

## Machine Base Measurement

By John Lambert

One of the biggest issues in the machinery installation process is that many machines are installed but they are left under strain due to the fact that they are bolted to distorted bases or frames. The problem is that the machines feet and the base are not in the same plane. In other words, the feet sit unevenly on the base. When the feet are tightened down the result is that the machines casing is distorted.

In the case of an electric motor, this distortion can alter the air gap and create a vibration which in time will cause the motor to fail prematurely. If the distortion is severe it can even deflect the shaft causing a greater vibration.

You can actually use vibration to find this kind of problem. Simply locate the highest reading (obviously with the machine running) in the vertical or horizontal plane and watch the reading as you loosen and tighten each of the foot mounting bolts. You may be surprised at what you see. Sometimes the reading will go down. This is because you have taken the strain off the motor, in other words, the motor is distorted and you are easing the strain.



**A base does not have to be level but it does have to be flat.**

How about a hypothetical question on the subject. If you were installing a very large motor onto a base, and the motor has been out being repaired, and let's say the motor weighs one ton and the distance between the front and back feet is 48". If the base frame was twisted by 0.010 would you expect to find this twist using the traditional feeler gauge method, i.e. tightening and loosening the hold down bolts?

Would the foot spring up? This is a twisted base frame, not a short or distorted foot. Remember a motor is a hollow casing with a stator attached to it. The end bearings support the heavy armature that is suspended in it. If you think the answer is no, does that mean you assume that there is not a problem or would you try to measure the base in another way before installing the motor?



I believe that on heavy motors with light weight casings, the foot will not spring up when measuring a small amount of twist. If it doesn't spring up it is natural to assume that nothing is wrong so no other action is taken. I also believe, although motors (machinery) are designed to be mounted on flat surfaces, many of them are clamped down on twisted uneven bases.

The question is where is the problem? Is it the foot or is it the base? We use the term softfoot to describe foot problems but this is incorrect. The word is actually a description of the feeling you get when you are tightening the machines foot. Although the foot appears to be down, you can still tighten it and pull it down some more. It feels soft or spongy. If you feel this the foot is distorted.

To find and correct this problem we can quite easily measure it with a feeler gauge. We have to make sure that we measure under each corner of the foot so that we can make the proper correction. We can do this as a rough measurement with the bolts loose and then tighten them and re-do each foot tightening and loosening the feet.



You can spend a lot of time finding and correcting distorted, twisted machinery feet and it can be frustrating because you can create a problem just as easily as you can correct it. However, the effort to correct it is time well spent.

If the motor casing is distorted because it is bolted to an uneven base you now have an offset between the bearings. The offset tolerance for shaft alignment on a 1800 RPM motor is 0.002" to 0.004" thou, bearing in mind that you do have some flexibility from the coupling in this area. Now think about the offset tolerance between the two bearings in the motor. What should that be? Is the base creating internal misalignment of the bearings and motor shaft? A small amount of twist, say 0.010" thou, can give you a 0.005" thou of offset between the two bearing which is too much.

It is obvious that we ignore issues that we are unaware of but often we ignore issues that we should be aware of. For instance, we check and correct distorted machine feet (softfoot) when we are doing shaft alignment because we know that it will deflect the shaft and give inaccurate laser readings. If we know that the shaft is deflected then so should the casing be under strain, but why is it that we do not check for distorted feet on belt driven machines? Surely they would run better and longer if they were not under the stress of a distorted casing. Well it's the same for machines bases. We may even have an idea that there is a problem but we tend to ignore it and hope it goes away.





