

## **COMPARATIVE ANALYSIS OF ERGONOMIC AND ECONOMIC FACTORS IN EXCAVATOR OPERATION**

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The location of the excavator operator's cab and working conditions in the cab. The cabs of the Rope Shovels (RSC) are installed at a higher level from the bottom face than the Hydraulic Pit Excavators (HPE), which improves vehicle loading conditions and is safer for the operator, the ergonomic characteristics of both types of excavator cabs are identical and operators are well protected from vibration and noise.

Control of the digging cycle operations affects bucket filling. The HPE bucket is controlled by the simultaneous movement of the boom, arm and bucket. The ability to create a tearing force by turning the bucket while resting it on the face provides a high bucket fill factor, but requires a large number of hand movements and is associated with greater operator fatigue. On RSC, the less hand movement required for the digging process reduces the load on the operator's hands, but high bucket filling requires more time on the digging path from the bottom of the ledge and to the axis of the pressure shaft, and their operation in low ledges is ineffective.

Preventive maintenance, clean working conditions on diesel HPEs, requires highly qualified personnel, strict replacement of consumables, as well as keeping fluids clean and preventing leaks, which pose a potential fire hazard also in the case of burst hydraulic lines. At the same time, maintenance of hydraulic equipment presupposes minimum current maintenance intervention of the personnel in the process of its operation and provides mainly only planned aggregate replacement after expiry of its resource or detection of failures. Electric RSCs are less sensitive to the rigours of the quarry environment, vibration, temperature variations and dust contamination, but require frequent and regular rope changes in addition to normal maintenance of machinery and electrical equipment.

Disposal of HPE fluids, replaced several times a year, is a major challenge and costly. On electric RSCs, the oil in the travel, hoist, slew and head winches and travel gearboxes is changed once a year and at a lower volume.

Dust generation when loading rock into a dump truck with a mechanical shovel, due to the uncontrolled opening of the bucket bottom at a higher height, is accompanied by hitting the body with the entire volume of rock mass in the bucket, which also contributes to active dust generation. With the HPE, the jaw bucket is able to gently unload the rock, which preserves the body of the dump truck and reduces the amount of dust during loading.

The capital cost of the purchase (cost of ownership) of an excavator of the same class in terms of bucket capacity, for HPE is significantly lower than for RSC, by an average of 30...40%. The higher price for an electric RSC is due to the greater construction weight and the higher cost of the control electronics, but implies a longer service life for the machine.

Specific operational expenses per 1 ton of the loaded rock mass, in spite of high initial expenses for purchase of electric RSC, at considerably longer planned term of their operation in comparison with HPE, in average in 2...3 times lower, as a rule, due to lower expenses for electric power. However, at relatively short terms of HPE operation, within 5...7 years, average operation costs per 1 ton of mined rock mass, as a rule, are less or comparable with similar indicators, typical for electric RSCs.

Fuel costs are an important component of operating costs and can be higher than energy costs per unit of output. Energy costs for electric excavators are generally more stable and lower than those for diesel HPEs. HPEs, by throttling fluid at high pressure and high flow rates, generate a lot of heat, which is neutralised by large oil coolers that release heat into the atmosphere, resulting in higher power consumption per cycle compared to RSCs.

Standard service life of HPE before the first overhaul is on average reached after 5 to 7 years (20 to 30 thousand hours) of operation. Powerful electrical RSCs, after 2...3 overhauls, performed usually in every 6...7 year of operation, keep their service life for 18...30 years (120 thousand hours and more).

HPEs are usually assembled on a modular basis in 1 ... 15 days' work, by a team of 7 ... 8 persons in 10-hour shifts. The assembly of mechloops takes 50 ... 70 days and involves more specialists (up to 30), with higher qualifications.

The resale value of an excavator at the end of its working life (in the used equipment market), HPE, due to its lower initial price, is lower than that of RSC and that makes it more competitive.

HPE's support and service infrastructure should be more advanced, especially when operating them in low-temperature areas, where special arctic kits must be provided in addition to a refueller and a service shop.

Insurance liabilities usually take into account the higher risk of fire on HPEs due to the large amount of flammable liquids on them (several thousand litres), which increases the rate of insurance interest compared to electric RSCs.

The comparative analysis of possibilities of hydraulic and mechanical shovels, experts' prognosis and world experience show that volumes of quarry shovels with 25...45 m<sup>3</sup> bucket capacity are shifting to HPE on the world market and this tendency keeps getting stronger because of intensive improvement of their design, quality of machines, competitive prices and operational costs in a certain mining production sector.

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