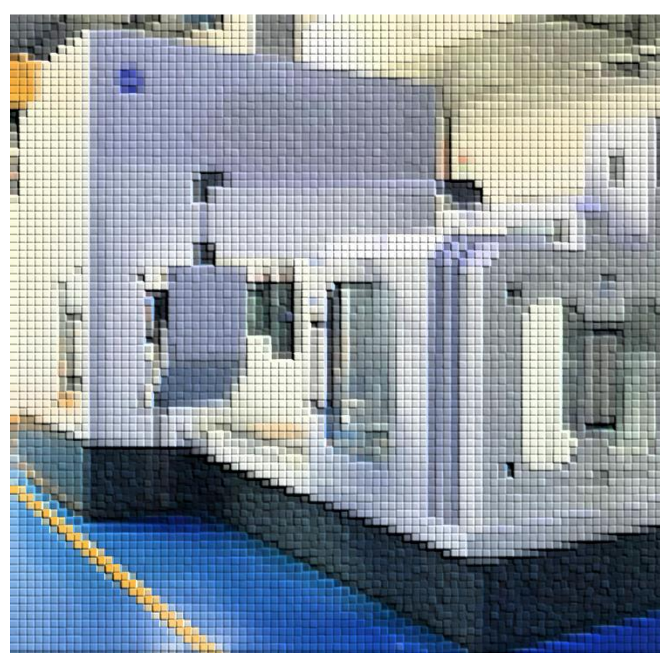
SEQUOIA
SMART SOLUTION FOR DYNAMIC MONITORING

ODS on Machine Tool

Operational Deflection Shape to
a Machine Tool



The Power of Knowledge Engineering

ABSTRACT

This report shows the potential of vibration analysis during the development phases of a new machine. Or highlight all those problems invisible to the human eye on the existing machinery park. Due to the arising of fatigue phenomena or wear.

The machine under test, in this case, is a machine tool with a frame structure. During the various milling phases, a vibration pattern that was not suitable for the quality of the machine was noticed on the workpiece.

The customer therefore asked us to understand what caused this vibration pattern on the workpiece during the different phases.

For the type of target set by the customer it was decided to operate an ODS (Operational Deflection Shape). Analysis that allows us to evaluate the machine movements (in the order of thousandths of a millimeter, therefore invisible to the human eye) during the operating conditions and reproduce them through animations that can be easily interpreted by the end user.

The results that we will show in this document will normalization to reference frequency and photo will pixelated for protecting customer data.

THEORY OVERVIEW

In the following the theory of Operational Deflaction Shape analysis techniques will be summarized.

What is an Operating Deflection Shape?

An Operating Deflection Shape or ODS is in the literature defined as the deflection of a structure at a particular frequency relative to a specific point on the structure. This specific point is called the reference point. This definition is referring to the frequency domain representation of the ODS.

However, it is also useful to observe the ODS in time domain, where the deflection is animating in time with absolute scaling, i.e. not relative to a reference point. In this representation the deflection is composed of all frequency content between 0 and Nyquist frequency at a certain time instant.

So ODS is not only one technology but rather two, Time Domain ODS (TODS) and Frequency Domain ODS (FODS).

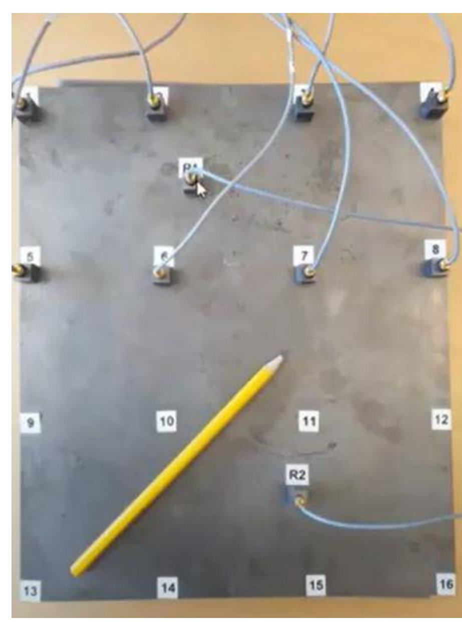


Figure 1 Example of configuration Measure setup on plate

Why Measure Operating Deflection Shapes?

