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A METHOD FOR ESTABLISHING BY CONTROLLED APROXIMATION OF THE LIMITTED FORCES DEVELOPED BY THE MECHANISM ACTIONED BY ALIGNMED OF THE HYDRAULIC CYLINDER

Conf. dr. ing. Niculai HAUK,
Conf. dr. ing. Adrian GOANTA
Conf. dr. ing. Daniela GHELASE
Universitatea "Dunarea de Jos" din Galati

ABSTRACT

Determination of the limited forces – in case of the mechanisms actioned by the alignmed of the hydraulic cylinders is a very difficult problem to be realized very exactly. This paper presents a numerical method with a preciss calculation which can be controlled based on the high speed of calculation of the electronical systems. This process allow the introduction, if is necessary, to another functional limitations.

1. The definition of the problem.

A concret case of a mechanism operated by aligned hydraulic cylinders is the one of thehydraulic excavators. Those are realized- each one for it's destination- by a various kinematic and hydraulic schemes.

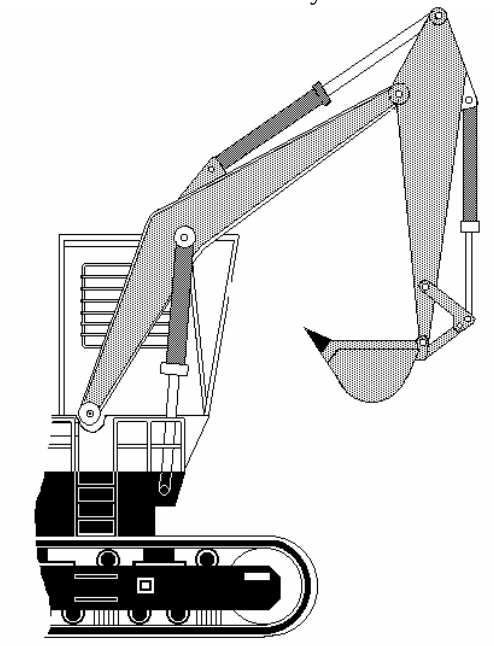


Figure 1. Excavator with reverse basket.

In figures no.1 and 2 are shown the kinematic scheme of 2 types of excavators: the first is a digging one with reverse basket and the 2nd is for loading. In the first case are used 3 groupes of hydraulic cylinders and in the 2nd case 4 (for opening the basket). In each case the main problem is to be determined the maximum forces wchich can be developed on the top of the basket teeth for a requested position.

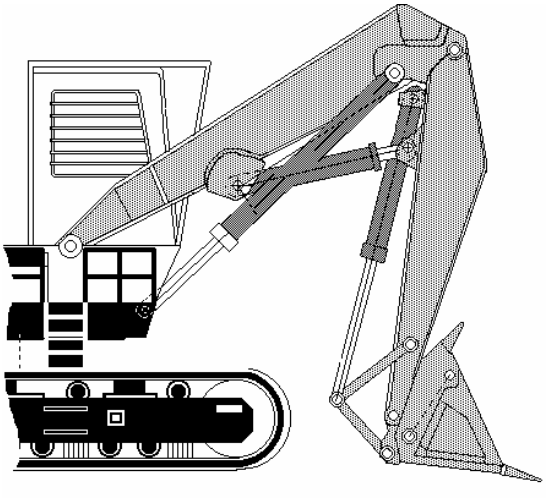


Figure 2. Excavator with direct basket.

It's assumed working in a ground of a low category the resulting force on the top of the basket beeingon the tranzit direction in opposed way. It is assumed that only one groupe of hydraulic cylinders is active. This groupe induce forces in all the mechanical elements.The forces which are requesting axial the hydraulic cylinders induce pressures – their value depending by:

- the way in which the demand is produced (hanlage o r compression);
- the active surface of the piston;
- the position of the piston related to the corp of the cylinder.

If the hydraulic cylinder is at one end of the course and the tendency of passing of this mechanic limitation exist, motion of the pressure of the hydraulic agent is meanless.
In figure no. 3 is showed a simplified part of the hydraulic action scheme.

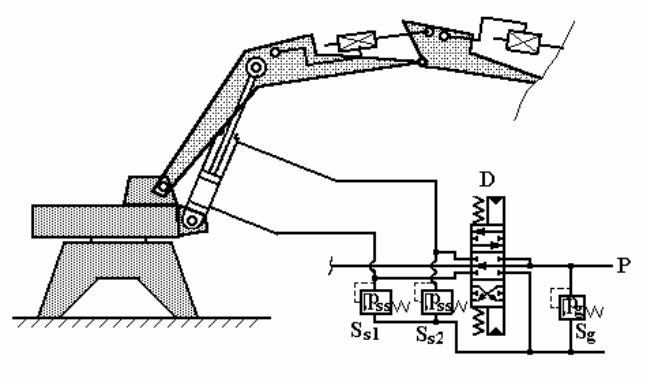


Figure 3. Hydraulic scheme of the action of a hydraulic cylinder of the mechanism.

