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Identification of low cycle dynamic loads acting on heavy machinery

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Abstract

Power and mining industry characterizes with common use of the machines and installations that size and mass exceeds the machinery and equipment used in majority of industries. Due to the scale of those objects, the objects dynamics and external loads characteristics comprises with low frequency, low cycle loads of large energy. The paper presents the objects (bucket wheel excavators, load carrying structures…) which are prone to that type of the loads. Proper loads definition, calculations procedures and the experimental testing and/or validation requires dedicated approach. Improper design and operational conditions assumption, due to the scale of the objects, often leads to the disastrous failures.

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1. Introduction

Bucket wheel excavators, spreaders, reclaimers are the group of the heavy machines commonly used in the mining, power and bulk-handling industry. Additionally, those machines are common in the design, which characterizes the slewing superstructure supported on the undercarriage which span is relatively small in comparison to the superstructure (Fig. 1). Mass of those machines can reach up to couple thousand of tones. This specific design, make the superstructure prone to vibrate, with very low frequencies, as an rigid body which is supported on the undercarriage that can be treated as the flexible support. Consequently, vibrations of higher frequencies represents

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the flexible modes (Fig. 2). What is worth noting, the rigid body mode of the superstructure, should be also taken under consideration when speaking about the alternating load in the undercarriage structure.
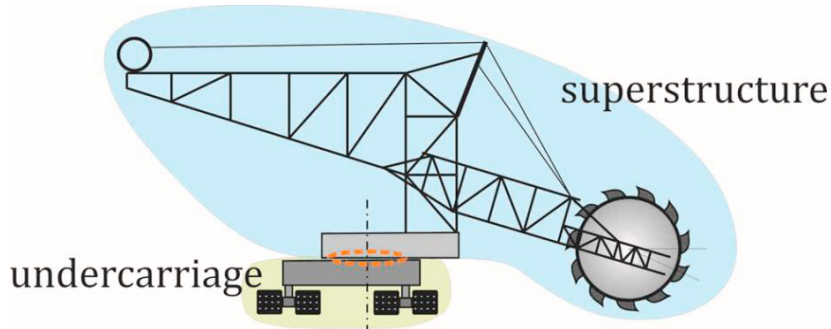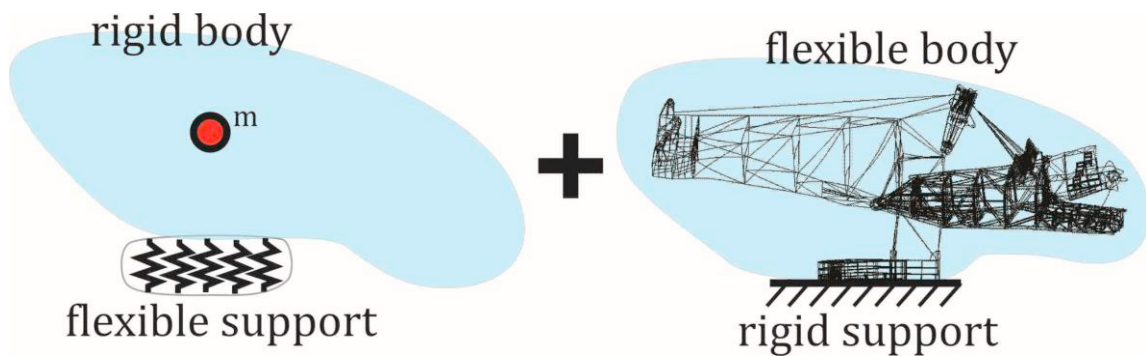

Fig. 1. Bucket wheel excavator

Fig. 2. Bucket wheel excavator vibrations

The dynamics of the described machines is one of the crucial element in the design process, while the operation loads, in most cases are not stable and can have the impact character [1][2][3]. For the excavators the major excavation energy is related to buckets discharge and alternating digging forces (or shocks in case of the non-mineable hit). Spreaders, which are not so exposed for external dynamic loads, like the excavators, are prone to vibrate too, due to the span of the structure and its slenderness. Common excitation sources for all types of the machines are technological movements (travel, slewing, hoisting) and the transportation system: belt conveyors idlers which are hit by the excavated material, material drop in chute points (change of the elevation between conveyors) (Figure 3).

The most common definition of the dynamic loads acting on the structure is the factor of dynamic effects ψ, which is described in most standards and main literature concerning the equipment for continuous handling of bulk materials. The factor ψ is defined as the ratio of the maximum acceleration peak-to-peak value (Δa) of the measured signal over the gravity (g) (1) [4].

$$\Delta a = \max a - \min a$$

$$\psi = \frac{\Delta a}{g} \tag{1}$$