ODS measurements can be helpful answering vibration related questions such as,

- How Much is a given structure moving?
- Where is it moving the most, and in what direction?
- What is the deflection of one point relative to another?
- Have repair actions reduced the vibration levels?

In general, all vibration is a combination of both forced vibration and modal response of the structure. Forced vibration can be due to:

- Internally generated forces of e.g. rotating parts of a machine.
- Unbalances of e.g. rotating shafts.
- Externally applied loads.
- Ambient (Natural) excitation.

An Operating Deflection Shape contains the overall vibration on a structure. In other words, the ODS contains both forced and modal response components. On the other hand, a mode shape characterizes only the modal response. If a structure is excited dynamically around the resonance frequencies of one or more of the structural modes, the resulting resonant vibration typically amplifies the vibration response of a structure far beyond the design levels for static loading. Resonant vibration is typically a significant contributing factor to many of the vibration related problems that occur in operating structures.

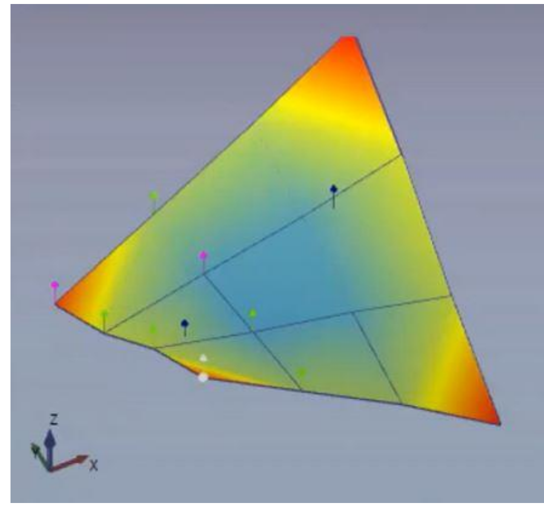


Figure 2 Example of result on plate

By using both ODS and modal analysis tools it is much easier to determine the cause of a vibration problem. The two types of tools let's you judge if a vibration problem is linked to the forced vibrations or to the structural system itself.

APPLICATION

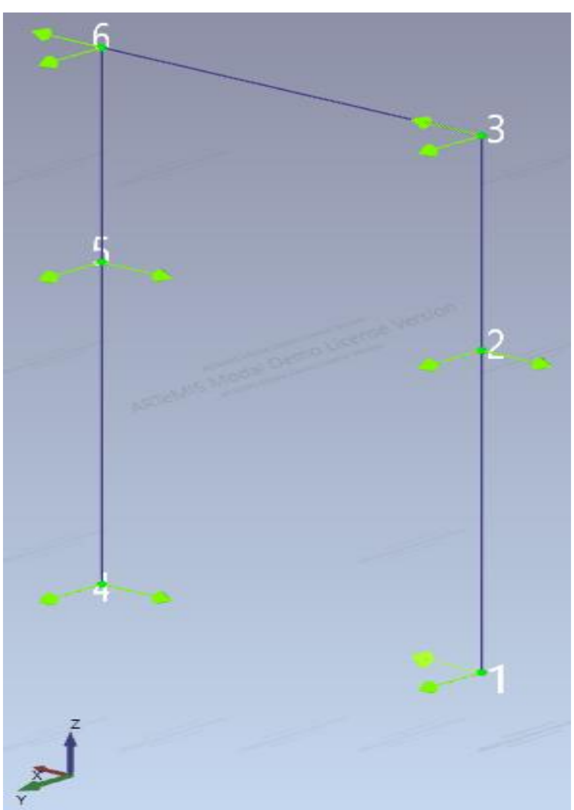


Figure 3 Structure Scheme

As you can see in the picture on the left, the machine's supporting structure has been recreated on the processing SW from the acceleration data.

