Elimination of Vibration and Noise Problems in Existing Systems

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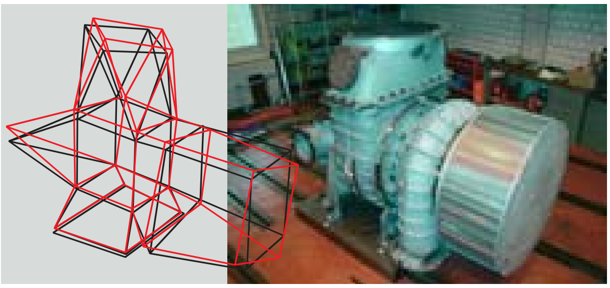
Traditional mechanical engineering still remains an innovative sector today. In addition to the development of completely new machine concepts, the continuous improvement of existing machines represents a great challenge. In many cases, the goal here is to increase productivity, which can be achieved through extensive automation on the one hand, and by higher processing speeds on the other. While the level of automation mainly brings up questions related to mechatronics and information technology, increasing the speed of such systems can lead to classical mechanical problems, which frequently result in development of objectionable vibrations and noise emissions.



1 Results of a modal analysis showing the vibration mode for one selected resonance frequency using the example of a turbocharger.

Difficulties that were thought to have been solved long ago reappear when breaking through physical barriers. The consequences range from an impairment of the comfort of persons through noise, as well as poor product quality, up to the endangerment of the system reliability as a result of uncontrolled vibration behavior. Although these phenomena can nowadays be simulated in principle, such methods are, however, often neglected in the evolutionary development. As a result, the situation can arise in which machines or vehicles are delivered and put into operation, but cannot achieve their planned performance due to unexpected mechanical problems, and, in extreme cases, for example, street cars, have to be temporarily taken out of operation for safety reasons.

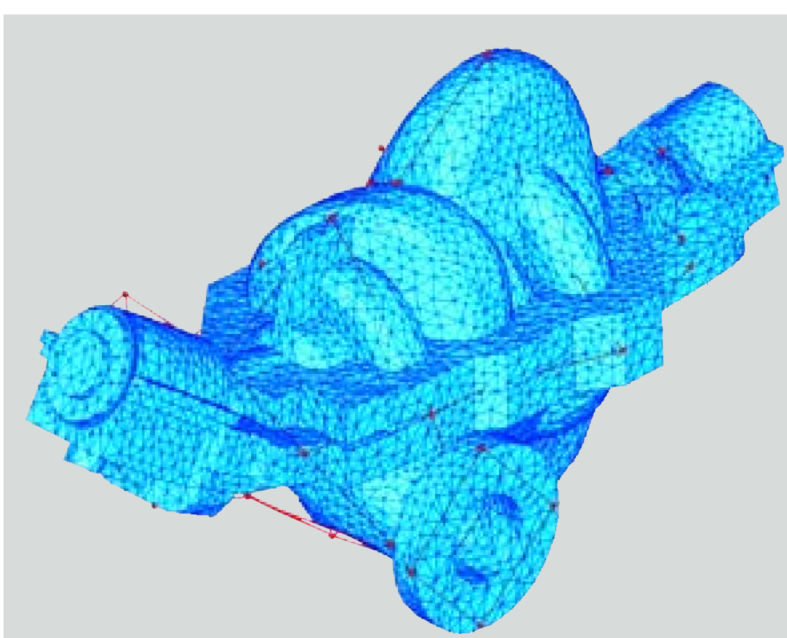
The Mechanical Systems department of Sulzer Innotec is specializing in the elimination of vibration and noise problems in existing systems, whereby, as a rule, a similar cycle is always followed. The analysis of the problem is followed by the interpretation process, the understanding of which then finally leads to the improvement measures that are derived from this.

