ZESZYTY NAUKOWE POLITECHNIKI ŚLĄSKIEJ 2007
Seria: GÓRNICTWO z. 280 Nr kol. 1765

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THE GENERATION OF DYNAMIC FORCES OF THE DISINTEGRATION PROCESS OF BUCKET-WHEEL EXCAVATORS

Summary. It is the following factors that have the influence on the magnitude of dynamic forces generated in the course of disintegration by the wheel of excavator: **design** – dimensions of a chip, the number of buckets, **rock** – rock layer inhomogeneity, planes of discontinuity, variability in technical properties, a tendency to form blocks.

POWSTAWANIE SIŁ DYNAMICZNYCH W PROCESIE URABIANIA ZA POMOCĄ WIELONACZYNIOWYCH KOPAREK KOŁOWYCH

Streszczenie. Wyróżniono następujące czynniki wpływające na wartość sił dynamicznych generowanych wskutek dezintegracji calizny przez koło koparki: **projektowanie** – projektowane wymiary skrawu, liczba czerpaków, **skała** – niejednorodność warstwy skał, usytuowanie płaszczyzn nieciągłości, zmienność właściwości mechanicznych, skłonność do odspajania bloków.

1. The Length of Lips

The length of lips of all engaged buckets is a quantity determining the force load on the wheel and the whole drive. This is a variable quantity and, at the given number of wheel buckets and the required efficiency, changes cyclically depending upon the position of individual engaged buckets – Fig. 1. In reality, the position of upper bucket disengaging can be never determined precisely, because this depends on the properties of excavated material, especially cohesion, strength properties and tectonic faults that may lead to block formation.

In the course of wheel turning, a change in the length of lips of engaged buckets occurs. At turning, the length of lips linearly increases; the gradient of partial line being proportional to the number of engaged buckets. At bucket disengaging, a step change takes place and the cycle will repeat itself.

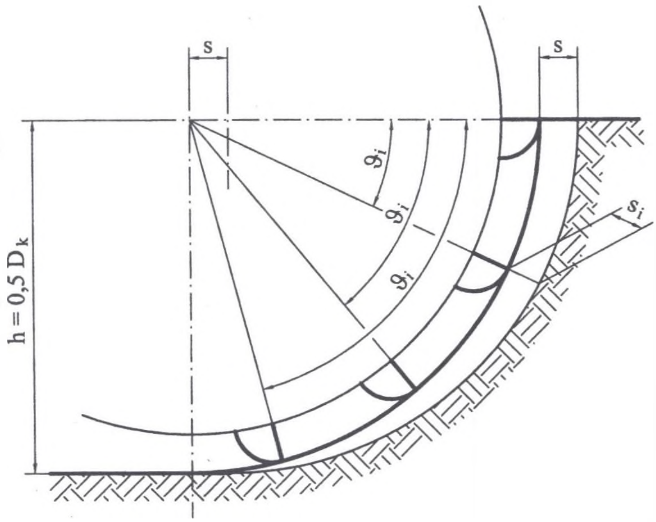

Fig. 1. A change in chip depth in the case of individual buckets at h = 0.5 D_k
Rys. 1. Zmienność głębokości skrawu dla poszczególnych czerpaków, w przypadku gdy: h = 0.5 D_k

2. The Analysis of Cutting Forces on the Bucket Cutting Edge

The cutting forces on the bucket cutting edge or on the whole wheel are a result of interaction between the tool and the rock. Thus, technical and rock factors enter into the disintegration process. The rock factors are not susceptible to influence. To the technical factors, both the structural design of buckets and the whole wheel and the regime parameters of excavation – the selection of height, depth and width of a chip belong. Therefore, it is evident that by the suitable selection of technical parameters we are able to influence, to a certain extent, the magnitude of cutting forces or the behaviours of them, and thus also a demand for the installed capacity.

The present methodology for the evaluation of excavation process is based on the force on the cutting edge related to the length of lip (kN.m^{-1}). This means that under constant rock conditions the specific digging force will be constant and the cutting force will correspond to the total length of lips of buckets engaged. This though is in fact theoretical, because the cutting force will be influenced by the shape of the chip (ratio of chip sides, s/b) and the angle of approach β (changes in the course of boom rotation). However, we adhere to the defined force and can state that the cutting forces will be proportional to the length of lips and a change in them – see Figs. 2 ÷ 5.

