EVALUATION OF HELICAL SPRINGS

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Abstract. The springs of different construction and size are an important part of almost all engine plants. Their quality control is necessary likewise the quality control of all the other parts. The resulting quality depends on many factors – on correct calculation, on the suitable selected material, its heat treatment and on the service conditions. The concrete method of operation is proved by the example of three helical springs of an agricultural machine.

Key words: helical spring, material, heat treatment, metallography, quality evaluation.

Introduction

The springs are integral parts of machines and engine plants. The accurate service depends on its workmanship. The spring defect can evoke an accident with very heavy effects. Therefore, it is necessary to take care of their design, production and operation. The importance follows from the knowledge acquired at the quality evaluation of three helical springs. The evaluation was carried out at our department. The aim of the test was the complex quality assessment. After the delivery the springs were mounted in a universal combined stubble plough. In the course of service a slackening, the preload decrease occurs. During the service the preload was continuously adjusted by the operator. According to the user's opinion it was evoked by the incorrect spring production. The deterioration of the machine could be the consequence.

Materials and methods

Three compression helical springs of an agricultural machine were tested. All springs were made by the inland manufacturer, but the material was not known. Also the values of the working load were not known, therefore it was not possible to check their calculation accuracy. For the quality evaluation the methods were chosen, by which their spring constant, the used material and the truth to the heat treatment were possible to judge. Before the tests the springs were measured and marked. The initial height, the used wire diameter, the outside and inside spring diameter, were measured. The results are presented in Table 1.

Table 1

Basic sizes of tested springs

Spring	Initial height l, mm	Wire diameter D, mm	Inside diameter D_{min}, mm	Outside diameter D_{max}, mm
1	323-331	20	96.5-97.0	135.5-136.0
2	323-326	20	95.0	135.0
3	352-355	22	115.0-115.5	159.0

pitch diameter $D = (D_{max} + D_{min})/2$

The spring constant was determinated using the universal tensile testing machine ZDM 5 at the load capacity range 50 kN and the rate of loading 20 $\text{mm}\cdot\text{min}^{-1}$. The springs were placed between the pressure plates without any clamping. The user's requirement was to load the spring to the close touch of coils. Next tests were carried out after the cutting of springs by use of the metallographic samples preparation apparatus. The chemical composition analysis, the microstructure study and the hardness measuring are the basic pieces of information for the suitability of the used material and its heat treatment. The measurement of the variation in micro hardness is necessary to do at the surface treated springs (e.g. by shot peening).

Results and discussion

At the tests all springs were loaded, unloaded and again loaded and unloaded. All test results are shown in Figures 1-3 and presented in Table 2.

