1. Introduction

Bucket wheel excavators 4600.30 (fig. 1) and 4600.50 (fig. 2) are machines with the same excavating system.

Bucket wheel with 11 buckets is driven by three electric motors, 530kW power each. The system is not working properly in Polish geological conditions. The dynamic loads are very high and the original construction of bucket wheel do not withstands the loads [1]. Cracks occurrence and maintenance problems are common. The need of construction a new mining system led to the problem of evaluation of buckets numbers (the same for both machines). Wrong buckets number could cause resonance. At the same time, the number must be possibly high to decrease dynamic loads. In purpose to avoid undesirable phenomenon, complex investigation of the machines dynamic were proceeded [2].

2. Experimental Results

The complexity of experiment is very high. The smaller machine is over 36 m high, 60 m long and the upper part weights 1700 tons. The bigger one is over 60 m high, 120m long and the upper part weight exceeds 3000 tons. Dynamics of both machines had to be completely investigated to determine resonance area. Measurements were done with use of the 24 channels recorder and with use of 17 accelerometers of different type. The placement of sensors and direction of measurements were selected in way to avoid space aliasing. In measurements, two methods were used: experimental modal analysis and operational modal analysis. Such a approach allowed to check machines behaviour in different working conditions. The measurements sets were taken during mining of overburden and coal, with standard method and working to deep. Additionally, measurements during technological movements like slewing, hoisting and travel were done [3-5].

As a result of measurements, mode shapes (fig. 3) and natural frequencies were obtained.

![Fig. 3: First normal modes of the machines: a) SchRs4600.50, b) SchRs4600.30](image-url)
shows the range of frequencies that are possible to excite in working conditions.

3. Evaluation of buckets number

Both machines work with the same parameters. The nominal angular velocity of the bucket wheel equals 0.32. Different number of buckets results in different frequency of excitation force (dots in figure 4).

![Fig. 4: Evaluation of buckets number for BWE SchRs 4600.50](image)

Solid horizontal lines represent natural frequencies of the BWE 4600.50. Horizontal broken lines represent harmonics of eigenfrequencies. With elimination method the optimal number of buckets for both machines were determined. For the BWE 4600.50 are two possibilities without danger of resonance: 17 or 18 buckets. For the BWE 4600.30 possibilities are three: 17, 21 and 22 buckets. In this case, the best solution for both machines simultaneously is 17 buckets.

4. Summary and conclusions

Up to now, evaluation of buckets number were determined mainly by construction solutions and capacity demanding. Machines like mentioned in the article, were designed in times when advanced numerical methods were not commonly used. Assessment of resonance phenomenon for complex structures like bucket wheel excavator, with traditional analytic methods, was impossible.

Complex investigation of modal modes of buckets wheel excavator, shows that the resonance frequencies for this type of machines are low. Especially useful was operational modal analysis method. Thanks to it, the changes in dynamic characteristics were obtained. Determination of resonance areas allowed to specify proper number of buckets. Bucket wheel with 17 buckets will provide decreased vibration level and lower amplitude of excavation forces.

5. References