The nodes in the figure, which recreate the stylized structure, correspond to the position of the accelerometers used during the measurement set. The green arrows, instead, identify the acceleration vectors indicating their direction.

In this case a sampling frequency of 1024 Hz has been set. This gives a bandwidth of 512 Hz in accordance with Shannon Nyquist's Theorem. The sample rate is not a random choice. It is a function of the type of phenomenon investigated and the type of structure under test. It is a very important parameter. A wrong imposition of it would result in the loss of fundamental information about the behavior of the structure. In this case, being a metal structure stressed by relatively low frequency events, the bandwidth is largely sufficient to investigate the phenomenon.

RESULTS

Some results from the analysis are shown in figure X. It can be seen that not only are the acceleration data available for each investigated point. It is also possible to correlate the displacement history derived from the acceleration histories through a double integration. By imposing an appropriate filtering method. In order to avoid any drift during the integration process.
Obtained the displacement in the domain in time it is necessary to animate the model and obtain the real movement of the structure.
The analysis can be conducted in both time and frequency domains. In this way to associate part of the total displacement to each frequency of the spectrum. Assessing, according to a modal analysis, possible resonance phenomena, in order to identify the cause of the problem.

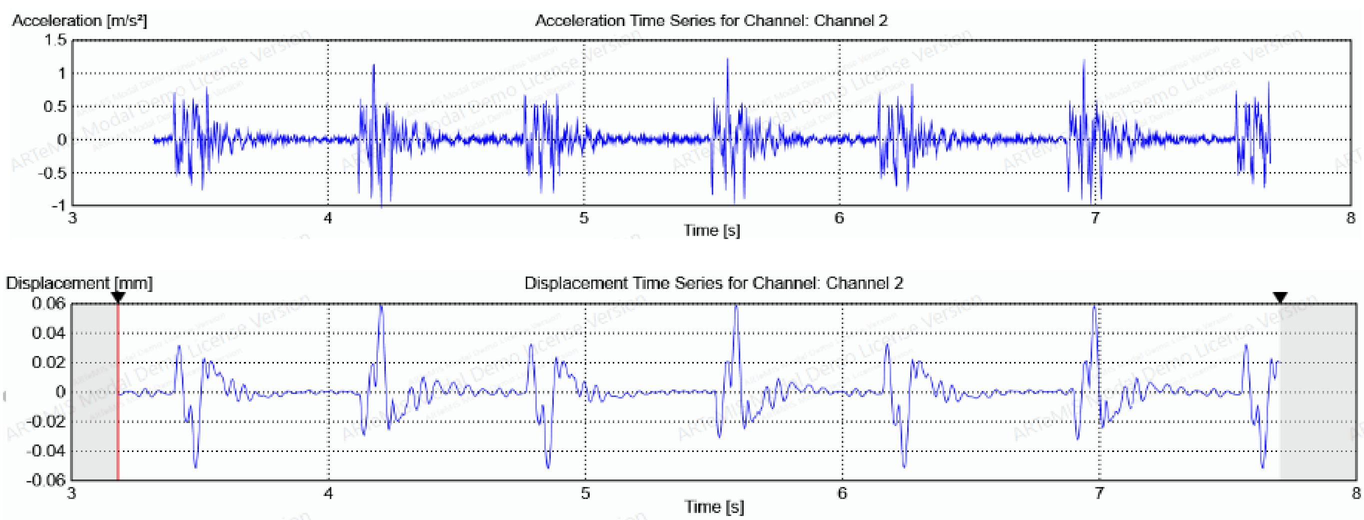


Figure 4 Example of Results

CONCLUSION

The advantage of using an analysis like ODS (Operational Deflaction Shape) is obvious. Thanks to it it is possible to investigate the behavior of the structure under the real boundary conditions to which it will be subjected during the processing. Then find any defects / abnormal behavior that affect the efficiency and quality of processing. Once the abnormal behaviour has been found, it will then be easy to take the necessary countermeasures to correct the defect/problem.
It is obvious how such an analysis can be fully exploited by associating an OMA (Modal Operational Analysis). This is because it is possible to trace possible resonance phenomena to structural movements that act in that frequency range.