Cautionary Tale XXXII - Spring Equipment

The equipment used to manufacture and to test springs is mostly unique and exclusive to our industry. As other articles in this edition will explain, you need a machine with high stiffness and great precision in order to make compression springs with close tolerances. You need a similarly endowed test machine to measure accurately the load and rate of compression springs.

However good your spring coiling and testing equipment is though, it is inevitable that an axially loaded compression spring will produce forces that are not axial, and usually, are not wanted. That is because you cannot make a perfect spring that is geometrically symmetrical and accurately square, despite the claims of the best manufacturers of spring coiling equipment about how good the latest generation of spring equipment has become - it is, indeed, better than heretofore, but ….

The point of this cautionary tale is to relate that these non-axial forces are inevitable and will change as the spring is compressed, and what is more they can be measured, and by both manufacture and design, they can be minimised, but not eliminated.

A compression spring, when loaded, will exert shear forces and a torque because the axis of the main load is not coincident with the geometrical axis, the shear force will give rise to a tilting moment acting upon the end coil.

From the considerable research work undertaken by IST, it has been shown that the non-axial performance of a spring is directly related to the lateral rate (Figure 1). The higher the lateral rate, the higher the potential non-axial forces. The lateral shear force can be as high as 15% of the axial load, but as Figure 1 shows, it may not be a maximum at the maximum deflection, because a spring tends to ‘square up’ under load. IST know this because they build machines to measure these non-axial forces. That is to say, a conventional spring load tester but with six load cells instead of one, arranged so as to measure the magnitude of the forces at all positions of the available deflection range of the spring. Having measured these forces they are then analysed using a computer to quantify their magnitude and the position at which the forces are acting. Hence the test machine will measure the axial load, quantify the position at which this axial force is acting compared with the geometrical axis (the centre of the top and bottom end coils, which have to be accurately located for this type of testing) and both the shear forces and the torque output.

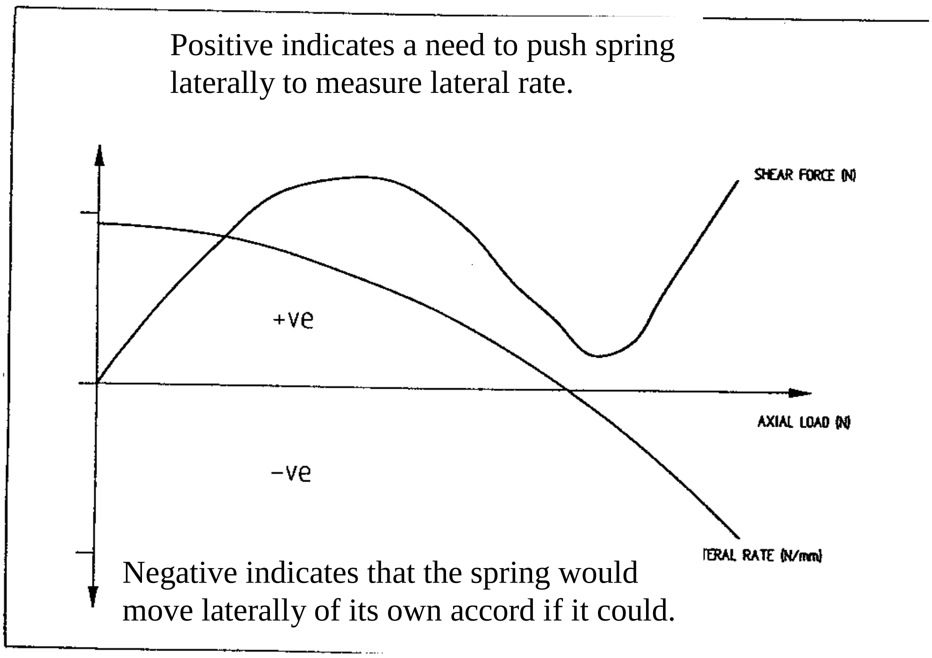

Figure 1: Schematic relationship between Shear Force and Lateral Rate

Having explained how the non-axial forces are measured, it is important to recognise that these forces are minimised by accurate spring manufacture laying-on the end coils at each end in an accurate and symmetrical way is the most important and difficult to visualise. The end squareness and parallelism are also obvious influences, but however efficiently and accurately you coil your springs and grind their end coils, there will still be significant non-axial forces.

So how can these forces be minimised by design? The greater the number of coils, the lower the non-axial forces will be, and what is more, a whole number of coils will give significantly lower non-axial forces than designs with x + ½ active coils, as shown in Figure 2.

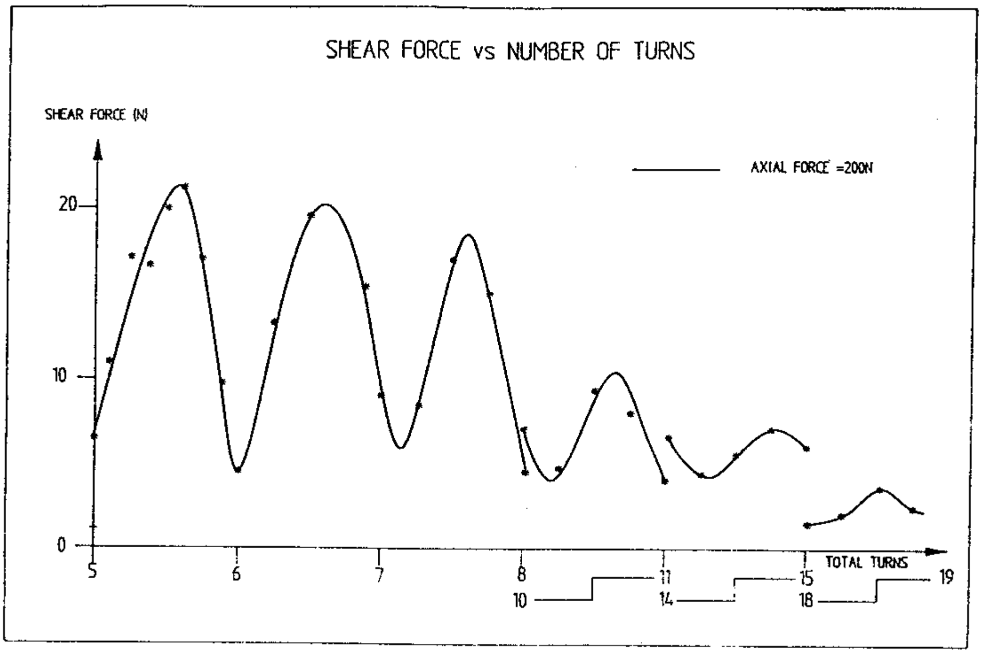

Figure 2: Effect of Number of Turns on Shear Force

If there are x + ½ active coils there will be x coils contributing to the axial load on one side of the spring, but x + ½ on the other side, and so it can easily be imagined why such springs give relatively high non-axial forces.

Much more could be written about this subject, but the author would encourage readers to request further explanation and discussion before embarking on a cautionary tale of such technical complexity.

Mark Hayes is the Senior Metallurgist at the Institute of Spring Technology (IST) in Sheffield, England. He will be at Springworld in Chicago (Booth 0909) on 18 – 20th October 2006, and would encourage readers to identify other topics that would enable this column to be continued. Alternatively, he maybe contacted by telephone +44 114 252 7984 or Email m.hayes@ist.org.uk.