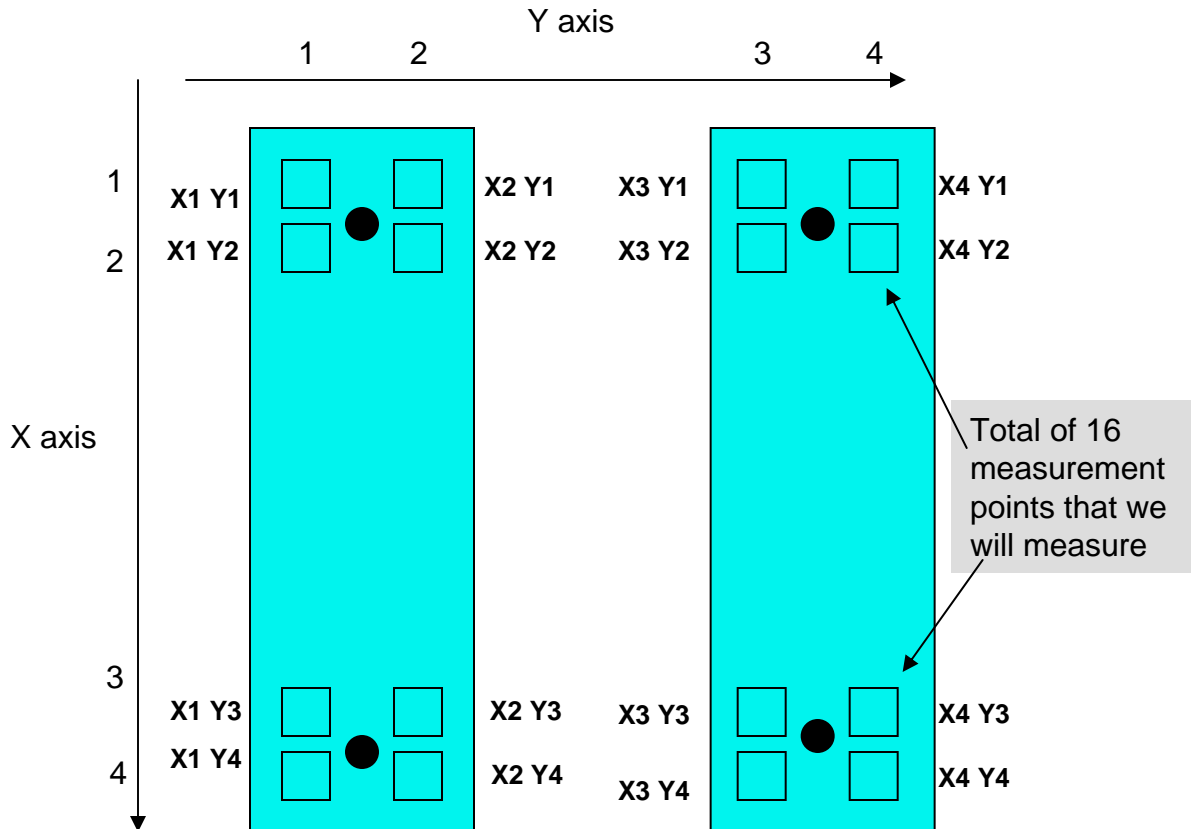
**Base flatness measurement**

## Flatness Case Study

Here we are using a laser shaft alignment system and we have added a D22 swivel laser that can sweep across the base in order to measure flatness in both X and Y coordinates.

Before we show you the results let us first show you how we plan to measure. Although the base appears to be two long rails the motor only sits on the shim packs which are positioned under the mounting pads on the motor.

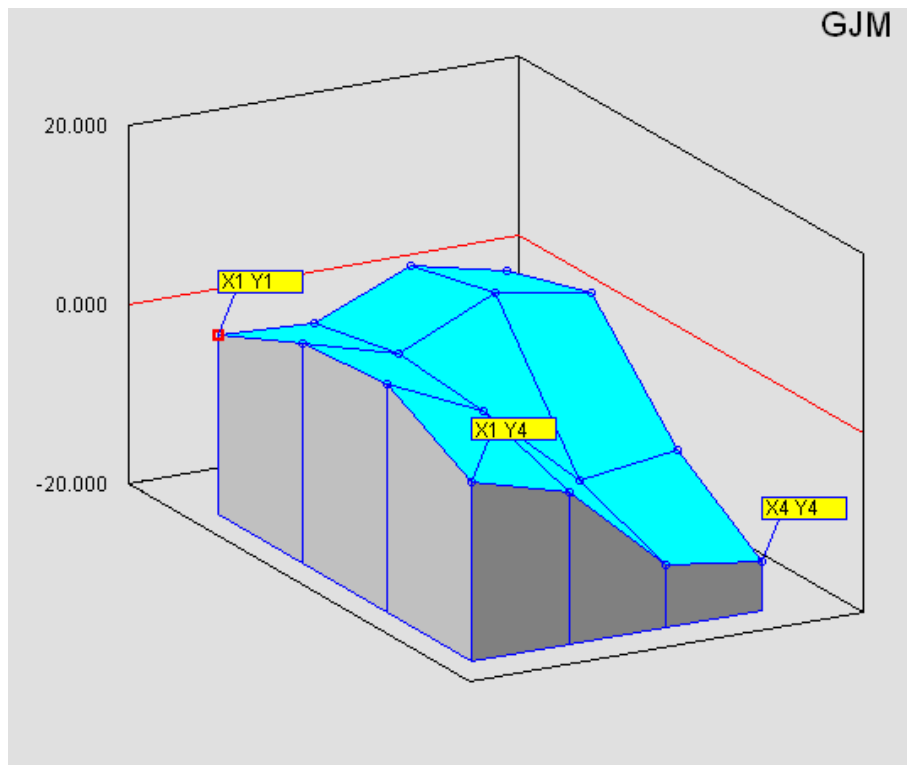
This means that we only have to measure around each of the bolt holes. If we measure at each corner of each bolt hole we will have an area of about 5" x 5" sq. So first we set up a grid.



