

Modernization of device for compression springs hardening

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Abstract. Springs operating at high load speeds with coils collision or under static low-cycle contact load between coils, exceeding the strength of the compression of the spring, are used in engineering, auto and defense industries. Unfavourable conditions in the operation lead to considerable residual deformations, development of latent defects of the metal of springs and their breakage. This decreases the reliability and safety of machines and pieces of machinery. The recommended method to harden and control the quality of such springs is plastic surface treatment – contact predeformation. To harden conical springs having the forming surface of a complex shape, the modernization of the device for contact spring hardening has been offered. The device can be used in mass industry. The advantage of the modernized device as compared to all known is that it can increase the resource of conical compression springs up to 40%.

1. Introduction

Safety and stable operating characteristics of most of machines are limited by the resource of springs. The main consumers of this product are engineering, auto and defense industries. The improvement of operating characteristics of springs is to a large extent determined by the demands of these industries in terms of increasing their reliability, accuracy, reducing their weight and dimension [1]. Much attention is paid to high load springs, for example, the springs of the valves of internal combustion engines and fuel injection equipment of diesels, suspension springs, lock valve springs and other springs operating at high load speeds with coils collision or under static low-cycle contact load between coils exceeding the strength of the compression of the spring.

Unfavourable conditions in the operation lead to considerable residual deformations, development of latent defects of the metal of springs and their breakage. This decreases the reliability and safety of machines and pieces of machinery. For example, the destruction of the engine valve spring leads to an emergency failure of the whole engine, including the breakage of other parts. The performance requirements of a valve spring imply that it must not fail by fracture or by load, relaxation loses so much of its controlling force that it fails to maintain control between a tappet and a cam [2]. Compression of automobile suspension springs, as a result of coils collision, is accompanied by an early fatigue of frame rails and the body of a car. Malfunctions of lock valves in automobile cargo lifts as a result of the breakage or compression of the spring (fig. 1) lead to an emergency situation.





Figure 1. Defective springs of lock valves of a cargo lift B-28 (OOO KPK “Avtokranservis”, Stavropol).

The extremely important trend connected with the use of high load springs is the development of technologies of springs hardening in the process of manufacturing [3, 4]. One of the methods to harden the strings is plastic surface treatment – contact predeformation that is the additional compression of spring coils after their contact. As a result, a stripe of hardened metal (cold working) is formed along the line of coils contact. The process of hardening is accompanied by structural changes in the deformed layer and, correspondingly, by increasing its firmness and strength, the formation of favourable residual compressive stress and entirely new macro- and microgeometry of the surface of spring material [5]. The resource of compression coil springs hardened by means of such a method increases up to 40%. It is stated that the use of contact predeformation at 200-250°C makes it possible to increase the resource of springs to 60% [6]. Appliance of contact predeformation as a control operation prevents from fixing low-quality springs in work pieces. The increase of the spring resource by 15-30% makes it possible to increase reliability of machines and pieces of machinery by 15-25% [7].

Conical springs possess higher stability than cylindrical ones do. Being compressed, they have minimal height and along with cylindrical springs are widely used in in engineering, auto industries and other branches. Therefore, an urgent task is to modernize known devices to have the possibility of hardening conical compression springs.

2. Results and Discussion

For contact predeformation of cylindrical coil compression springs, known devices are used [5, 8, 9]. The analogous one is a device (fig. 2) that contains the upper and lower inserts, a bucket for fixing the inserts inside it and the test spring between them and a drift with a spherical surface contacting with a circular surface of the upper insert. The inner diameter of the bucket has the limits from the diameter of a compressed cylindrical spring to the diameter of a coiled spring. The upper insert and the drift are connected by means of a shouldered screw [8]. The disadvantage of the device is the impossibility to harden conical compression springs having the forming surface of a complex shape (conical surface or rotational paraboloid).



Figure 2. Device for springs contact predeformation.

The indicated disadvantage can be eliminated by new elements and new connections, namely: the device contains the upper and lower inserts, a bucket for fixing the inserts inside it and a test spring between them and a drift with a spherical surface contacting with a circular surface of the upper insert with the lower insert being fixed so that it could rotate about the bucket axis and the upper one so that it could rotate and shift along the bucket axis and diverge of the axis from the axis of the drift. The lower insert is connected with the lower cylinder of the press by the rod and the upper one is connected with the drift by a shouldered screw to perform the removal of the spring out of the device (fig. 3). The diameter of the inner operating surface of the bucket is equal to the outer diameter of the compressed spring and has the form (conical or rotational paraboloid) that clasps the outer surface of the compressed spring. Cylindrical surface of the lower insert is manufactured with a circular channel on its side face having the diameter corresponding to the minimal inner diameter from the narrower side of the spring and with the depth not less than the height of a spring coil. Cylindrical surface of the side face of the upper insert has a circular channel corresponding to the ultimate inner diameter from the wider side of the spring and with the depth not less than the height of a spring coil. The channel is performed according to the shape (conical or rotational paraboloid) of the inner surface of the compressed spring.