Data Acquisition Through Measurement

The mechanical problems are often noticed and described by the suppliers or the operators of the machinery in an "unscientific" manner. "Noise", "Vibrations" or "Quality deficiency in the product" are typical statements that the vibration engineer hears over the telephone or on-site in the installation when he is called in to help. First of all, these kinds of statements must be translated into measurable parameters. And to do this, Sulzer Innotec has modern measurement technology at its disposal, together with the know-how of its experienced vibration specialists. Nowadays, it is possible to record different physical quantities simultaneously such as pressure, displacement, force, expansion and noise from different points of an installation at the same time, together with operational parameters obtained directly from the machine control system. Large amounts of data are obtained from this, especially when slowly changing processes such as running-up to speed have to be recorded.

Modal Analysis

With today's computer technology and the associated measurement technology, it is possible to quickly record comprehensive sets of data. For their interpretation, however, a specialist is required, whose work can be supported by computers. One example of computer-assisted assessment is the so-called Modal Analysis. With this technique, the resonance frequencies and the associated vibration modes of a technical system can be determined. The results are very descriptive, because abstract measurement results can be displayed visually (Fig. 1). Modal Analysis has yet another important function, which can be used during the design process: With its help, it is possible to verify and adapt available Finite-Element models of the component or the machine. This technique has been successfully applied for the AIOC injection pumps and MSD pumps from Sulzer Pumps (Fig. 2). With the verified models, more reliable



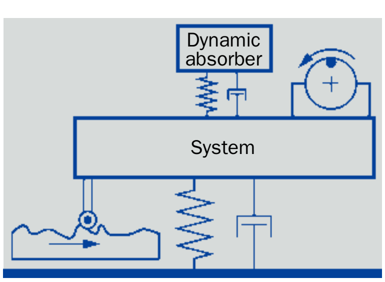
2 Improved Finite-Element model of a pump through comparison with experimental modal analysis.

statements can be made regarding the operational safety of the pumps.
Modal Analysis requires that a machine or installation can be stopped for the measurement phase. In many cases, this is not possible because, for cost reasons, the operator of an installation is unwilling to stop his production, so that only the measurement of the vibrations under operating conditions is possible. This measurement also indicates vibration phenomena that are caused by the operation, and that cannot be detected in the Modal Analysis during a shutdown. Nowadays, even measurements of this type can be visualized with computer assistance. An animation of the measured system, in which the recorded displacements are emphasized, has proved to be a suitable aid for the interpretation of complex forms of vibration. With this understanding, corrective measures can be planned and implemented in a better manner.

Counter Measures

After the recording and the understanding of the vibration problem, corrective measures must be developed, implemented and, in many cases, also be confirmed by measurements. Many vibration problems on machines can be eliminated passively through suitable detuning of the system. In doing so, resonance frequencies that lie close to the excitation frequencies are shifted by suitable modifications so that they can no longer be stimulated (Fig. 3). The illustrated support has a resonance frequency that was excited to unacceptable vibrations by a tooth-meshing frequency in the gearbox. Through the application of an additional mass, the resonance frequency is shifted out of the critical range, and the system is successfully quietened.
Another possibility of detuning is shown by the example of a generator which carried out unacceptably large vibrations relative to its motor—whose rotation frequency provided the excitation. The connecting bell between the motor and the generator was initially made of aluminum. Changing to ductile graphite iron increases its stiffness to such an extent that the critical resonance vibrations no longer arise.
If these kinds of passive measures do not help to eliminate the vibration problem, a so-called dynamic absorber can be used to avoid vibrations. A dynamic absorber is a passive vibration system that is tuned to the vibration frequency to be addressed. If the excitation takes place, the dynamic absorber begins to oscillate, and thereby suppresses the development of the vibration in the main system (Fig. 4). Dynamic absorbers have been used for some years now, primarily in civil engineering for structures such as bridges, chimneys, high-voltage lines and high-rise buildings. The Mechanical Systems department has already successfully applied dynamic absorbers in several machines and vehicles. Each absorber was specifically developed for the particular application (Fig. 5). ◀

4 Sketch showing the principle of a dynamic absorber: passive vibration system which is tuned to an objectionable vibration frequency.



3 Example of a successful passive detuning: gearbox test bench with additional mass applied (RUAG).

5 Today, many Post container wagons travel on the Swiss rail network with dynamic absorbers developed by Sulzer Innotec.

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