If in a passive cylinder – beeing on a whatever course and not having mechanical limitations would by induced forces to lead to high pressures than the opening pressure for the overload valve than this one is automatically opened and will limit the maximum axial force and the force from the top of the basket, too.
The limitted forces are determind separatelly for:

- each cylinder or groupe of cylinders which action the mechanism;
- the 2 posibilities of droping down;
- from the slipping limits on hanlage and pushing (the last 2 conditions are available only for the mobile systems).

2. The numerical programmed statically model.

Taking into account the outlineing necessites it have been establisheh a mathematical model of the behavior of the hydraulic excavators with a reverse basket consignee gor working in low ground category.

The model allowed the exact calculation of the main parametres realized by digging equipments. The basis theory from which started to relise the mathematical model are:

- it's been neglected the influence of the „time" paramter, calculations been made into the statically domein;
- the digging equipment is a mechanism of a 3rd degree of mobility, the courses of the 3 groupes of hydraulic cylinders defining the position of the mechanism;
- the hydraulic scheme by it's presurre valves limited the maximum pressure of work and overload pressure on each groupe of hydraulic cylinder;
- the every kinematics element masses are concertraited in their weight centres.For the hydraulic cylinders the weight center has been established on the half of the current lenght;
- the position of the weight centre of the empty basket is the same with the position of the weight center of the material load into the basket;
- the forces and pressures determined in statically conditions have values limited by the dependence which shows in the 3 groupes of hydraulic cylinders through the hydraulic scheme;
- the digging force is the summarized effect of the forces due to the pressure from the active hydraulic cylinders groupe of weight of the elements and of the weight ofthe material from the basket (when case). It's shown on the level of the basketteeth as limited digging force;
- the stability of the excavator is affected by the tendency of overturn over a excavator crawler or over the wheel chain (in case of the excavator with wedging the overturn is considered raported with those systems).

The most delicate issue in theaccomplishof the logical scheme has been the interpretation εof the intelinking between groupes of active and passive hydraulic cylinder.
Is possible when in the active hydraulic cylinder groupe is been registered a lower pressure than the maximum working pressure in one or both passive hydraulic cylinders to be exceed the maximum pressure of additional valve adjusting. The excavator in this case can't work. It must be determine the maximum pressure from the active hydraulic cylinder on which the excavator can still dig (with limits of the pressure into the groupe of passive cylinder at the limit of controling for the additional valves).

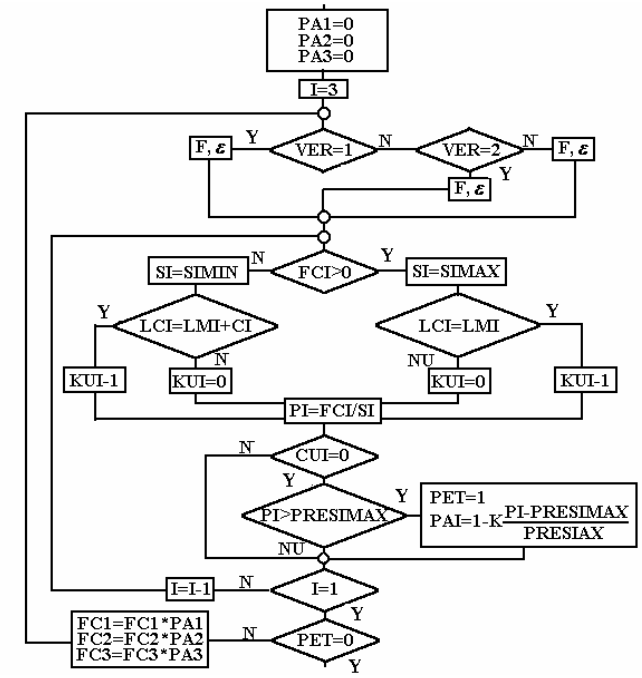
In case that one or baoth groupes of passive hydraulic cylinders are at the end of way and are pushed for overpassing that limit (the one completely opened are requested at hanlage or the one completely closed at astriction) the forces which shows can overpass the maximum force adequate of the additional valve adjusting. So limit forces higher than the ones shown in the previous model.

Logical scheme part which resolve all this aspects is shown in figure no. 4.

