COMPOSITE HEAT TREATMENT WITH INDUCTION HEATING OF TRACTOR REAR HALF-AXLES

V. S. Baranov, L. S. Kosmovich, and A. L. Parnas

The rear half-axle of a Belarus' tractor (Fig. 1) is subjected to significant alternating sign loads, which are constantly increasing with improvement in the base model and an increase in the power and operating speed of the tractor. However, the use of widely known methods of hardening of such parts (hardening with simultaneous heating of the whole surface, continuous hardening or simultaneous hardening of the whole surface with heating by a straight-through loop inductor of the rotating part) was inapplicable in this case as the result of the complex configuration of the part including a difference in diameters of the individual portions of from 70 to 100 mm and the presence of a short circular projection (shoulder), a key slot, a rack on the wheel end, and splines for connecting the half-axle to the reduction gear. The above types of treatment of such parts led to significantly non-uniform heating, the formation of cracks, and significant deformation.

It was possible to eliminate these shortcomings by the use of the following method.

1. The part is heated by the continuous method with a 2.4-kHz frequency by a multiturn cylindrical inductor with turns located at an angle of 17-25° in relation to a plane normal to the axis of the part. The use of such an inductor made it possible to avoid overheating of the edges of the key slot located along the axis of the part and also of the teeth of the rack located perpendicular to the direction of the axis.

2. The shoulder is protected from overheating by a controllable screen which is a closed water-cooled ring, a portion of the perimeter of which (the active) is concentric to the shoulder and a portion of which (tail) of which is colinear to the turns of the inductor. The screen has the capability of rotating around the axies of the part, which changes the link between the inductor and the tail from the maximum when the plane of the tail is parallel to the turns of the inductor (Fig. 2a) to the minimum when the plane of the tail deviates by the maximum from the plane of the inductor turns (Fig. 2b) [6].

3. The end of the half-axle with the 70-mm diameter neck is heated by an eddy current concentrator located in the gap between the neck and the inductor, which makes it possible to harden the whole part without changing the inductor or the conditions.

4. Quenching is done with water from a sprayer located after the inductor (in the direction of hardening) which quenches only a portion of the circumference of the rotating half-axle. The quantity of water supplied to the sprayer is measured by float-type flow meters.

5. The part being quenched is partially heated by the longitudinal branches of the active conductor connecting the inductor and the coil for heating for tempering located after the sprayer. Heating reduces the average quenching rate of the part.

6. Tempering of the part, the same as hardening, is done by a continuous ring inductor connected to the longitudinal branches of the active drive. To regulate the intensity of cooling the inductor is made in the form of a polygon the sides of which are equipped with packets of iron (magnetic conductors) which may be rotated around the current conductor, directing the magnetic flux to the part or away from it [1].

The use of such a method made it possible to replace the 38KhGS steel of which the half-axles were produced by 40Kh steel and to obtain a uniform-hardened case from 4.5 to 8.0 mm thick over the whole surface of the part. The hardeness of the hardened case is 45-54 HRC\textsubscript{eq} and the microstructure troostite and martensite.

Fig. 1. Plan of placement of the half-axle in the hardening machine: 1) rear half-axle in centers; 2) shoulder; 3) key slot; 4) rack; 5) splines; 6) inductor moving in the direction of the arrow; 7) rotating screen; 8) neck of the half-axle; 9) concentrator.

Fig. 2. Rotating screen in the positions of maximum (a) and minimum (b) screening: 1) half-axle; 2) rotating screen; 3) inductor.

Stand tests of the half-axles were made on a resonant stand. The frequency of loading of the parts in the tests was about 20 sec\(^{-1}\). The load was controlled by the current on the vibrator drive. The tests of standard half-axles were made until failure and of the experimental* until not less than \(2.5 \times 10^6\) cycles. With such loading the experimental half-axles withstood 5-6 times more cycles than the standard without failure.

A special hardening machine equipped with mechanisms for automatic loading and unloading of the parts and a control system providing the specified hardening cycle was designed for hardening of half-axles.

The introduction of induction hardening of a half-axle over its whole length makes it possible to not only increase its fatigue resistance but also to reduce its cost as the replacement of 38KhGS steel by the less expensive 40Kh steel. The expected saving is 1.44 million rubles.

One of the basic factors determining the quality of heat treatment, its labor requirement, and related operations is warping of parts.

*The stand tests were made under the supervision of V. N. Koshman.