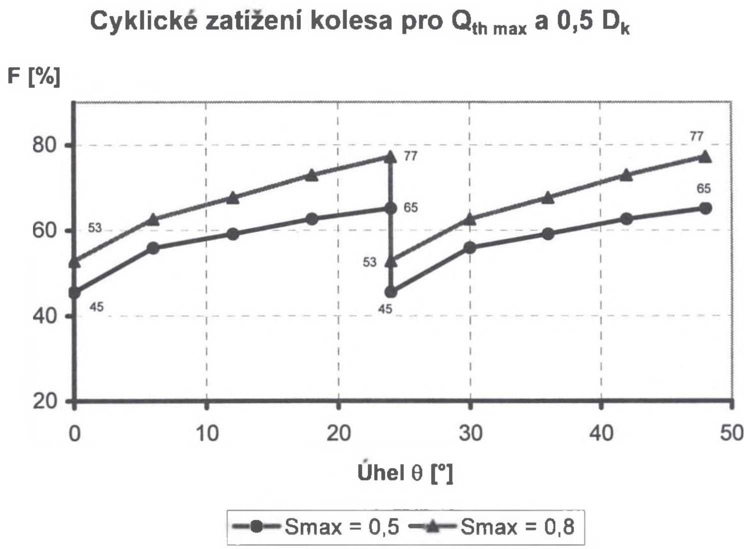

Fig. 2. Cyclical load on the wheel for $Q_{th\ max}$ and 0.5 D_k
Rys. 2. Cykliczne obciążenie koła, dla: $Q_{th\ max}$ oraz 0.5 D_k

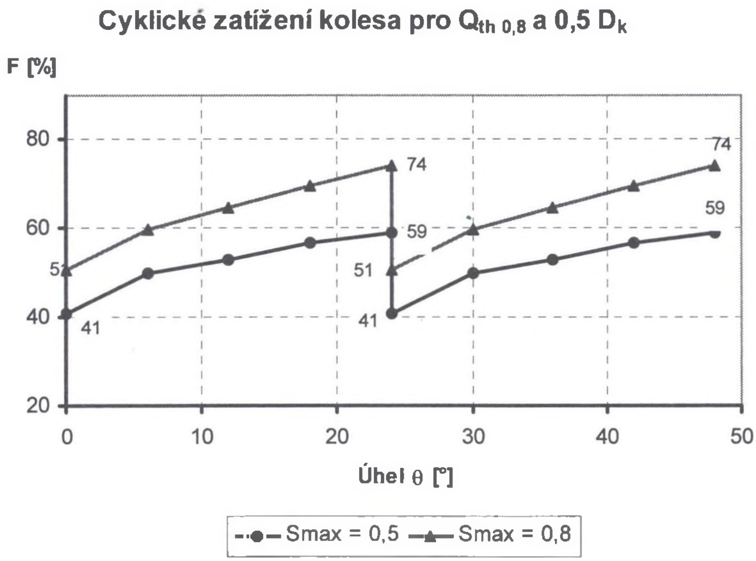

Fig. 3. Cyclical load on the wheel for $Q_{th\ 0,8}$ and 0.5 D_k
Rys. 3. Cykliczne obciążenie koła, dla: $Q_{th\ 0,8}$ oraz 0.5 D_k

