Technically Speaking XIV

Spring Load Testing

A spring manufacturer recently wrote to the author that he had discovered something alarming. He collected a small batch of springs from the load test area in the factory and put them in his pocket. Some time later he re-checked the load test results and was surprised that the spring rate was reduced. He realised that this could be due to the increase of temperature from his pocket being warmer than the shop floor, but thought that the change would be very small, almost too small to measure. The change of rate was 0.4%, and this prompted the question, “Could this be correct?”

The answer is that, if the change of temperature was 15°C (27°F), then the change in rate of 0.4% is about right whatever the spring material. In the context of compression spring tolerances, which are usually about +/- 4%, the effect of this small change of temperature is not very great, but it is certainly large enough to measure. For springs supplied to a very precise rate, then this change is important for the spring manufacturer’s load test facilities, which ought to be kept in a temperature controlled environment. The change of rate will occur over a wide range of temperatures within the recommended range for each spring material, and whilst the change is not precisely linear, or exactly the same for each material, it is about 4% for every 150°C temperature change. This means springs operating at elevated temperatures will be weaker than shown on the spring manufacturer’s test certificate, whose test would be done at ambient. Naturally, springs operating below zero will be stronger – the author suspects that most end users don’t realise this temperature effect on springs.

The purpose of this article is to explore the causes of the change of rate with temperature. One effect is linear expansivity. As spring materials get hotter, their volume increases. For instance the expansivity of steel is $15*10^{-6}$ per degree centigrade. That is to say the section of the wire will increase by $15*15*100*10^{-6}$ % for a 15° temperature rise, or about 0.02%. The rate of a compression spring is proportional to the wire diameter to the power 4, and so the expansivity will account for an increase in rate of about 0.08%. The expansivity will also cause the outside diameter of the spring to increase, but this is an even smaller effect and will cause a very small reduction in rate. So the net effect of expansivity is to cause the rate to go up as temperature increases. Clearly, there is another more important parameter affecting the rate.

That other parameter is the modulus of the spring material. The torsional modulus, G, of spring steel is often quoted as a fixed value, but it varies with temperature, decreasing as temperature increases. The modulus change is not exactly the same for all spring materials, and the change is not exactly linear, if the published values are accurate. However, the change of modulus with temperature around ambient is about 4% for every 150°C, or 0.4% for 15°C exactly as observed at the start of this article. A typical load/deflection characteristic for a compression spring is illustrated in figure 1 – for greater precision it would an improvement if the test temperature were recorded.

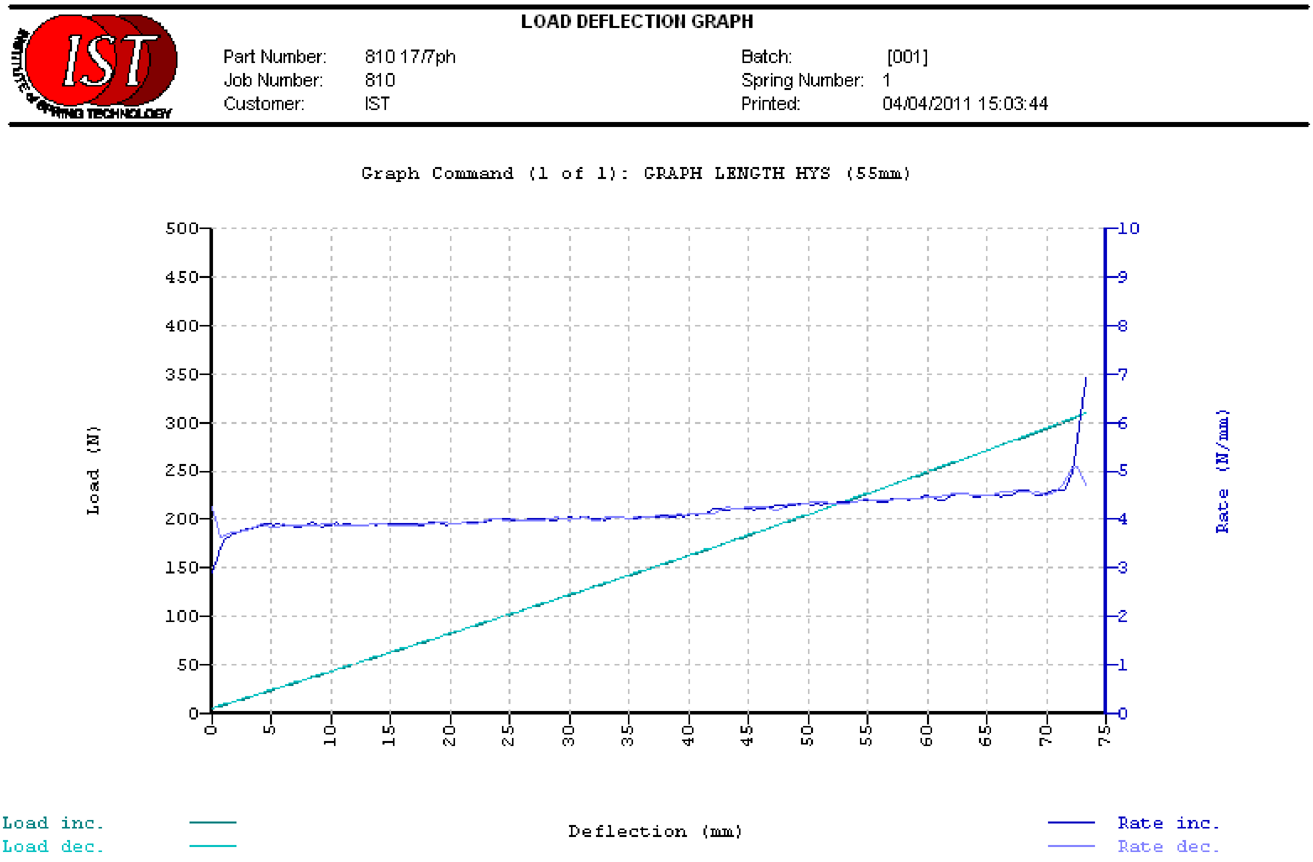

Figure 1 Rate increases after a deflection of 40mm due to a reduction in the number of active coils.

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Readers are encouraged to contact him with comments about this technically speaking column, and with subjects that they would like to be addressed in future.
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