability of metal/location to execute the unbalance compensation. So the number of places, unbalance can be compensated is only component specific.



- Q.** Can I do zero gram zero degree balancing?
- A.** The zero balancing term is not applicable in balancing operations. You always balance below some tolerance say 20 millimeter gram. In short the residual unbalance can be any where between 0- 20 mmg. The component is said to be with in the tolerance. The angle of the balancing machine indicates the location of the final residual unbalance. Around the circle any where the residual unbalance is left without further compensation. So the value of angle say 5 degree or 257 degree has same effect.
- Q.** I am getting low unbalance amount but high angle. Why?
- A.** The Job is well balanced. Refer the answer to the previous question why you can not get a low degree value.
- Q.** What is an ISO proving rotor?
- A.** A dynamic balancing machine needs to be checked and calibrated periodically to know the correctness of the Indication. ISO rotor is a fully machined and ground rotor with a provision to add and remove known weights at known locations. The rotor is used as component and machine indications are checked with known weights. Please get more details from the engineer or read the standards ISO 2953 for test procedures.



Q. How do we decide to go for single plane, two plane, and Multi plane Balancing?

A. In a dynamic balancing requirements the component or the end user decides the number of planes of balancing. In absence of such information refer to the standards. Normally when the length is more than diameter you go for two plane balancing. For disc shaped components like small fly wheels, pump rotors, clutches you can do single plane balancing. In components like multi stage pumps, turbines, crank shafts there will be provision for multi plane balancing. The main reason for multi plane balancing is only for ease of placement of weights.

Q. How do we decide the size of the machine?

A. The size of the machine should be optimum for the range of jobs you wish to handle. In case of mass produced components it is advisable to opt for tooled up machines with in built correction equipment. In case you wish to handle a range of components opt for the machine for the maximum range of components you wish to handle. A machine of 1-50 range is the best solution. That is a machine can handle 1kg to 50 Kg or 100 Kg to 5000 Kg or similar range. Such a machine will do jobs falling in the middle ranges in G 2.5 grade and 50 range at G1 grade and 1 range in G 6,3 or G 10 grade. A machine can not balance the complete range of weights in the complete range of speeds to the best level of balancing quality grade.

Any other bigger range, say 1-100 is a compromise and may not be worth the time of men and machine.

Similarly the power of the machine is decided by the inertia of rotors as in case of motor rotors, the power consumed while balancing as in the case of fans, or the speed with which you wish to stop and start the components. Remember in case you want to double the speed of balancing in a fan you need three times more power.

You also need to check the physical size to be accommodated on the machine for driving safely for balancing.

- Q.** What are the criteria for selection of end driven, belt driven, self driven, vertical balancing machines?
- A.** In a dynamic balancing requirement, the accuracy of the component and the ease of balancing decide the most technological solution in selecting the balancing machine and drives. Mass produced components which are disk in shape, and small in size are invariably balanced on a vertical machine with built in correction equipments. High precision jobs requiring fine levels of balance like turbines, turbochargers, are balanced on belt driven machine. Components like fans and heavy rotors which need considerable power for acceleration and deceleration are driven through universal shafts on a balancing machine. Very high speed components like automobile turbochargers wherein the error induced by drive elements are not acceptable are balanced by using their own real life simulated power sources like compressed air. The advantage of the belt drive arrangement over universal shaft driven machine is the time to fix the adapters on the component is saved and errors due to adapters on the residual unbalance are avoided.
- Q.** What are the units of unbalance?
- A.** The units of unbalance are the product (Multiplication) of permitted un balance weight at the radius of correction.

For example

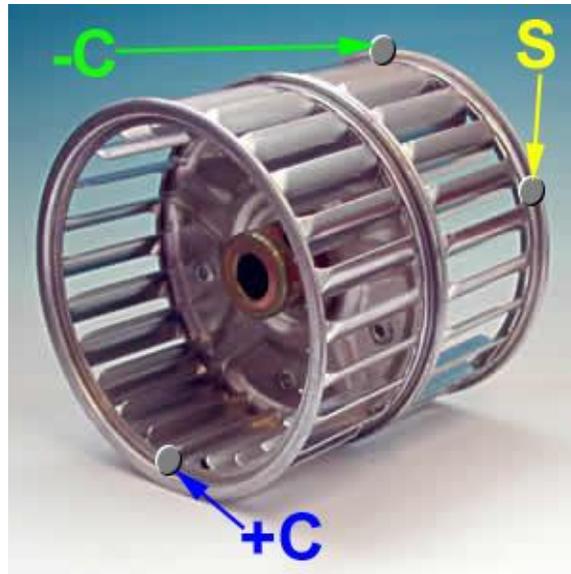
X gram of unbalance at Y millimeter radius is defined as XY mmg of unbalance. Based on the practice the units can be in

Meter gram
Ounce inches
Gram inches
Millimeter gram
Millimeter milligram

Or the product of a linear distance unit and a weight unit. the relationship between all the units is straightforward and can be transferred for operational convenience

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- Q.** We have balanced a fan on the balancing machine and when we test on a static balancing stand we see heavy spot in the fan?



- A.** In the picture above a dynamic balancing machine measures the resultant of the three resultant unbalance forces namely the static component “S”, and the couple component “+C and -C”. The values can be recorded by using the program two plane measuring and static/couple measuring sections.

When using a machine you compensate all unbalances ie S,+C,-C. But when check on a static balancing stand the couple portion unbalance do not get compensated, and only S is compensated. So you have the high spot settling at the bottom on a static balancing stand for components balanced on a machine. In actual service conditions when the dynamic effect of all three forces are acting the fans balanced on a machine for both Static and Couple will be smoother.