

WAYS OF INCREASING THE SERVICE LIFE OF THE STEEL ROPES IN THE MINE HOISTS

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ABSTRACT

The purpose of the paper is to put forward ways of reducing the expenses on the hoisting ropes, which are a considerable part of the total expenses in the enterprises for underground mining of mineral resources. The preliminary measures were examined for extension of the steel ropes durability as early, as at the time of their manufacture, and also some suggestions on the choice of both the ropes and the pulleys are made. The kinds of procedures were systematized for increase of the service life chiefly of the hoisting ropes, and recommendations are given on the improvement of their operating conditions.

INTRODUCTION

Among the main units of the mine hoists (MH) are the hoisting and balancing ropes. Their operation lifetime depends on how correctly they are chosen and used and it in turn has a strong effect on the financial condition of the whole mining enterprise.

The principal reason for the destruction of the steel ropes is their frequent folding when they are reeled and pass by the guide pulleys, under the continuous effect of variable tensile forces. Corrosion and mechanical wear and tear step up the aging processes. The ways of increasing the steel ropes operation lifetime can tentatively be divided into two groups: *research and development ways and operation related ways.*

The ropes durability can be varied as early as at their manufacture, and also when they are dimensioned at the MH designing. The good routine maintenance, cleaning, lubrication, inspection and technical checking, as well as the securing of normal operating conditions (with no additional dynamic load, adverse bending or inadmissible contact stress) are also a precondition for a reduction in the expenses.

RESEARCH AND DEVELOPMENT WAYS

Activities involved in the rope production fall into this group, and also recommendations on their correct calculation and selection, as well as their combination with appropriate structural features of the hoisting machines, the guide pulleys and the suspension devices.

The physico-mechanical properties of the wires greatly influence the rope serviceability. The wire strength is determined by the chemical composition of the steel, its thermal treatment and the aggregate reduction in the cross section at cold drawing. Normally steels having C content from 0.4% to 1% are chosen. If its content is increased, or at larger differences in the cross section (a greater number of steps-

nozzles) higher strength can be achieved, however it is at the expense of a decreased flexibility and elasticity 220 N/mm^2 is put forward as the optimal strength limit. In selecting hoisting ropes it is necessary to take into consideration the relationship illustrated in Fig.1, between the number of the bending cycles up to the point of destruction N and the tensile strength (the temporary tearing resistance) σ_a . It can be seen that the wire tensile strength increase at constant load does not lead to a serviceability increase, while with a constant safety factor n this parameter greatly worsens[3].

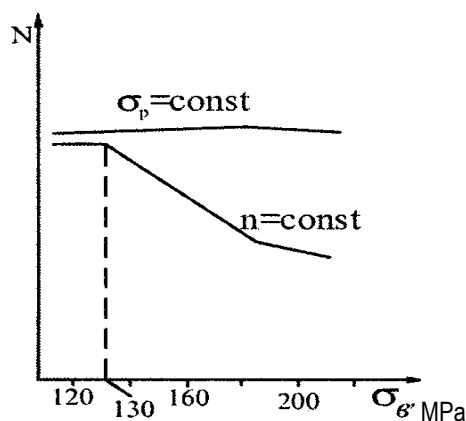


Figure 1.

Mn - from 0.3% to 1% is added to increase the wear resistance and an additional Zn coating is applied. In a normal operating medium the use of zinc-coated wires in a rope does not affect its durability. In a corrosive medium however such coating increases many times the rope life. If the zinc coating protection against corrosion is not sufficient, the wires should be made from corrosion resistant alloy steel. Up to 30% increase in the wire durability can be achieved if the hot rolled blanks having $d \geq 5 \text{ mm}$ undergo 7-8 different processes of chemical heat treatment.

In recommending the choice of rope design, particular attention should be paid to the way of twist- parallel or reverse-

laid one. From the average statistical results in testing ropes at bending [6] it turns out that the ones with parallel twist withstand a considerably higher number of bends than those with reverselaid twist. Therefore the choice of parallel twist ropes is normally recommended for hoist ropes. Only with prevailing requirement for non-untwisting (e.g. big depths, multi-rope friction pulleys, etc.) is allowed the use of reverse-laid twist or of non-untwisting ropes. The parallel curve ropes have 20-30% higher service ability than the ones with reverse-laid twist, and at the presence of reverse bending (with the deflector pulleys of the multirope MH) such advantage augments.

