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White Paper - Harmonic Analysis

A harmonic is simply a repeated frequency or undulation in 360 degrees, harmonic software can breakdown these frequencies into individual amplitudes and phase allowing the user to understand and predict component behaviour as well as allowing feedback to the manufacturing process. Utilising This frictionless air bearing spindle and high precision encoders all Taylor Hobson roundness instruments are capable of analysing mechanical bearings and other components for form errors that may be detrimental to function.

Distortion

The most common cause of a harmonic is simple clamping, a part placed in a three jaw chuck can be over tightened and simply distort the part at three locations spaced equivalent to the jaws of the chuck, this sort of distortion will produce a dominant third harmonic. (Figure 1)

- Another common cause of tri-lobing comes from the centreless grinding process; this is where the part due to its nature (often small parts such as needle bearings or injector components) cannot be held in a chuck. The part is sandwiched between two contra-rotating grinding wheels and held up by a stay. The action of these three components invariably produces a three lobed effect which has to be controlled via accurate machine set-up. (Figure 2)
- Other causes of distortion can come from over tightening of components during assembly, for example a cylinder bore can become distorted by over tightening of the cylinder head bolts. If there are four bolts equispaced around the cylinder bore then a four lobed effect can occur. (Figure 3)

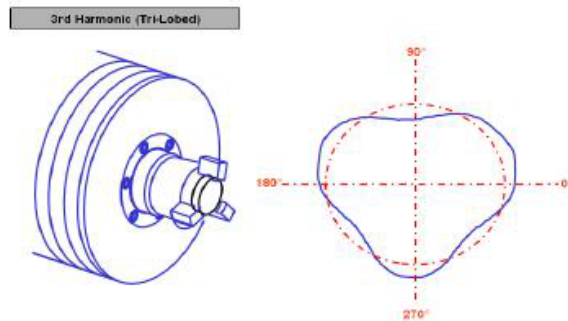


Figure .1.

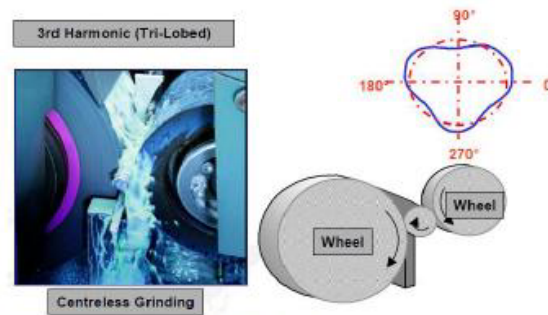


Figure .2.

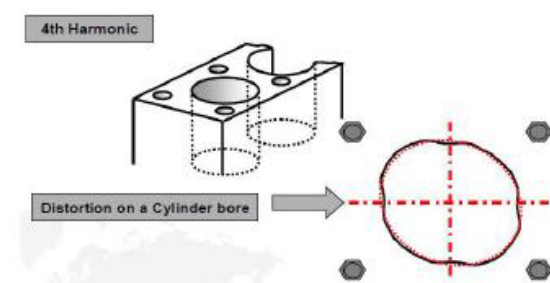
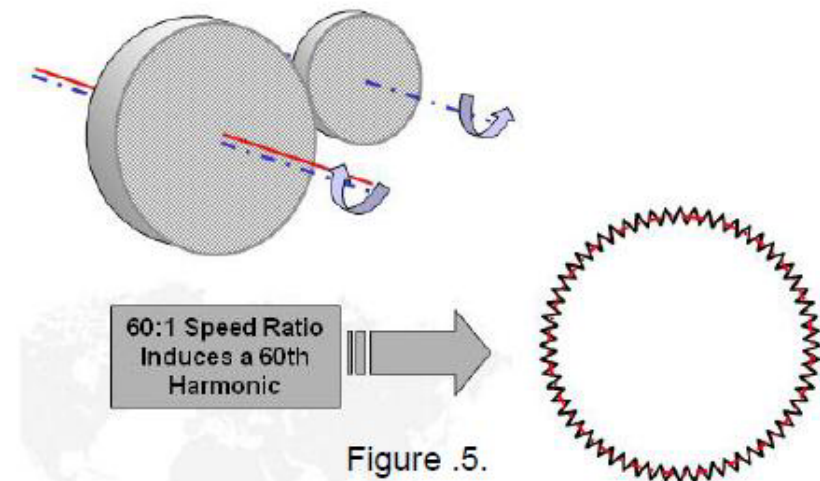
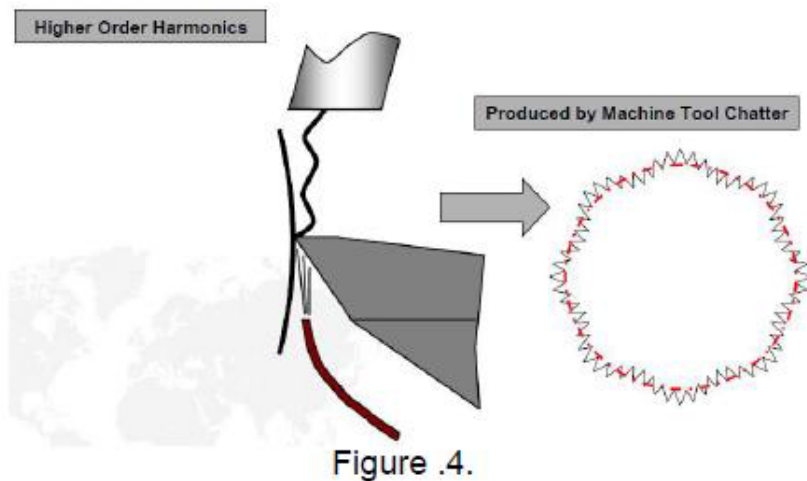


Figure .3.

Out of balance or eccentricity

- Higher order harmonics can come from machine tool chatter, an out of balance spindle, or an eccentric grinding wheel. All of these phenomena can be detected by a simple roundness measurement; the results of these measurements can be reduced to their harmonic content utilising a Fast Fourier Transform and then viewed for the harmonic phase, number and amplitude. (Figure 4)
- A part machined in rotation using an eccentric grinding wheel will impart a number of flats on that part, these flats or undulations will have a harmonic frequency equivalent to the ratio of the part and grinding wheel rotation speeds the amplitude of which will be equivalent to the eccentricity of the wheel. (Figure 5)
- For example if the part is rotating at 10 rpm and the wheel is rotating at 600 rpm then the ratio is 60:1, if the grinding wheel has an eccentricity of 1 micron then it will impart 60 undulations on the part equivalent to two times the amplitude of the wheel eccentricity.



It should be noted however that harmonic amplitude is not measured from peak to valley like a roundness plot but is the half amplitude; therefore ignoring all other possible errors the amplitude of the harmonic should be equivalent to the eccentricity of the grinding wheel. This simple calculation allows the user to trace the source of his error and rectify.

Predicting Behaviour

For bearing manufacturers whether on wind turbines, aerospace or automotive applications understanding the effects of harmonics is critical, helping to prevent vibration, noise and wear and maintain efficiency and life of the bearing. Behaviour of mechanical bearings can be predicted by understanding the harmonic content and amplitude of a subsequent roundness (or flatness) measurement of that bearing. Special software packages such as Taylor Hobson's Velocity analysis software also allow bearing manufacturers to look at harmonic content and control their amplitudes with respect to velocity allowing prediction of function with respect to speeds.

Contact us

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