Figure 3 presents a device consisting of a bucket 2 fixed on the plate 1. A test conical spring 3, the upper insert 4 connected with the drift 5 by a shouldered screw 6 and the lower insert 7 connected with the lower cylinder of the press by the rod 8 are placed in the bucket. Herewith, the side faces of the compressed spring contact with circular channels on the side faces of the inserts 4 and 7 abutting from the narrower side of the spring against the channel of the lower insert and from the wider side of the spring against the channel of the upper insert and the coils contact with the inner operating surface of the bucket 2 that clasps the outer surface of the compressed spring and has conical or rotational paraboloid shape.

The device operates as follows. It is fixed on the immobile table of the press and the drift 5 is fastened to the upper movable plate of the press. A test conical spring 3 with its narrower side being placed down into the bucket is fixed so that its side faces contact with circular channels of side faces of the inserts 4 and 7. Then the drift 5 is moved down by means of the press, the spring, being compressed, increases its outer diameter until all its coils come into constant contact with the inner surface of the bucket 2.

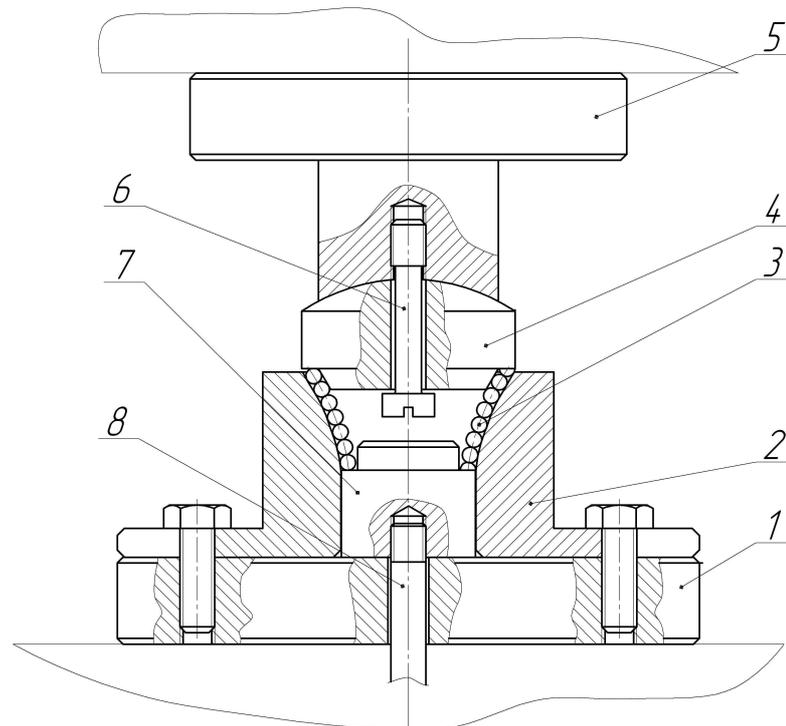


Figure 3. Device for conical springs contact predeformation.

Due to the contact of side faces of the spring with circular channels of side faces of the inserts and the contact of the spring coils with the inner operating surface of the bucket clamping the outer surface of the compressed spring and having the conical shape or a shape of a rotational paraboloid the compressed conical spring will take a correct geometric form. Due to the presence of the spherical surface on the drift 5 and the upper insert the force of the press will be equally dispensed to the diameter of the compressed spring. After holding on load of $10 \dots 300 F_3$ (F_3 – spring force before coils contact) the drift 5 with the insert 4 is raised to loosen the spring 3. The spring 3 is displaced from the bucket 2 by the movement of the lower cylinder of the press by means of the rod 8 and the lower insert 7. The spring 3 is removed or pushed off the lower insert 7 by means of known methods and devices used while pressing and sent for further manufacturing. The research method of mode of deformation of coil compression springs while plastic hardening is presented in the work [10]. For a conical spring the mean spring diameter in the calculations should be taken as midvalue between its ultimate and minimal diameters.

3. Conclusion

The device for hardening and quality control of the springs by the method of plastic treatment has been modernized. It can be used in mass production. The advantage of the modernized device compared to known ones is that it makes it possible to increase the resource of conical compression springs having complicated shapes of the forming surface.

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