In the modern structures round ropes are normally used with 6, 8 or 9 fascicles. The bending tests show that with one-layer winding, as a whole, the ropes with more fascicles take precedence. The reason for that is the reduced contact and bend stresses between the wires. With large-diameter pulleys and the presence of groove lining such advantage does not matter much. It was demonstrated [1] that when the ratio between the rope winding pitch and the fascicle winding pitch is an integer, then the number of the destruction inducing bending cycles reaches its maximum value - Fig.2.

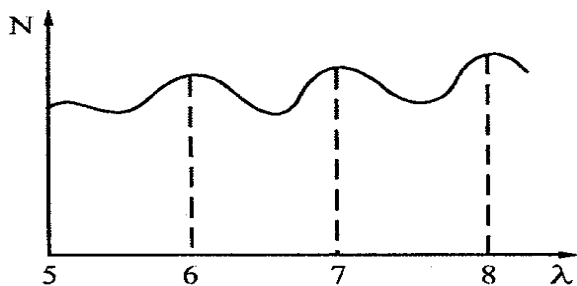


Figure 2.

The rope core serves to provide its round cross-section and for even taking up of the radial forces at the fascicle twisting along the helical line. Metal core is recommended with ropes operating in a very corrosive medium; high temperatures; need for small permanent elongation and large durability. Aluminium core has not been used in the latest structures due to the following shortcomings: fast corrosion, strain and penetration between the fascicles. The combined core has the highest strength parameters and durability - steel fascicles, bonded in polyamide medium or other medium. The rope tends to untwist diminishes, and so do the changes in its diameter at operation loads. The use of ropes (e.g. PK 8x26+7x17 turboplast, PK 8x26+4x17/4x7+1x7/ turbo-lift, etc.) can increase their serviceability more than twice.

Fig.3 shows the dependence of the number of bending cycles up to the point of destruction, on the ratio between the pulley diameter D and the rope diameter d and the magnitude of the tensile stresses σ [2]. Hence the conclusion comes that rope serviceability increases with the increase in the D/d ratio and the decrease of σ .

MPa

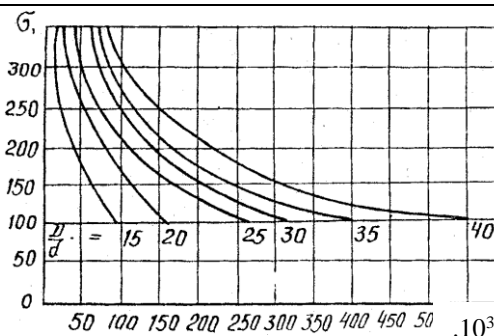


Figure 3.

The groove shape of the winding member of a hoisting machine - Fig.4 is crucial for the time of operation of a rope. A number of authors [2], [3], [5] and others recommend, with the aim of reducing the harmful residual stresses (which appear in the wires when the rope cross-section over the reel is formed), the following relationship:

$$r_k = (0.52 - 0.53) \cdot d \quad (1)$$

where: r_k is the groove radius, mm
 d is the rope diameter, mm

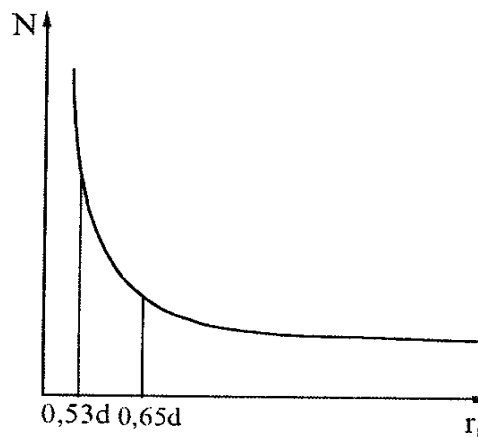


Figure 4.

If the groove radius increases up to $0.65d$, the rope serviceability strongly worsens. It is recommended, in order to reduce the secondary stresses, to cut at the groove bottom a narrow strip with b width, at the ratio of $b/d = 0.15$ - Fig.5. That is easily feasible with grooves having no lining.

OPERATION RELATED WAYS

Respect for the general technical requirements of the routine maintenance (RM).

As soon as the hoisting ropes are purchased, it is necessary to subject them to tests at the relevant rope testing laboratories with the objective of finding their technical fitness. Rope rejection because of factory defects makes up 3-4% of all the reasons for that.