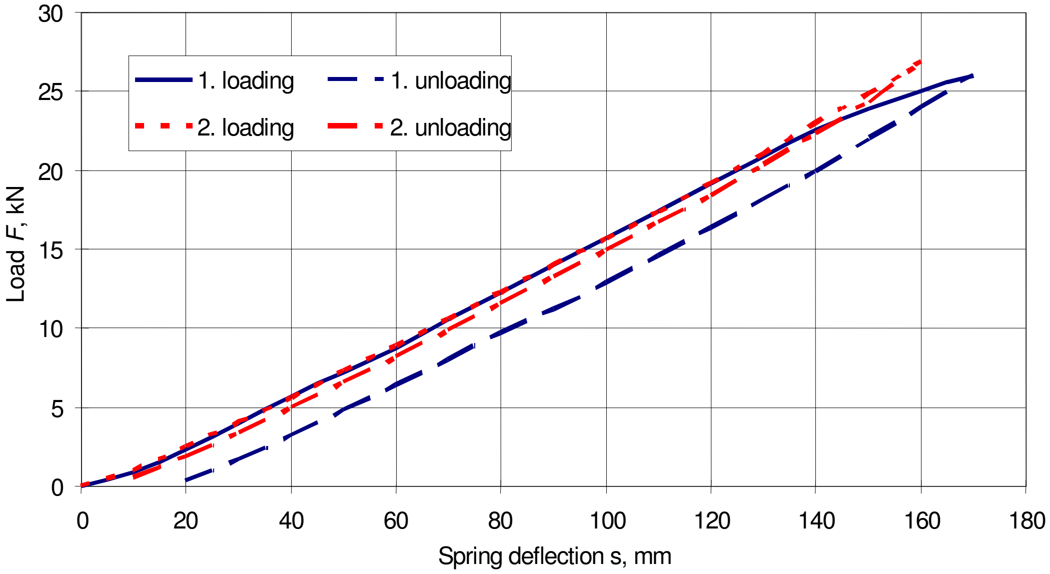

Fig. 1. **The behaviour of the spring (sample No 1)**

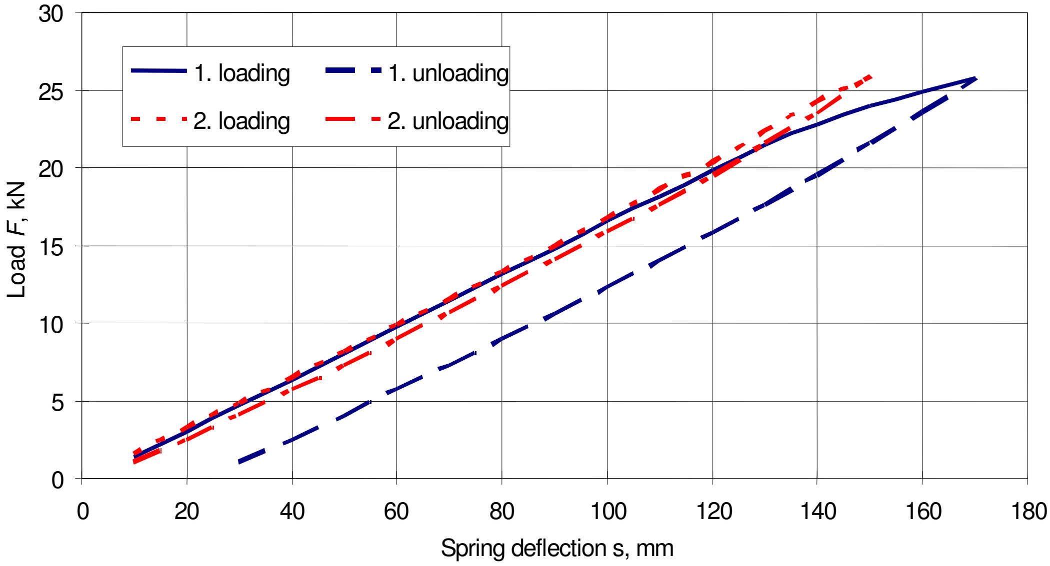

Fig. 2. **The behaviour of the spring (sample No 2)**

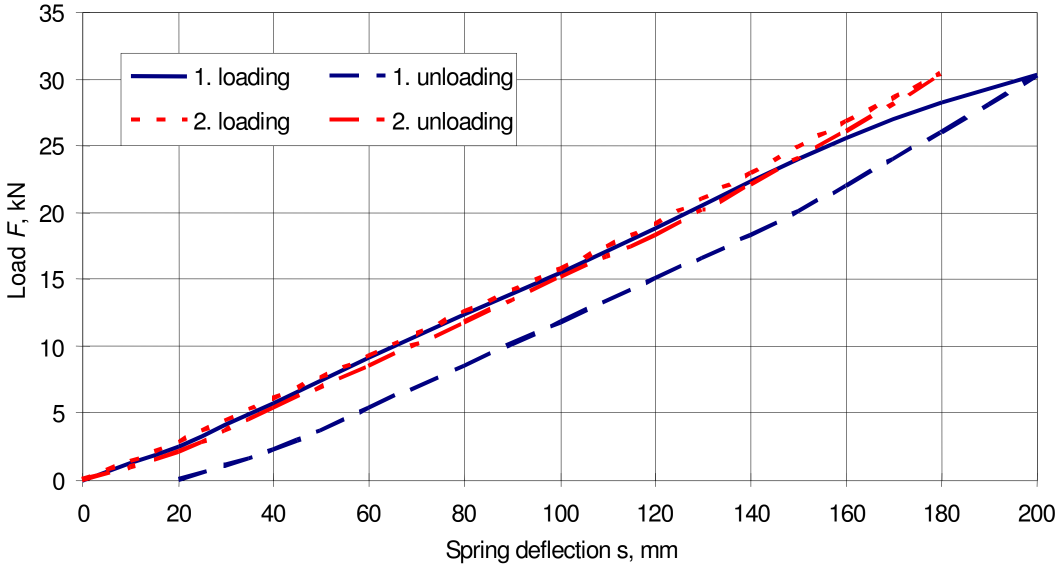

Fig. 3. **The behaviour of the spring (sample No 3)**

The spring constant is calculated using the relation

$$k = \frac{dF}{ds} . \qquad (1)$$

After the substitution of the measured values in the Equation (1) we get the results presented in Table 2.

