Modeling the Strength Characteristics of Shaped Cutters for Turning Locomotive Wheels

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***Abstract*—Due to their more intensive use compared to wagon wheels, locomotive wheels are subject to significantly greater wear. Therefore, they require more frequent restoration repairs during which the original profile of the working surface is recreated. There are two main technologies for such repairs worldwide – wheel turning and wheel milling. In the countries of the former USSR, the restoration repair of locomotive wheels is most often used on KZh-20 machines. At the same time, the quality of the processed surface of the wheels depends on the maintenance of the shaped cutters. The authors in previous works proposed new designs of cutters with a large number of cutting elements. This work is devoted to modeling the strength of such cutters, and FEM was chosen as the main technique for analysis. As a result of research, it was proven that using new cutter designs will not worsen their performance but will help improve performance characteristics.**

Keywords—wheel turning and wheel milling, restoration, working surface, locomotive wheels, KZh-20 machines

I. Introduction

The operation of locomotives, as opposed to wagons, has some significant differences. These differences are associated not only with the much more complex design of these means of transport but also with the fact that the locomotive has the task of providing traction for the entire train. This difference leads to the fact that the working surfaces of locomotive wheels are subject to a more intense wear process and, accordingly, require more frequent repairs. In addition to changing the profile shape, which can affect the safety of the locomotive, fatigue damage accumulates in the surface layers [1]. Restorative repairs can eliminate these shortcomings. Most often, such repairs involve the removal of defective near-surface metal layers of locomotive wheel tires using mechanical processing. It is obvious that in this case, the outer diameter of the bandage decreases. After several treatments of this type, the specified diameter reaches critical values, and the bandage must be replaced.

To avoid this situation and extend the service life of the bandages, it is proposed to carry out surfacing of worn surfaces. Such surfacing can be carried out using both traditional welding methods [2] and laser technologies [3]. However, such technologies have their drawbacks. Firstly, effective surfacing can be carried out only when the wheelset is rolled out from under the locomotive, which is only possible during a major overhaul. Secondly, wheelsets with bandages restored by surfacing can only be used for relatively uncritical operating conditions of rolling stock, i.e. in cases where the destruction of the bandage does not threaten catastrophic consequences. For example, such technologies are used to operate locomotives in industrial enterprises, such as metallurgical or mining and processing plants, where travel speeds are not very high.

It should be noted that for wheelsets restored in this way, before putting them into operation, various surface treatment methods are proposed, which can improve their quality, reduce the number of critical defects, reduce or improve the fields of residual stresses, etc. Such processing methods include mechanical hardening by knurling [4], laser [5] or induction hardening [6].

In any case, the above methods can be effectively used in the case of rolling out wheel pairs of locomotives, which makes sense when overhauling rolling stock. Unfortunately, the need for routine repairs of wheel sets is a much more frequent need. This is usually due to the operating conditions of the rolling stock, for example, in mountainous areas or in areas with complex terrain, where there are a large number of small radius curves. In this case, the wear rate of the working surfaces of locomotive wheels is much higher and there is a need to treat them without rolling out the wheel pairs. Traditionally, two technologies for such processing of locomotive wheel pairs compete in the world.

Wheel turning technology is widespread in European countries, where there are several well-known companies [7], [8] that produce machines for implementing the machining process of wheelsets using this technology. Wheel milling technology is used in the USA [9] and the countries of the former USSR, which, based on American technology, have developed machines of the KZh-20 series of various modifications. These machines were widely produced in Ukraine (Kramatorsk Heavy Machine Tool Plant KZTS) in the 80s of the last century [10] (figure 1). Currently, a number of factories have mastered the overhaul of these machines, and in these countries, repairs of locomotive wheel sets without rolling out are still carried out using this equipment.

II. Shaped Cutters for KZh-20 Machines. Geometric Modeling

When processing locomotive wheel sets on KZh-20 machines, the problematic element is the shaped cutters themselves. In order for the processing to be carried out efficiently, i.e. In order for the completed profile of the working surface of the wheels to meet the requirements of the instructions for the maintenance of wheel pairs of traction rolling stock, for example, [11], [12], the shaped cutter must be constantly monitored, repaired and adjusted on special stands. This is a fairly labor-intensive procedure that requires qualified operators. It is obvious that despite the improvement in the designs of cutters and the materials used in them, this is a tool that is quite loaded during operation and will certainly be susceptible to breakdowns. Thus, the task of tool designers is to improve its design characteristics.