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Closed length

A significant debate has been initiated in recent weeks by users of "Spring Calculator Professional" (SCP) concerning the closed length to be used for verifying a compression spring design. This article aims to set down IST's philosophy with respect to calculating the closed length (often called the block or solid length), and how that compares with the closed length that is calculated in standards – this being of most importance for compression springs with closed and ground ends. Recent discussions that the author has had with spring manufacturers and users showed a clear division of opinion and prompted some measurements to be made on typical springs so that actual and theoretical results can be compared.

To start, it is necessary to clarify how these measurements were made. A range of springs of various coiling ratios was obtained, and these were measured and load tested per normal methods for free length, rate, outside diameter and wire diameter. Also measured was the closed length, which was measured on a load tester using an applied load of 50% more than the theoretical closed load, as calculated using the formula that all international standards utilise. Finally, the tip thickness was measured using a shadowgraph, taking care to measure the tip thickness at each end as springs are seldom completely symmetrical in this respect however carefully they are ground. These measurements were then compared with the calculations made in SCP. Table 1 gives the results

Wire, d	Diameter, D_o	Total coils, n_t	Rate, R	Average tip, t	Closed Length, L_c		
					Actual	EN calc.	SCP
5.58	43.20	15.5	13.02	2.79(50%)	86.8	87.03	86.49
3.74	27.20	7.90	26.02	1.31(35%)	28.65	29.75	28.43
3.70	29.70	6.46	23.23	1.11(30%)	23.06	24.11	22.42
4.80	40.56	11.58	11.66	1.92(40%)	55.07	56.00	54.62
2.29	6.88	7.20	528	0.58(25%)	16.84	16.68	15.36
1.98	48.46	4.50	0.51	0.99(50%)	8.96	9.02	8.91

Table 1 Measurement results

The EN calculated result is $n_t * d_{max}$ where d_{max} is the wire diameter at the maximum of its permitted diameter tolerance at the point of supply to the spring manufacturer. The SCP calculated result is $(n_t - 1) * d + 2t$.

This small sample shows that it would be inappropriate to utilise the EN calculation for the purpose of verifying spring designs particularly when the tip thickness is less than 50% of d, as some users of SCP have proposed. This is because the actual closed length in five of these six designs is shorter than the measured diameter, and the sixth case (d = 2.29mm) is for a spring with an exceptionally small coiling ratio. The small ratio would lead to considerable distortion of the wire diameter when it was coiled. The case of small index springs requires further investigation.

If it is required that the stress at the EN calculated value of L_c is needed then that length may be input (say as L3) to the program and then the stress would be calculated.

This small sample also shows that the SCP calculated value is rather smaller than the actual in every instance, and this is not ideal either. Hence a better formula for calculating L_c is required. Ideally the distortion of the wire diameter due to coiling would be calculated and used here, but as far as IST are aware, an accurate formula for this section distortion is not yet available. Until such time as it is available, then it is proposed to change the formula in SCP to

$$L_c = (n_t - 1) * d_{max} + 2t$$

This would give a result nearer to the actual value in every instance. IST maintain that use of a formula that considers the tip thickness is an essential step in the verification of compression spring designs, and it is hoped that this article confirms the need for this approach.

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