THE ANNALS OF "DUNAREA DE JOS" UNIVERSITY OF GALATI
FASCICLE XIV MECHANICAL ENGINEERING, ISSN 1224-5615
2007

THE STUDY OF THE INFLUENCE OF STABILITY FOR HYDRAULIC TRACKED EXCAVATORS WITH BUCKET USING ASSISTED DESIGN

Assoc.Prof.Dr.Eng. Niculai HAUK
"Dunarea de Jos" University of Galati

ABSTRACT

The technological process of digging the natural earth using hydraulic excavators with bucket has the following steps: dislocation, transporting and depositing in means of transportation. During this process the excavator have to remain with all traveling train components on the ground. It is possible that in certain situation the limit of stability to be exceed and the excavator can not develop the forces.
This paper presents a series of considerations regarding the mentioned aspects.

1. The definition of maximal working forces without the consideration of the stability

The determination of the maximal developed forces on the crest of tooth of the bucket for a certain position has to be made in each case. It is supposed that the working takes place in a low category soil, the developed force on the crest of tooth is on the opposite moving direction and only one group of hydraulic cylinders is active. The active group of hydraulic cylinders develops forces in all the elements of the mechanism. The forces witch axial strain the hydraulic cylinders are creating pressures with values depending on:
- the way in witch the strain is produced (pull or compression);
- the size of the active surface of the piston;
-the position of the piston inside the body cylinder (if the hydraulic cylinder is based on the end of the stroke and where is the tendency to exceed this mechanical limitation, the concept of pressure of hydraulic working agent is meaningless);
- the number of cylinders of the respective group.

In figure 1 is presented in a schematic way the conditions of the forces developed by the working equipment by the regulations of the pressure valves of hydraulic installation.

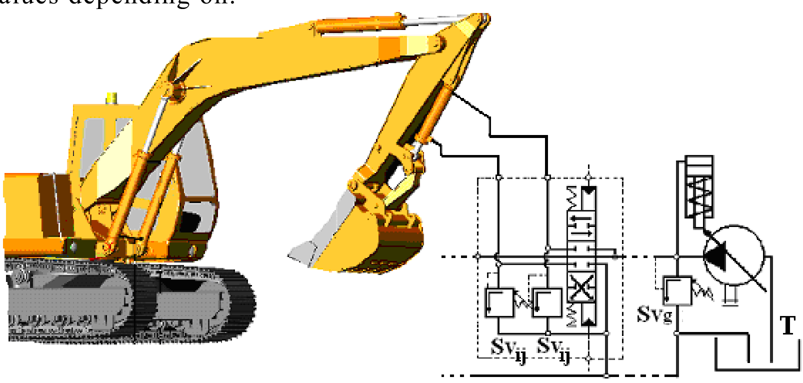


Fig. 1. The schematic way the conditions of the forces developed by the working equipment.

If in a passive cylinder who is positioned at a certain stroke and does not have mechanical limitations, forces are developed to lead to pressures bigger than the opening pressure of the overload **Svij** valve, then the valve is automatically opened, limiting the maximal axial force including the force on the crest of tooth.

The limit forces are calculated separate for each cylinder or group of cylinders who are driving the mechanism.

The calculations can be made in different ways, such as:

- the calculation of the pressures in passive cylinders and making the calculation in retrograde way if the control pressure of the valve is exceed by the involved overload;
- the gradual decreasing of the pressure from the active cylinder (if in those passive cylinders the maximum control pressure is exceed) till a value which does not develop in the passive cylinder pressures above the admitted ones. The precision of the calculation can be increased applying the method of bisector to the interval of values in witch the searched pressure is situated.

2. The stability of the tracked excavators

The stability is calculated regarding the size of the reactions that appears between the ground and the track on the overturning line of the excavator.

The stability is lost when one of the reactions on the mentioned lines is annulated. The negative values of this reaction do not exist; reaching the zero values means the beginning of the rotating process.

