Selection of A Rational Form for The Steel Winding Tower as A Preventive Measure to Increase Its Industrial Safety

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Abstract

Herein there is a new approach to improve industrial safety in terms of operation of the steel winding tower based on rational design solutions.

Keywords: Industrial safety, corrosion, defects, multi-functional steel jibs of winding towers-.

1. Introduction

In the complex of mine structures a winding tower takes a special place. Besides the fact that it is a high structure, designed to provide position of the pulleys of the hoist at a certain level, it is also a complex structure taking extremely loads from a hoist. It guarantees safe and reliable operation of the hoist for the entire period of its operation (35-45 years).

However, the results of a survey [1] showed that the actual operational life of the winding tower under high aggressive impact and without proper repair and maintenance is often reduced by a half versus to a standard service life.

2. Work description

According to the OJSC 'Kuzbassgiproshaht' and OJSC 'Sibgiproshaht' defining scope and range of loads for winding towers, which Kuzbass mines will need in the nearest future, the most popular are the winding towers for ventilation and auxiliary shafts of 7 ч 8m diameter with the marked center of the hoisting pulley +34,000 m ч +36,000m.

The available winding towers operating under similar conditions, as a rule, are four-pole and rig type (Fig. 1). The results of the expert appraisal [1] of their technical condition showed that most of the available structures have no access for rust removal and protective coating renewal. All these cause intensity of corrosion of the metal at rate of 0.8 ± 1 mm/year.

At the same time it was found out that a rig 1 (see Fig. 1) as the main supporting structure, transferring load from the hoist (including emergency) to the wellhead via the rig base of the winding tower, is the most exposed to the aggressive environment.

Typical defect of the rig parts is corrosion, and it mostly pronounced at the interface with the rig base. The most common damage of the rig base is a significant corrosion on the entire surface of its parts due to high humidity of the air entering

from a shaft, corrosive gases and coal dust. The entire body of the rig under coating is also significantly exposed to corrosion due to the abundant condensation in winter time.

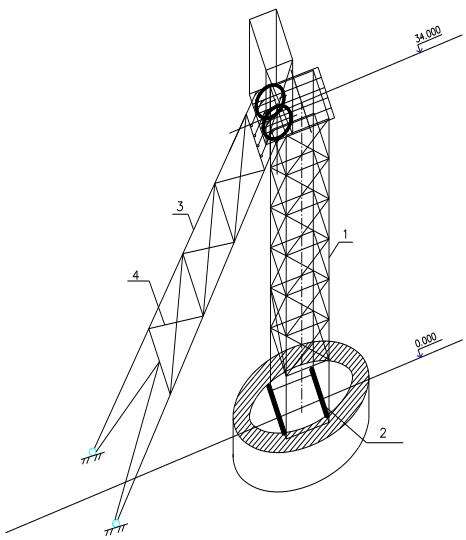

Fig. 1. Scheme of the steel single-cut four-post winding tower
1) rig; 2) rig base; 3) jib; 4) braces

Jib of the winding tower 3 provides stability of the structure, and takes effort from hoist, as well as a significant part of the emergency load. The main defects and damage of the jib can be attributed to deformation due to mechanical impact.

A large number of jibs promotes accumulation of coal dust, slag and lube in junctions of the jib and braces, and consequently, occurrence of significant corrosion in the stagnant areas.

The condition of stairs and fences does not affect the carrying capacity, but defects and damages of these parts affect the safety while winding tower repair and maintenance operations.

Traditional approaches to the design of winding towers, taking into account their failure-free operation and economic efficiency are crucial, by all means, at selection of rational constructive solutions.

However, solving the problem of provision of the longevity of structures and reduction of costs for their repair and maintenance is no less important for structures subjected to corrosive wear. Therefore, choosing cross sections and junctions of winding tower, an aspect of their resistance to corrosion as a guarantee of safety and durability must be considered.

The department ‘Construction of Underground Structures and Mines" KuzSTU has developed fundamental constructive solution of the steel winding tower (Fig. 2) [2] and made its prototype (Fig. 3).

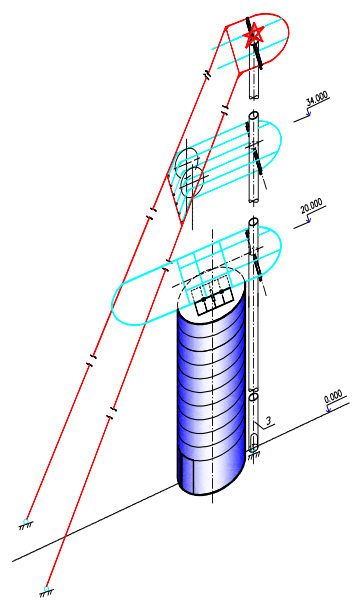

Fig. 2. Sketch of a multi-purpose winding tower for the operation period:
1) - jib; 2) – central tubular pole; 3), 4) pulley pad; 5) ring brace 6) rig

Fig. 3. Prototype of a steel multi-purpose winding tower for the mining period

The winding tower has pulley pad, including frame jib 1 (see. Fig. 2) of variable cross section, central tubular pole 2, pulley pads 3 and 4, ring brace 5 and round-shape rig 6, leaned against wellhead via curb.

The developed structure of the winding tower has advantages versus the traditional decisions of the 4-poles winding towers of the rig type as follows:

- high tightness of box-like and circular sections of pulley device allows avoiding penetration of coal dust, and hence increases their resistance to corrosion;
- lack of bracings on the jib frame 1 facilitates easy access for inspection and protection of elements and components of the structure, as well as eliminates the accumulation of coal dust, slag and lube at the nodes of connection;
- frame machine 6 does not transmit load from hoist on wellhead of the shaft and has no rig base and braces, therefore, the cost for their maintenance is not required;
- a railing in the shape of barrel significantly improves the airtightness of the machine, and also reduces the amount of undesired joints compared with traditional fencing panels;
- free space inside of the central tubular pole allows you to place a hoist for equipment and head-frame service, what creates more comfortable and safe working environment;
- hoist structure device inside the tubular rack 2 can not only improve the service conditions, but also eliminates the need for traditional metal ladders along the jib located in the area of hoist ropes, what is undesirable for safety reasons.

Since the mine winding towers experience various types of dynamic loads (seismic load, dynamic load of equipment, wind pulsation, emergency load), an important factor for their calculation is limited by the natural oscillation frequency.

The proposed structure (see Fig. 2) is designed considering the limits by the natural oscillation frequency, upholding of which characterizes the dynamic equilibrium of the structure. If required, the ring brace 5 can be regarded as a damping element by changing its the mechanical parameters we can displace resonance points of the vibrational system to the direction of frequencies (up to 4 Hz), which are safe for the working personnel.

3. Conclusion

The found technical solution reflects the essence of the new approach to finding effective design solutions that takes into account the requirements of durability and safety, along with the requirements of reliability and economy.

Thus, when designing winding towers operating under difficult conditions, the choice of a rational design itself is an effective preventive measure to improve industrial safety, reliability and optimal physical resource.

4. Reference

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