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THE DYNAMIC STUDY OF THE CUTTING ELEMENTS FROM THE MINING INDUSTRY USING THE FINITE ELEMENT

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Abstract: The determination of static and dynamic components from a structure, in the context of actual economy, the design of structures must be optim concerning the material and higher productivity.

1. Introduction

The dynamic analysis offers simulation to the most closed to the reality behavior of the studied elements. The cutting elements (the teeth of the buckets, the knives, etc.) used on the equipments from the mining industry are under some intensive exciting variations of forces which are further leading to intensive variations of the forces within the studied element in a period of time. This period is established in function of the length and of the manner of the technological process where the respective element is used.

In the fig 1 can it can be seen the cutting elements of the buckets which are enduring the excavators type ERC 1400 (ERC = Bucketswheelex-cavator = BWE) used in the open - pit - mines from the area Rovinari, and in the fig 2, the geometrical model of the right tooth used for the endowment of the buckets for the same type of excavator.

Under the pressure of the excavation force, these elements are breaking (crushing) the material to be excavated, resulting an impact wear because of the permanent impulses existing between the metal surface and the material to be excavated in a period of time given by the active way (lap) for the excavation.

$$\frac{du}{dt} = \alpha \frac{lH}{HB}$$

where:

α - coefficient featuring the impact angle size;l - coefficient depending on the physical-mechanical features of the contact materials;
H - the impulse for resulting the impact;

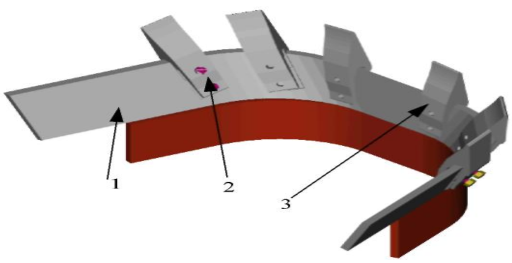

Figure 1: The cutting elements as parts of the bucket
1 - cutting teeth; 2 - side tooth; 3 - right tooth

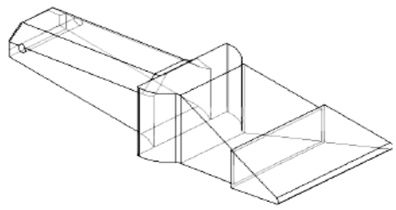

Figure 2: The model of the right (cutting) tooth

HB - the hardness of the working body (part). On the other hand, due to the permanent contact between the material to be excavated and the cutting element, due to the difference of material and hardness, it is realized also the process of abrasive wear process to of the cutting element, too.

2. The component elements of the dynamic stage

It can be defined an elastic system within the excavation process, as in the fig 3:

The system from the fig 3 could be an equivalent system in the study of the excavation process regarding the destroying of the cutting elements trough the impact with the material to be excavated by EH of impulses received from the system tooth - bucket due to the permanent contact, on the active way between the surface of impact of the cutting element which reaches into contact with Em weights of material to be excavated. For an easier manner of writing, the elements component are shorted renamed as in the fig 3.

In function of the dynamic features of the system ET (IT) - $I_p(B)/R_p(W_b)$ - Bc(Ar), the splintering forces are generating vibrations which might affect the quality of the surface ET(1T), the cynematique of the whole assembly. The splintering force is given as force of excavation and it could be divided as in the fig 4 under its components.

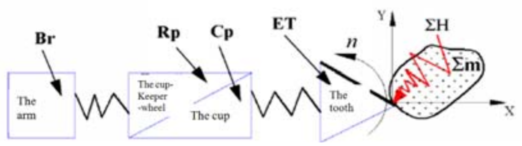

Figure 3: The component parts of the elastic system in the excavation process

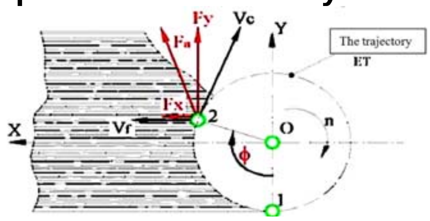

Figure 4: The components of the splintering forces

The splintering force F might be divided in an active force Fa, which is situated on the work plan, with the components Fx, Fy, and the direction of the active force Fa is changing depending on the entrance angle φ.

In function of the dynamic features of the complete system, the splintering forces are generating vibrations which might affect the life time (hardness) of the cutting tool. After their mode of generating, they are divided in forced vibrations and in self vibrations. In case of the forced excitation, the technological system vibrates with the frequency of the excitation forces. In the actions of excavation the problem is that not all ET (cutting talk =

CT) are constantly engaged in the splintering process. The middle splintering force Fcm, which acts on ET (CT), is given by:

Fcm - Zei Fcmz (2)

where: Fcmz is the middle splintering force of a splintering edge. As the value Zei is bigger, as less is the amplitude of the splintering force.

The self excited vibrations are making the system to vibrate at one or at many own frequencies and they are not resulted as disturbing forces. This type of vibrations is occurring due to the effect of re-creation and they are known as regenerative vibrations. 3. Study on the evolution of the life-time (hardness) of the cutting bodies required by hazardous (duties)

To each frequency is corresponding a type of vibration, called common mode or own mode of vibration; this is the shape that the system is talking while the free vibration with its own frequency.

The own least frequency is called basic frequency and is determined for the cutting element.

For the basic mode the structure of the system might be defined by a single parameter, so the system is behaving as a system with one freedom degree, for this the calculation of the previous life time of working of the required parts to wear and of the resistance (strength) to wear equivalent is based on the notion of accumulation of the defects, in case of the hazardous loads (duties), where the amplitude of the unit efforts varies continuously between enough large limits, while for the harmonica solutions there is only one value of the amplitude. For the building of a method of calculation it is adequate in advantage to introduce an equivalent unit effort (called usual reduced unit effort) "σe", which is producing same degree of wear as the spectrum (n_1, σ_E), (n_1, σ_E) ..., after the same number of cycles.