In figure 2 are presented the maximal risk situations of losing the stability in witch can be an excavator. In the first situation the digging equipment is across the relative moving direction of the tracks and in the second the same equipment is parallel to it.

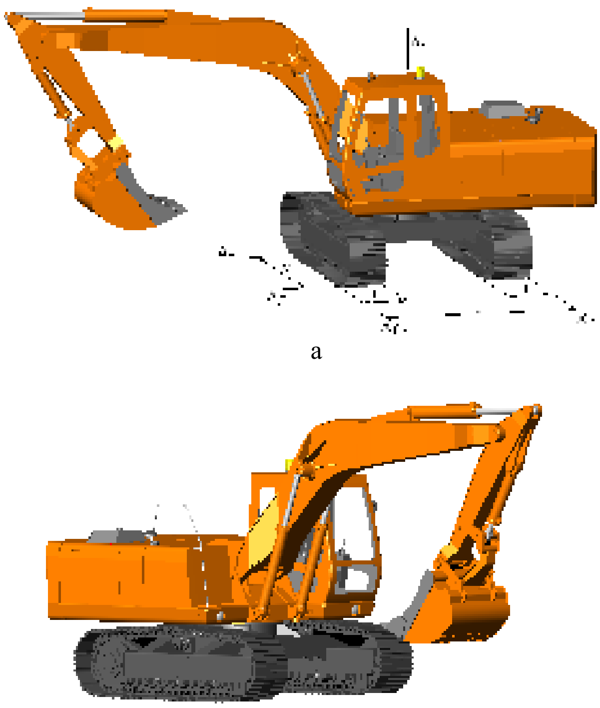
The lines when the stability can be lost are indicated in figure 2a:

- Δ_l and Δ_r in case a;
- Δ_f and Δ_b in case b.

Both cases present two situations: the indicated positions and the positions when the equipment is rotated with 180º.

The design assumptions of the mathematical model are:

- the elements of the excavator are components of a mechanism according the theory of mechanisms, regarding all the consequences;
- the soil is considered non-deforming, the tangential ground-track frictions are preventing the slipping;



a

b

Fig. 2. The maximal risk situations of losing the stability.

- the centre of mass of the components witch are containing liquids do not change;
- the analyze is made in static conditions;
- the bucket can be empty or can contain a material with a known weight.

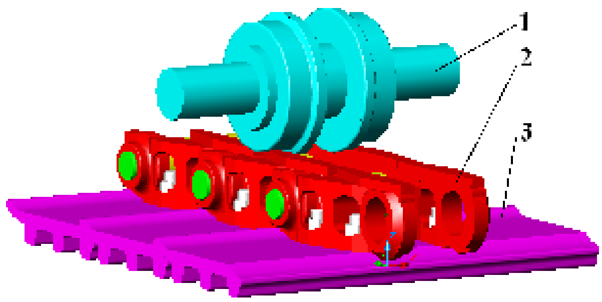


Fig. 3. Part of the tracked system.

In figure 3 is presented a part of the tracked system which is also used as a fixing system to the ground during time work. The roller 1 pushes the chain 2 witch elements are fixed on the track 3. The rigidity of the system is big because the chain is drawn with a pneumatic/ hydraulic system. This explain the position of the overturning lines Δ_l and Δ_r in case a. For a more realistic approach is possible to move the two lines (in a symmetrical approach) decreasing the distance U with a percent of L.