Table 2

The summary of the test results

Spring No.	Loading, spring constant k (kN·m^{-1})		Unloading, spring constant k (kN·m^{-1})	
	At 1st loading	At 2nd loading	At 1st unloading	At 2nd unloading
1	157.5	156.5	129.0	149.0
2	165.5	167.5	122.5	158.5
3	156.0	158.0	118.0	151.0

It has been determined that at all delivered springs it comes to their (different) irreversible deformation, namely after the first loading, as it follows from the data in Table 3.

Table 3

The spring shortening at the tests

Spring No.	spring shortening Δs (mm)	
	After the 1st loading and unloading	After the 2nd loading and unloading
1	15	3
2	23	3
3	23	3

The study of the used material and its heat treatment was the part of the quality evaluation. The chemical composition analysis results of the used material are presented in Table 4.

Table 4

Chemical composition analysis

	Chemical composition (wt. %)									
	C	Si	Mn	Cr	Cu	Ti	Ni	V	P	S
14 260	0.5-0.6	1.3-1.6	0.5-0.8	0.5-0.7	< 0.3	-	< 0.5	-	<0.035	<0.035
Spring 1	0.56	1.25	0.68	0.51	0.13	0.032	0.080	0.029	-	-
Spring 2	0.55	1.28	0.66	0.51	0.15	0.032	0.075	0.031	-	-
Spring 3	0.58	1.37	0.58	0.59	0.15	0.037	0.088	0.035	-	-

The heat treatment was made practically conformably. Detailed microstructure description is presented in Table 5.

Table 5

Spring metal microstructure

Spring No.	Microstructure description
1	sorbite directed along the original large-grained needle-like martensite – mild overheated at hardening (Fig. 4a), partial decarbonized surface – max. of 0.004 mm depth (Fig. 4b), surface treatment was not determined, hardness 499 HBW (1726 MPa), the corresponding steel is 14 260.8 (ČSN 41 4260.8)
2	at the hardening, partial decarbonized surface (max. of 0.004 sorbite directed along the original large-grained needle-like martensite – mild overheated mm depth), surface treatment was not determined, hardness 482 HBW (1648 MPa), the corresponding steel is 14 260.8 (ČSN 41 4260.8)
3	sorbite without ferrite, partial decarbonized surface (max. of 0.004 mm depth, surface treatment was not determined, hardness 492 HBW (1697 MPa), the corresponding steel is 14 260.8 (ČSN 41 4260.8)

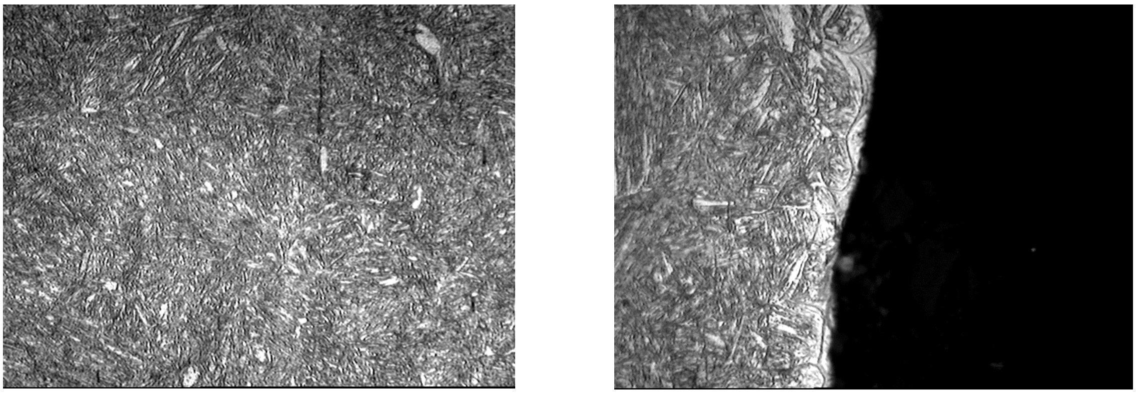
a) b)

Fig. 4. **Microstructure of the spring No 1 material**

References

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