Case study: Solving a chatter problem in a cold rolling mill

By Vicente Martin & Tom Farley, Innoval Technology Limited

Innoval Technology provides specialised aluminium product and process consultancy services. Thanks to sound technical capabilities and extensive experience in aluminium manufacturing, Innoval Technology's multidisciplinary teams are able to provide the right mix of skills and expertise to identify the root cause of any quality issue. An example of this is illustrated in the follow case study.

One of our customers was experiencing periodic surface markings in the products manufactured through one of their rolling mills. These markings were preventing them from supplying high surface quality material from this particular mill.

The defect appeared as alternative light and dark transversal stripes on both surfaces of the strip seen under carefully controlled lighting conditions. Spacing of these stripes was regular and measured to be between 20 and 25 mm. No significant change of thickness was measured on the strip and the stripes were more prevalent on fully annealed material.

From the spacing of the defect and knowledge of the mill speed at the time, the frequency of the defect can be easily calculated. Strip marking results from forced vibrations acting on the work rolls and these may be amplified by natural resonances of the rolling mill. These natural resonances are typically between 500 and 1000 Hz and are often referred to as the 5th octave resonances of the mill. In this case, the forced vibration had a lower frequency and was of sufficient amplitude to mark the strip without excitation of any 5th octave resonance of the rolling mill.

The Innoval consultants immediately identified these stripes as mill chatter marks and arranged for vibration measurements to be carried out on the mill.

Accelerometers were attached to each of the roll chocks, sensing motion in the vertical direction, with another accelerometer on the gearbox and a tachometer monitoring rotational speed from a drive coupling.

Innoval personnel analysed the vibration measurement on the mill, as the mill speed was varied, to properly capture and understand the motion of the rolls.

The vibration spectrum showed a significant peak developing at low rolling speeds. The frequency of this peak increased in direct proportion to the rolling speed and the vibration amplitude of this peak also increased with rolling speed. At 470 m/min the peak frequency was close to 315 Hz.

Figure 1 shows a typical vibration acceleration spectrum from one of the work roll chock sensors at a rolling speed of 470 m/min.

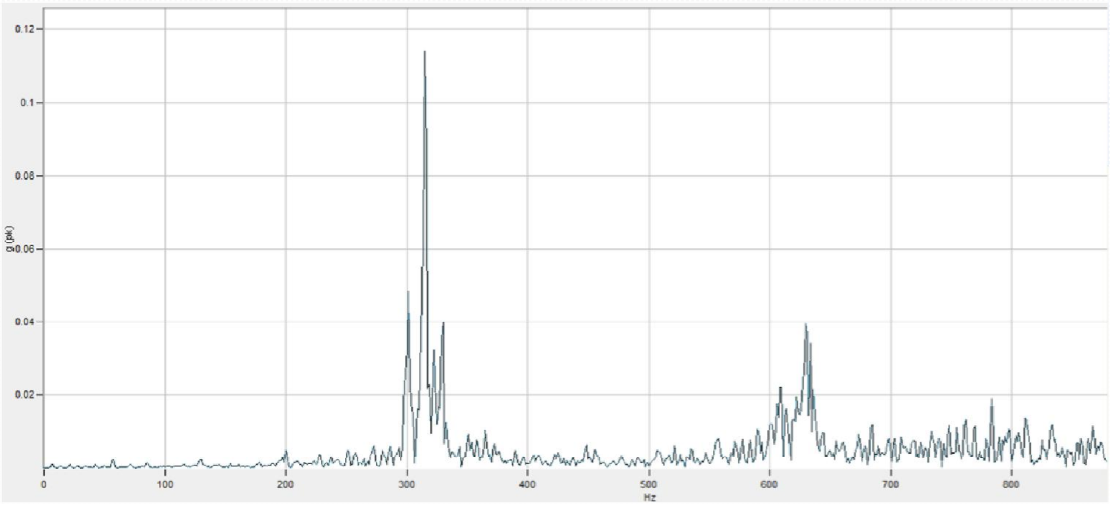

Figure 1. Vibration spectrum from a work roll chock at 470 m/min showing forced vibration peak at 315 Hz

Converting acceleration amplitude to displacement showed the displacement of the roll chocks increased to approximately 0.6 microns at the highest rolling speeds.