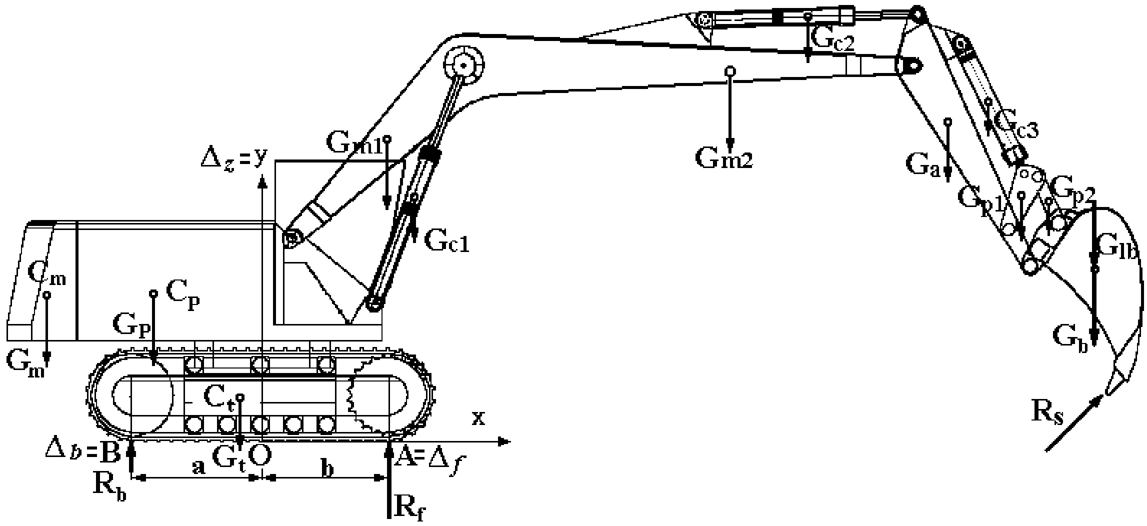


Fig. 4. The forces who are straining outside the excavator.

3. The utilization of the assisted design

In figure 4 are indicated the forces who are straining outside the excavator. The resistance **Rs** of the soil appears only during the digging process.

The determination of masses and centers of weight of component elements is very laborious because needs a big volume of work and time. Even in the experimental stage, the determination of these characteristics is difficult.

For increasing the efficiency of the designing it is used the 3D representation of component elements. The assisted design systems calculate automatically the volumes of excavator's elements. There are also calculated the coordinates of centers of weight reported to the coordinates systems (**UCS**).

Knowing the volumes and the densities of used materials, it can be calculated the mass and weight for each element.

The obtained data are used for the evaluation of the limit digging forces and the stability of excavator in the mentioned phases.

To study the limit digging forces, taking into account the stability of excavators, is created a program of numerical calculation especial build.

In this way measures of repositioning the elements from the swing platform can be taken.

The mass deficiency is compensated adding a counterbalance (indicated with **Cm** center of weight).

The optimization of the mass distribution on the excavator is very important because:

- a center of mass of the unit (the swing platform and the traveling) positioned to much in the back (on axe x) decreases the capable digging forces and increases the moment of inertia during the swinging, also the stability during the lifting of the full bucket;
- a center of mass to much in the front increases the capable digging forces and decreases the moment of inertia during the swinging, also the stability during the lifting of the full bucket.

The optimization consists in the distribution of masses with the purpose:

- to realize digging forces closer to the capacities of the digging equipment;
- maintaining the stability during the lifting of the bucket;
- creating a minimal moment of inertia for reducing the times of acceleration/breaking during the swinging. This last aspect presents interest also regarding the energy consumes.

The same unit can use work equipments of different dimensions and different kinetically principles. As a result, the optimization takes a very complex character witch needs the use the assisted designed on a large scale.

REFERENCES

[1]. **A. OPREAN , FL. IONESCU , AL. DORIN** *Actionari hidraulice. Elemente si sisteme*. Bucuresti. Editura Tehnica 1982.

[2]. **D. MANGERON, N. IRIMICIUC**, - *Mecanica rigidelor cu aplicatii în inginerie*. Bucuresti, Editura Tehnica 1981.

[3]. **D. Cohn, N Fulton, R. Halle, M. Morisin, T. Ryan, P. Sheerin, C. Sharp, R. Whobrey** *Using ATOCAD*, Bucuresti Editura Teora 1996.

[4]. **N. HAUK**, *Contributii teoretice si experimentale privind comportarea in regim dinamic a cilindrilor hidrauluci montati pe excavatoare*. - Teza de doctorat, Universitatea "Dunarea de Jos" din Galati, 1998 pp. 71-76, pp.88 - 92