Measurements were taken on each corner of each of the four foot positions.



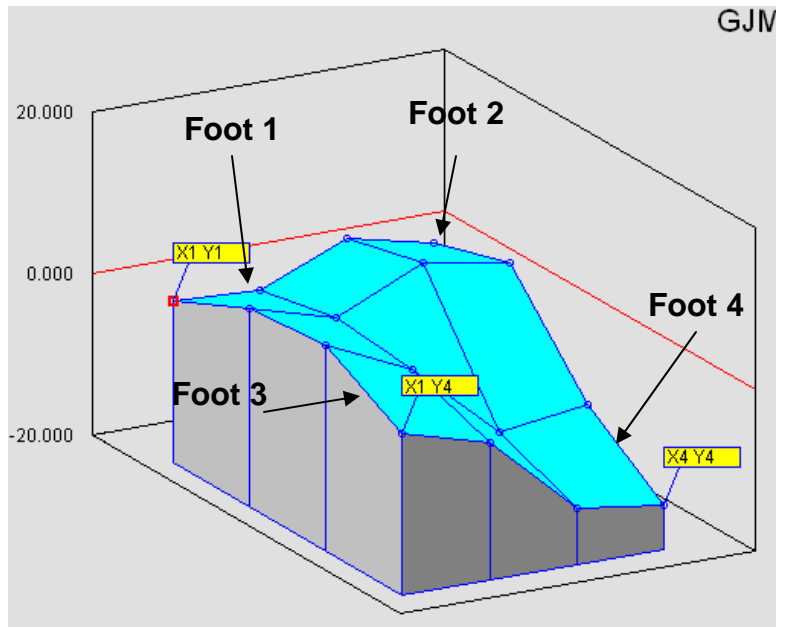
After the measurements were taken, the information was transferred to the EASY-LINK software program and a line graph was produced.



This is the wire diagram that the software uses to show you a picture of the measurement results. The centre is colored but you can still see the two rails down each side showing you that #2 foot is high and the #4 foot is low.

This is the full report you get and I have numbered the feet. I have also highlighted (in red) the reference point and the highest and lowest measurements that were taken.

Easylink 2.2 P31  
 Registered to John Lambert,  
 Benchmark Maintenance  
 Services Inc.  
 Filename: GJM  
 Date: 08.11.13  
 Time: 12:10  
 Program: Flatness  
 Unit: thou  
 Serial: 38335 / 38139  
 Temp: 75.0F  
 Pos Ref Value



