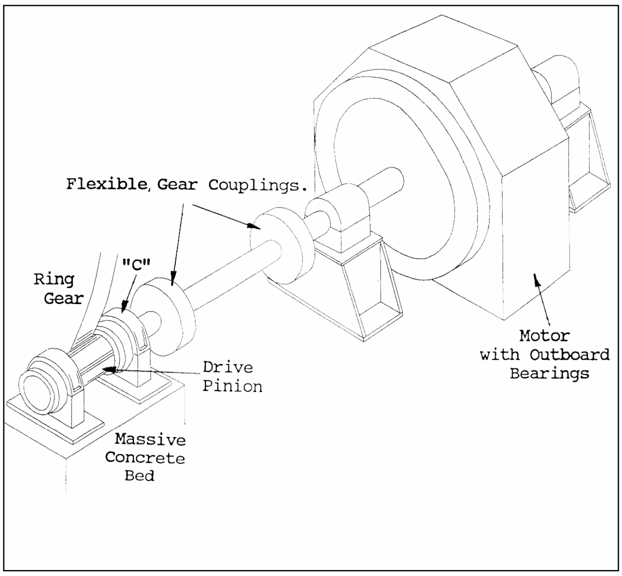
Exploding the myth

EXAMPLE 2

Brief
To carry out a vibration survey of a mill, with special reference to the excess vibration from the number 2 motor and drive shaft. Define the source and cause of the vibration and suggest possible solutions.

Description
Fig 7 shows the arrangement of the motor and drive components.



The motor is 1 725 kW running at 167rev/min. The bearings are white metal non-thrust, the rotor runs to its magnetic centre.

The pinion bearings are Cooper split bearings on a 325 mm diameter shaft, bearing 'C' is the end thrust control.

The couplings are both flexible, single gear type with both the male halves mounted on the intermediate shaft.

The pinion bearing supports were massive while the motor supports were not. Obviously the flexible couplings were expected to protect the motor from the majority of the gearmesh forces.

History
Recent work had been carried out to repair the concrete bed supporting the drive pinion bearings and to replace the Cooper thrust bearing 'C'.

Heavy vibration was accepted as normal from the drive pinion but, since the remedial work, the motor bearings were exhibiting high vibration not previously present.

Inspection of the drive pinion and couplings by site engineers and the manufacturer had failed to find an adequate explanation for the new vibration at the motor. The inspection did identify considerable wear of the pinion and ring gear, but although this was likely to increase the vibration, the pinion was still serviceable. The couplings had slight wear but were serviceable and the end clearances were satisfactory.

Discussion and Results

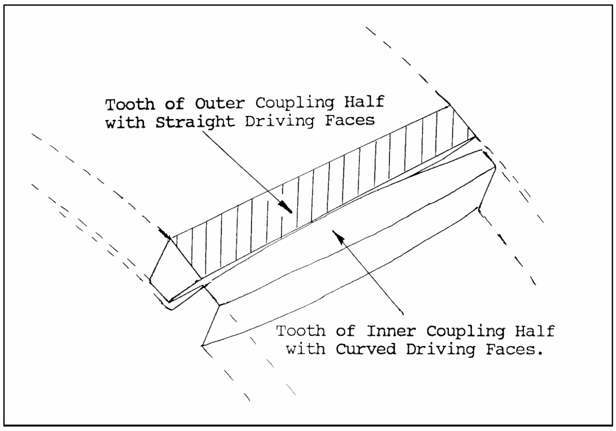
The vibration at the motor was found to be predominantly axial at pinion gear-mesh frequency, and at 39 mm/s rms, was not acceptable. This was the highest vibration amplitude found from any part of this machine.

The axial component of the vibration from the pinion bearing 'C' was 9 mm/s, far less than from the motor.

The radial component of the vibration from the Cooper bearings was a maximum of 24 mm/s. The vibration found from these bearings was described as 'not unusual'.

It is abnormal for gearmesh vibrations from straight gears to produce a predominantly axial vibration, also, when vibrations are transmitted along a shaft, the amplitude tends to diminish as the distance from the source increases. These factors identified the couplings as the most probable source of the axial vibration. However, the mechanism by which the axial vibration was being produced remained obscure.