For the calculation of the probable life time (hardness) for a required system by any load (duty), the foreseen number of cycles having the amplitude between the period (cσ, σ + dσ) is provided by multiplying the total number of cycles (at the frequency cηn/(2π)) by Pm(s), where Pm(s) is called the distribution Rayleigh.

In these conditions the equivalent unit effort has the expression:

$$\sigma = \left(\frac{\int_0^{\infty} \sigma^{k\alpha} P_m(\sigma) d\sigma}{\int_0^{\infty} P_m(\sigma) d\sigma} \right)^{\frac{1}{k\alpha}}$$

It can be supposed that the pulsation of the unit equivalent effort is ft),,, which is the pulsation of the basic mode.

The (time) length of the unit effort could be:

$$T_{al} = \left(\frac{2\pi}{\omega} \right) N(\sigma_E)$$

For the determination of the equivalent unit effort for hardness duties (loads) determined the discreasing of the equivalent it is forces Von Mises maximum for the basic mode of vibration. By establishing the discreasing of the maximum forces Von Mises, it can be determined the no. of cycles in a period of time. The work cycle is as follows:

1.It is determined the maximum value of the forces Von Mises for the both models;

2.It is determined the discreasing of the maximum forces Von Mises with an interpolation polynom. The function which can generate any impulse on the tooth, which is fitted on the bucket, might have the shape as in the fig 5:

For determination of the basic mode of vibration it should be applied the method of the finished element by the method A - of discreetization of ET (CT), by putting the border limits conditions - as in the Figure 6a and the discreetization of the structure with tethraedrical elements of size two, as in the fig 6b.

It will be determined the basic mode for the model, fig 7. By applying they impulse function, the equivalent forces are going to be changed. The study of the forces is done for the determination of the maximum value where these forces might reach, for the basic mode, under the action of a hazardous impulse in a period of time and those evolution in time, fig 8. The discreasing for the maximum force - fig 9 - is done with a polynom of degree, which might give pretty well the hazardous.

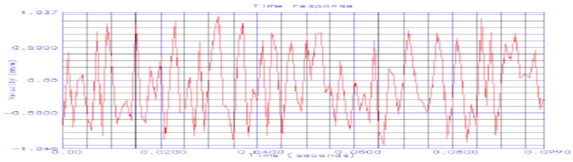

Figure 5: The impulse function

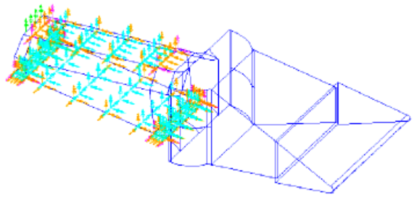

Figure 6a: Bordier limits conditions ET (CT)

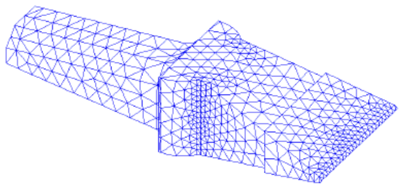

Figure 6b. Discreetiyation ET (CT)

Share of the maximum for ces, for the detrmination of the trust period of accuring of these forces and of the intensity for a period of time.

Estimating the hardness factor for the medel, it is calculated in function of the maximum forces for the given impulse in a period of time, the value of the hardness T=9,22e-5<1.

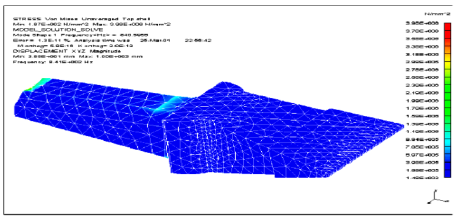

Figure7. The basic mode for model.

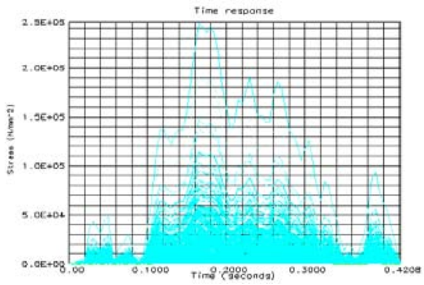

Figure 8. The variation of the equipment forces.

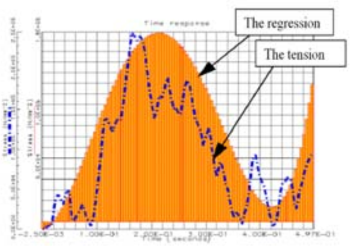

Figure 9 Maximum force.

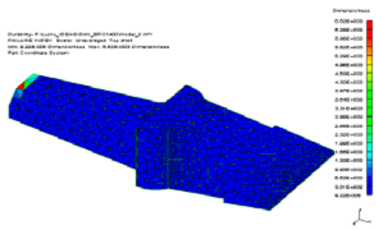

Fig 10. The estimation of the hardness.

1. Conclusions

From the transitive analysis under the action of an exciting impulse for a period of time t = [0-4,77e-01s], the forces are variating to maximum values, and en a time period (0, 0,25), they reach to the maximum value specific for each model, so that for a model more rigid, the forces being less for the same period comparing with the less rigid model. From this it results that the model is valid from point of due of the dynamic hardness (life time) and the problem provides in establishing the life time for the assessed materials and for a number of cycles in function of working hours. Same time it is done again the analysis for different coefficients of viscosity amortization, which are depending on the excavating layer, and of the material to be excavated.

4.Bibliography

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