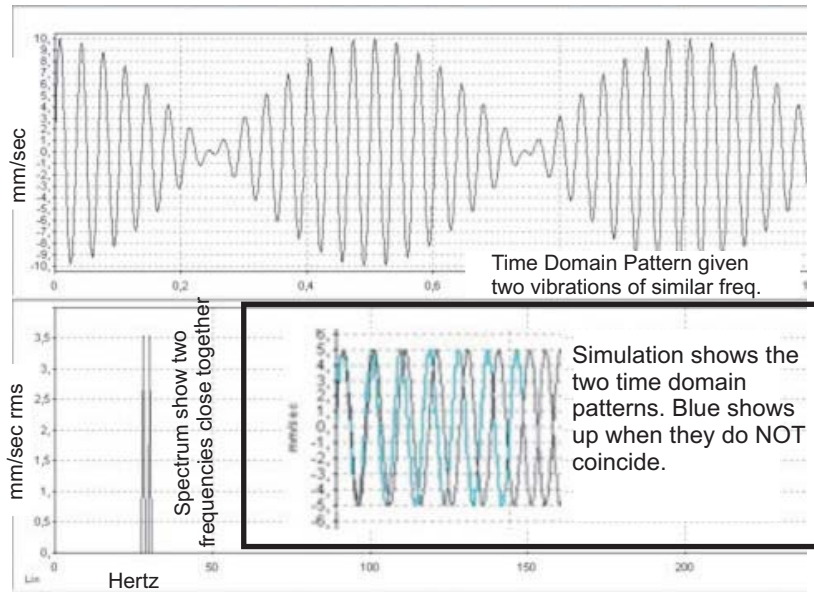


# Beat Vibration at a Pumping Station

## The Phenomenon of “Beating”

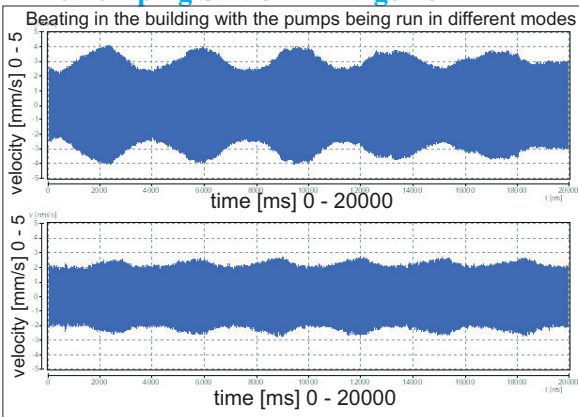
If two vibrations of a similar frequency are superimposed, beating occurs. This phenomenon is clearly audible in the acoustics. The tone, which is made up of two individual tones of slightly different frequencies, changes its volume at the beat frequency, rhythmically becoming louder and softer. Due to the high amplitudes that this can cause, beating generated by two neighboring machines can lead to enormous vibration damage and even machine failure. Because the cause of beating cannot always be eliminated, it is important to keep its damaging effects as small as possible.

The principle of beating and the beat frequency is simulated here. Beating can also be detected in the display of FFT vibration analyzers. The recorded time signals of the vibration velocity and other measured quantities must be of sufficient length. If this type of analyzer is not available, you should become sceptical if amplitudes fluctuate wildly.



This was the case at a pumping station. The operator detected conditions with strongly fluctuating machine and building vibrations. The source was thought to be the pump and an inadequate building foundation. In the control room, the sense was that the vibration intensity was linked to how the pump was operated and that the vibrations only occurred during high pump output. But why? Systematic vibration analyses were carried out. The basic measurements revealed a number of unfavourable conditions that led to pronounced building vibrations.

## The Pumping Station Arrangement



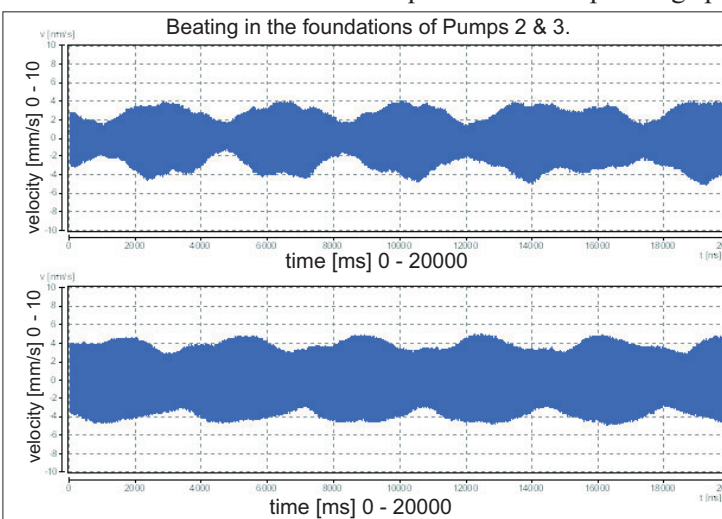
In the pumping station, the pressure increase is achieved in three consecutive centrifugal pumps that run at different speeds. Pump 1 is the slowest, pump 2 runs somewhat faster, and pump 3 is the fastest. On the measurement day, pumps 2 and 3 had a relatively high vibration level when running at a high delivery rate. It dominated the first order in the vibration velocity spectrum. Measurements of the building revealed additional beating in the vibration velocity. Beating changed as the pump speed increased. The operating mode of the pumps also had an influence on the beating. It could be shown that the beating was influenced by the pressure ratio of the pumps to each other. When only pumps 1 and 3 were operated together, the beating was reduced. However, this was not the solution the operator was looking for. On the contrary, increasing the delivery rate further is the order of day. Therefore, avenues were sought to actively reduce vibration.

## Imbalance

The vibration analyses showed that relatively strong rotational vibrations arose as the motor speed increased (1st order). The balance condition was checked. In the process, it was noticed that keys in the couplings protruded or were missing altogether. One of the first measures was to correct this situation. But this was not the only issue.

## Critical Speed

The motor in use had natural frequencies in its operating speed range. At approx. 3600 rpm, the motor even passed through a bending critical speed that led to a marked increase in amplitude peaks on the motor. Phase jumps were also found in the coast down curves.



## Precision balancing

A precision balancing procedure was performed. This reduced the vibration amplitudes, and beating was no longer noticeable in the building. Ultimately, beating in the area of 6 mm/s remained when operating at critical speed, which is why this speed could not be cleared for continuous operation. Extensive reconstruction or the use of a motor without natural frequencies in the operating speed range was a recommendation PRÜFTECHNIK had to make. It was also recommended that the new pump motors meet the requirements of EN ISO 13709. For further information, [fbuder@pruftechnik.ca](mailto:fbuder@pruftechnik.ca).