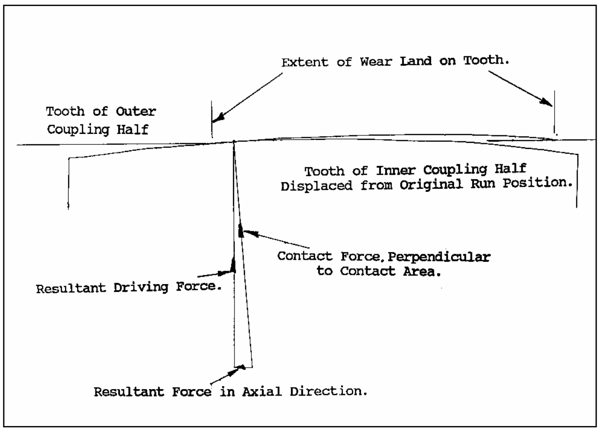
Fig 8 is a schematic drawing of the coupling to show the relationship between one tooth from the outer and one tooth from the inner. The driving face of the tooth on the outer half is cut straight. The driving face of the tooth on the inner half is curved. This is a design feature to allow for slight angular misalignment of the coupling. On the actual coupling the outer is considerably longer than the inner and the two halves of the coupling can move relative to each other allowing considerable tolerance in shaft length when setting up.



When the couplings had been inspected the wear was described as 'slight'. There was a flattened area on the crowns of the drive faces of the teeth on the inner and a polished area on a small area of the drive faces of the teeth of the outer. Since the outer and inner halves of the coupling are of the same material it seems more possible that there is likely to be similar amounts of wear to each half; the resulting depression in the drive faces of the teeth in the outer is unlikely to have well defined edges. Previous to work being done on the bearings the coupling will have been driving with the crown of the teeth of the inner sat in the depression in the teeth of the outer and causing no problem.

311 HOUGH LANE, WOMBWELL, BARNSLEY, S73 0LR.
Tel: (01226) 341800 Fax: (01226) 341899
Company Number 3058547– Registered in England and Wales

INSIGHT MONITORING SERVICES Ltd.



If, during the work carried out previously, the thrust bearing was replaced in a slightly different position the effective length of the shaft is altered. Normally this would be accommodated by the coupling halves sliding relative to each other but with worn couplings they try to run back to their previous fit creating a force along the shaft either pushing the ends apart or pulling them together. The mechanism of this is illustrated in Fig 9.

It is clear that the resultant force along the shaft is proportional to the torque and, with a steady torque, would probably have been no problem, but in this case the torque is pulsing at gearmesh frequency so the force along the shaft is also pulsing at gearmesh frequency.

If we compare the relative stiffness of the motor bearing pedestal and the pinion bearing pedestal, then consider them both to be reacting to the forces along the shaft then we would expect the less stiff motor bearing to exhibit the most movement. This pattern is shown clearly in the results.

The recommendation was to replace one coupling with a new one. The new coupling could then take up the difference in bearing centre distances between the old and new set-ups, thus allowing the remaining old coupling to move to its old running position.

The action taken was to change both couplings and the intermediate shaft since a complete assembly was available. The assembly was second-hand but the exchange was relatively quick and easy. The alternative of a new coupling involved long lead times and the vibration was considered bad enough to cause further and, more expensive damage.

Changing the shaft and couplings reduced the vibration at the motor from 39 mm/s to 10.5 mm/s, not perfect but well within the normal acceptance limits for machines of this group, as defined in British Standards. Subsequent monitoring showed that the vibration was continuing to decrease.

When setting up machines from new the design often allows tolerances which will disappear as the machines run in. When dealing with couplings or bearings the best answer is to fit new if the set-up has been disturbed. Where bearings or couplings must be re-used then every effort must be made to duplicate the original set-up.

For example couplings and gears should be marked up relative to each other before being disturbed and then fitted back to the original positions.

Shaft and bearing centres which are not fixed should be measured accurately before being disturbed so that bearings can be refitted to the original positions.

INSIGHT MONITORING SERVICES Ltd.
311 HOUGH LANE, WOMBWELL, BARNSLEY, S73 0LR.
Tel: (01226) 341800 Fax: (01226) 341899
Company Number 3058547– Registered in England and Wales