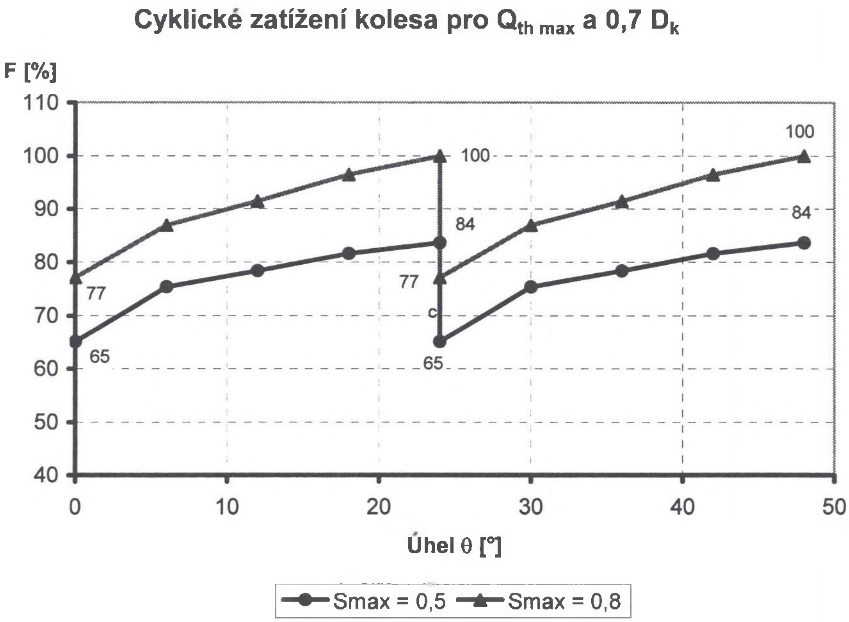

Fig. 4. Cyclical load on the wheel for $Q_{th\ max}$ and 0.7 D_k
Rys. 4. Cykliczne obciążenie koła, dla: $Q_{th\ max}$ oraz 0.7 D_k

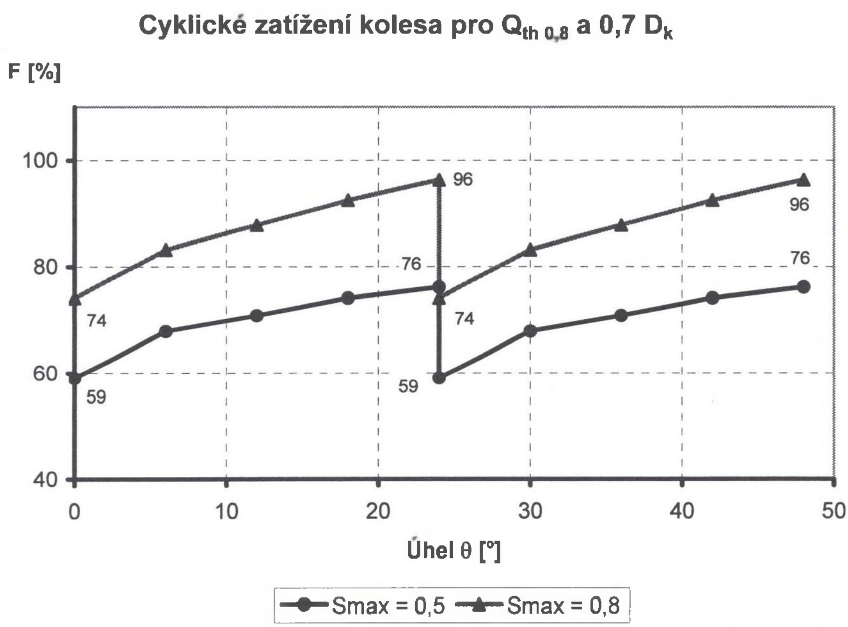

Fig. 5. Cyclical load on the wheel for $Q_{th\ 0,8}$ and 0.7 D_k
Rys. 5. Cykliczne obciążenie koła, dla: $Q_{th\ 0,8}$ oraz 0.7 D_k

The behaviour of force F (total cutting force) is given in relative values; as 100% the force at the maximum possible height of slice and the maximum excavated amount is taken. From the presented results, the following conclusions can be drawn:

- the step change in force (at bucket disengaging), which only depends on the number of wheel bucket z_k, is probably the same in all the variants: 22 ÷ 24% for $s_{max} = 0{,}8m$ and 17 ÷ 20% for $s_{max} = 0{,}5m$. This step change in the force brings the basic dynamic forces into the excavator. Here, it is necessary to consider the eigen frequency of machine structure as well,
- a decrease in the magnitude of step change is possible merely by increasing the number of buckets; the maximum value of force will not change. Moreover, it will not change markedly at a decrease in the quantity of excavated material from $Q_{th_{max}}$ to $Q_{th_{0,8}}$ either. The only possibility of diminishing the maximum value of force F is to decrease the depth of chip. As follows from the graphs, we shall obtain for $s_{max} = 0{,}5$ the maximum force by about 23% lower, and this could lead to a reduction in the component of input to the drives of the wheel intended for cutting by about 25%. This though is worth considering and taking into account other aspects, which will increase some handling times and thus decrease somewhat the efficiency.

The project was realised on financial supporting of state budget by Ministry of Industry and Trade of The Czech Republic (grant No. FT-TA4/018).

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