The parametres have the following meanings:

- VER – arrive from the program and indicate the active groupe of cylinders;
- F, ε – force on top of basket and angle mode of it with the articulation line basket – arm and top of the basket;
- FCI – force calculated in groupes of hydraulic cylinder, ***i***;
- SIMIN, SIMAX – the active surface of the hydraulic cylinder (min. and max.);
- LCI – the current lenght of the hydraulic cylinder from ***i*** groupe;
- LMI – the assembling lenght of the hydraulic cylinder from ***i*** groupe;
- CI – the current course of the hydraulic cylinder from ***i*** groupe;
- KUI – the parametres which show if the hydraulic cylinder is at the end of the course and is request in reverse way of it's moving possibility;
- PI – pressure into the groupe of cylinder ***i***;

Figure 4. Part of a logical scheme which allow



to determine the limit force and their pressure taking into account of the interconections of the hydraulic cylinders.

- PRESIMAX – the adjustment pressure of the additional valves on the groupe of hydraulic cylinder ***i***;
- PET – parametre which is different of zero indicate that into the groupe of active hydraulic cylinders must be adjust the pressure because in one or both groupes of passive cylinders it was overpassed the additional valve adjustment;
- PAR – corection parametre of the force from the active groupe of hydraulic cylinder.

Depending to the value of the Ver parametre it can be calculated the forces from the top of the basket. Based on it, can be made calculations at the every level of hydraulic cylinder groupe.

The sign of the FCI force indicate the nature of the strain (streching or astriction) and the surface on which the pressure is made.

After compare the current lenght of the hydraulic cylinder with the limit lenght (depending on force sense) it can calculated the pressure from the groupe of hydraulic cylinder analized.

If the groupe is at the limit lenght and is requested to overpass this limit it can be pass the next groupe of hydraulic cylinder. If not it's compare the effective pressure with one from the additional correcting valves when no overpass is determined it can pass to the next groupe of hydraulic cylinders.

If yes this will be pointed making the PET – 0 and calculating the reducing force parametre from the groupe of active hydraulic cylinders (PAI).

The calculation is over when none of the hydraulic cylinder groupes hasn't overpassed the correcting presurre of the ownes adjusting valves.

In tables 1 and 2 are shown the results of the 2 numerical simulations for a real excavator.

Tabel no.1

c2 m	p1 MPa.	p2 MPa.	p3 MPa.	Fvx KN	Fvy KN
0	34	19,2	20,1	147,7	14,1
0,111	34	17,2	21,5	158,1	15,1
0,222	34	16,9	23,3	170,7	16,3
0,333	34	17,7	25,5	186,6	18,6
0,444	34	19,2	28,3	206,8	19,8
0,555	34	21,7	32,1	233,7	22,7
0,666	29,9	23,3	34	247,3	23,7
0,777	22,7	23,9	34	247,3	23,7
0,888	15,2	24,9	34	247,3	23,7
1	7,5	25,2	34	247,3	23,7

Fvx represent the tangent force to the basket and Fvy the force which is quaquaversal request the basket.
The correcting pressures of the valves have been for the one od additional load 34 MPa and the general one 28 MPa. In first case has been considered cylinder 2 as beeing active, others beeing at c1-0.8 m and c3-0.1 m. It can be see that one by one the correcting pressures of the additional load valves in the passive hydraulic cylinder are reached. Valves Fvx and Fvy represent the maximum which can be reached for each and every one position.

Tabel no.2

c3 m	p1 MPa.	p2 MPa.	p3 MPa.	Fvx KN	Fvy KN
0	34	14,2	24,7	134	0
0,13	34	16,7	20,4	158	0
0,27	34	19,9	22,4	197	0
0,4	31,7	23,9	28	255	0
0,53	13,8	21,1	28	251	0
0,67	***3,2***	16,9	28	236	0
0,8	***14***	11,8	28	210	0
0,93	***22***	6,4	28	171	0
1,06	***24***	1,6	28	117	0
1,2	***17,1***	1,5	28	52	0

In tabel no.2 it's been realised a simulation with the cylinder no. 3 active. It can be seen that the no. 1 groupe of cylinders is initial request at compresion and then (on the marked zone) at hanlage.
After the pressure from no.1 groupe of cylinders decrease under 34 MPa the pressure from the active cylinder have reached the maximum value.
The proposed way of calculation inssure the determination of the limit forces with a desired precision.
For the realized simulation the aprox. precision of the corrected pressure for the adjusting valves haven't passed over 0.003 MPa in not one of the calculation points.
This precission is acceptable increasing beeing only a problem of option, incrasing the calculation time not beeing the goal.

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