Upon their reception the ropes should be kept in dry stores, put on thick wood pads, thus being insulated from dampness. No substances aggressive to metals must be stored in such premises - salts, acids, etc.

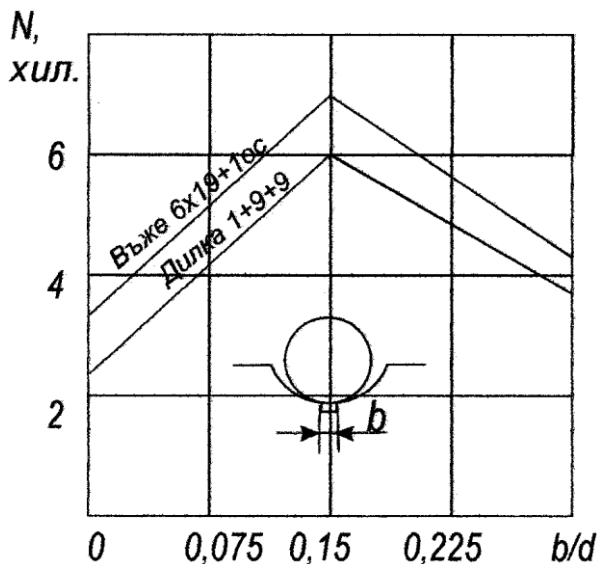


Figure 5.

When performing rewinding from factory reels, preparation for installation, or other operations, ropes must not be drawn axially, since that causes them to untwist, or to further twist, depending on the stitch direction. The phenomenon described above is particularly dangerous for MH with a friction winding member and with triangular fascicles. When they are untwisted, the triangular fascicle border comes out and intensively induces wear and tear both to the groove lining and to the rope itself - because of the irregular configuration in the cross-section. In spite of the lower resistance when tested for bending, compared to the round fascicle ropes, the ones with triangular fascicles are better suited to MH having multi-rope friction pulley and greater depths, due to their higher bearing capacity and lower trend to unwind.

The use of quality fastening elements further contributes to an increase in the hoisting ropes service life. The practical experience has been gradually giving up the use of the lever and wedge cells - KRG type - in that their members induce excessive stresses in the wires and the fascicles. The use of SKK type self-tightening cells and of still better KKB structures with built-in plastic rope fluctuation dampers is recommended.

With the multi-rope MH one should operate with equal winding diameters. The lining grooves are faced when a 0.5mm difference in the diameters has been reached.

To prevent the harmful effect of the mine environment - water, dust, various gases - is recommended the use of galvanized ropes (which are by 20-25% more expensive), and if that is impossible, regular lubrication must be carried out. It is recommended to be done at the areas of rope bending around pulleys, reels and other radiuses, in order to facilitate its penetration into the internals. Lubrication is basically intended to render easier the wires and fascicles reciprocal slip at the

rope bending. Just then it serves also as anticorrosive protection. In MH with a friction winding member are used lubricants guaranteeing normal values of the coefficient of friction between rope and coating. Particular attention should be paid to the "dead" tracts - the ones which do not pass by the guide pulleys or the winding member.

At the presence of two-layer winding, the critical tract (the place of transition from the first to the second layer of winding) must be changed in every two months by cutting out a length of the rope equal to a quarter of a turn. Such operation is carried out at the place of fastening the rope to the reel.

Control of the technical condition of the ropes.

The magnetic-inductive test of the ropes has been employed for years in the practice of a number of European and other countries, to find defects in their internals and on their surface. The destructionless check of the hoisting ropes for all MH types was not adopted formally in our country until recently. After it became possible (not however in the coal mines), the operation lifetime of most principal and balancing ropes of MH with friction winding member increased nearly twice. This means that for a long time ropes quite serviceable, but with expired rated service life of two years for the main ropes and four years for the balancing ropes, according to the old requirements of [4], were rejected. Therefore the methods of destructionless check of the technical condition of the hoisting ropes should be applied ever increasingly in the practical use for optimization of the capital and operating expenses for the ropes in MH.

An important point in the practice of the MH operation is the excellent knowledge of the kinds of rope defects, too. The types of damages, described in DIN 15020, and their fast and easy diagnosing by the mine technical staff, enables in a number of occasions further use of the ropes, without it involving risks for the underground workers.

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