Water Pump

X1 Y1 Ref 0.0

X1 Y2 4.5

X1 Y3 5.5

X1 Y4 0.0

X2 Y1 -0.5

X2 Y2 1.5

X2 Y3 0.5

X2 Y4 -3.0

X3 Y1 4.0

X3 Y2 6.5

X3 Y3 -9.0

X3 Y4 -13.0

X4 Y1 1.5

X4 Y2 4.5

X4 Y3 -7.5

X4 Y4 -14.5

Max 6.5

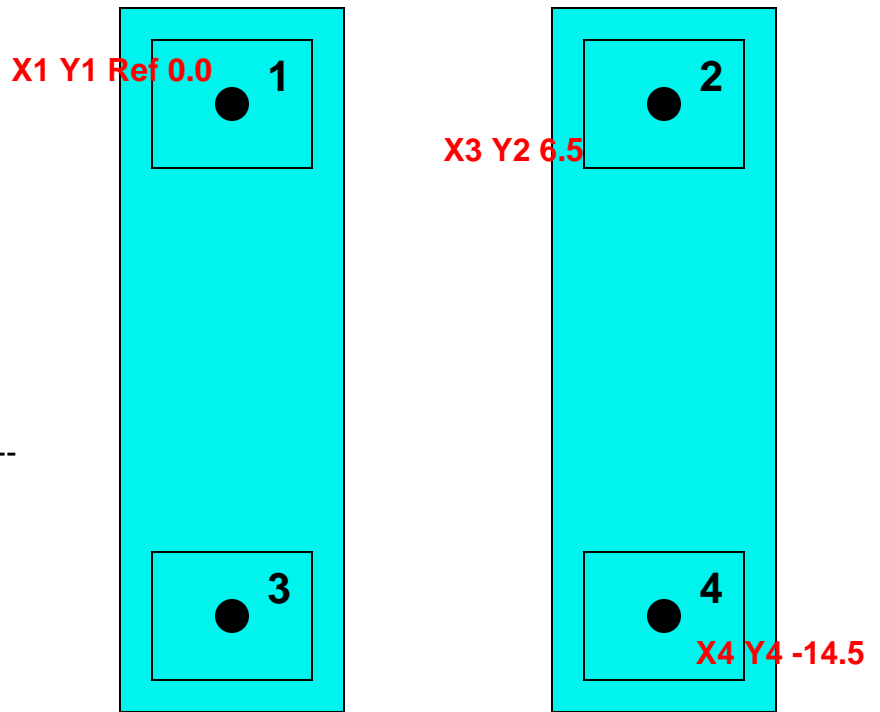
Min -14.5

Peak-Peak 21.0

Average level -1.2

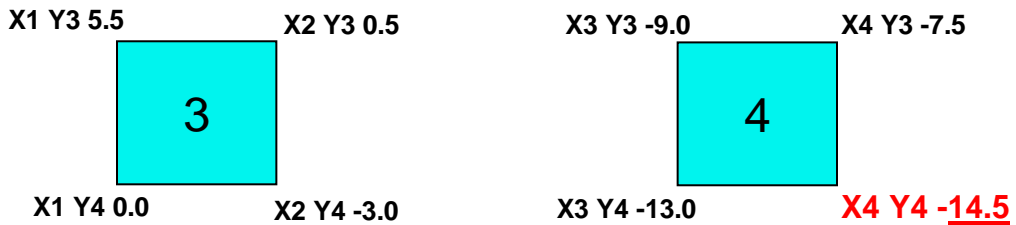
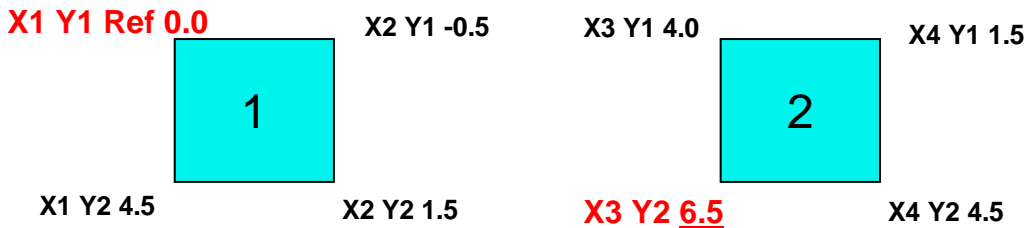
Standard dev 5.1

Flatness Rms 4.4



Non drive end of motor

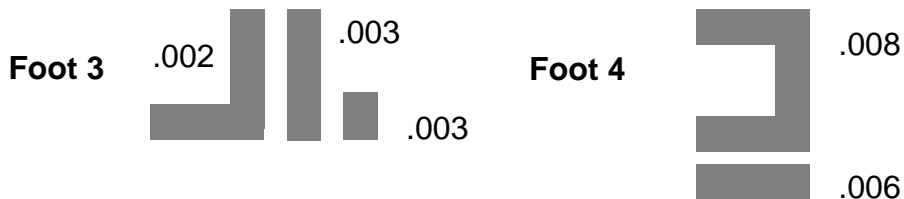
These are all the measurement results in the correct locations and again we have highlighted the reference point and the highest and lowest measurements that were taken.



To correct the unevenness you could cut up shim stock as I have suggested below. The other alternative is to machine it but it must be corrected because a distorted base such as this will obviously affect the operational life of the motor that was bolted to it.



### Shim stock.



If you are involved with vibration analysis of electric motors and you see high readings of rotor bar frequency, 2x line frequency (exactly 120HZ), etc. you may want to consider that the motor casing is under strain.

If you have a look at the picture of the base again you can see that it is a well made base that was machined flat after being fabricated but my guess is that it was not stress relieved and it has twisted over time.

To measure flatness you have the option of buying the basic Geometric system called the D600 or you can buy a shaft alignment system and simply add the D22 swivel laser.



**The D525 Shaft alignment System**

**The D22 Swivel Laser mounted on tripod**



John Lambert

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