This level of displacement is significant relative to the surface roughness of the strip and creates the pattern of chatter marking observed.

This type of speed-dependant vibration will be a mechanical forced vibration within the rolling mill, for example due to a defective gear or bearing. Data was collected for all potential sources of forced vibration and careful analysis of the vibration data showed the source to be a work roll bearing defect.

Figure 2 shows the fundamental work roll bearing defect frequencies based on a 1 Hz work roll rotation frequency. Rolling at 470 m/min corresponds to a work roll frequency of 505 rpm (8.42 Hz) and the forced vibration peak is observed at 37.3 times the work roll frequency which corresponds to the first harmonic (2x) of the fundamental inner race defect of 18.66 x 8.42 Hz. Observations at other rolling speeds were able to confirm this result.

Bearing Defect Type	Fundamental Defect Frequency [Hz]
Inner Race Defect	18.66
Outer Race Defect	16.34
Roller Element Defect	7.53

Figure 2. Fundamental work roll bearing defect frequencies for a shaft speed of 1 Hz

It can be seen in Figure 1 that there are sidebands either side of the forced vibration peak. The spacing of these sidebands is an exact multiple of the rotational frequency of the work roll which is commonly seen for inner race defects where the inner race is rotating. The defect rotates through a variable load zone and produces a modulated time waveform which is seen as a peak with sidebands in the vibration spectrum.

A survey of mill elements known to contribute to chatter was made, identifying defects in the work roll bearings inner races that were likely to create similar markings to the ones experienced in the mill, as shown in Figure 3. These defects were present in all the mill work rolls and were likely created during the chocking and de-chocking operations.

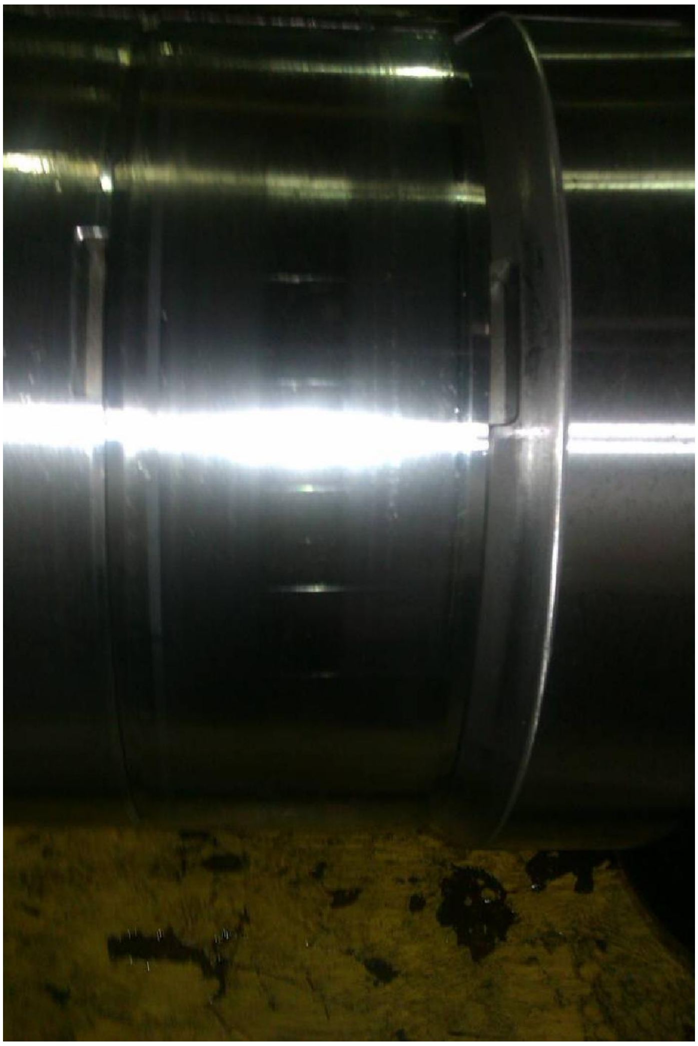

Figure 3. Defects in work roll bearing inner races

After reconditioning the bearing races and improving the chocking operation the plant was able to eliminate the strip markings and manufacture products from this mill with the highest surface quality.