TEKA Kom. Mot. Energ. Roln. – OL PAN, 2007, 7, 286–292

RESEARCHES OF GEOMETRICAL PARAMETERS OF THE ROTARY ALLOCATOR OF VARIABLE DISPLACEMENT AXIAL PISTON HYDROMACHINE

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Summary. This paper is dedicated to study of variable displacement axial pistpn hydromachine with inclined block of cylinders. The stress and deformation states of the main element of the hydromachine of the given type valve plate were observed. Calculations were conducted with help of the modern program package ANSYS. The maximum values of deformation and stress were established.

Key words: axial piston hydromachine, transmissions, valve plate, swinging unit

INTRODUCTION

A big number of volumetric transmission principle charts, differing with a number , kind and location of aggregates in a power stream, is used in agricultural engineering. The choice of transmission depends on the driving engine power, range of transmission relation change, maximal speed values and hauling effort, descriptions of applied aggregates, transmission arrangement, mass, cost, etc.

The main advantages of volumetric transmissions application in drives of agricultural engineering are [Petrov 1988]:

– variable displacement regulation of speed or tractive effort in the set range of parameters;
– increase of productivity due to automation, better maneuverability and fast-acting;
– increase of engine load at nominal operating condition.

Axial-piston hydromachines (APH) have got vide application in separately-aggregate transmissions with mechanic differential. Application of the regulated pump and hydromotor increase loading range with variable displacement regulation of parameters at least twice (Fig. 1).

During application of transmission with variable displaced pump (Fig. 2) to expand adjusting range the three-speed variable transmission gearbox is set, that provides an

operating condition at a low gear, speed mode at third transmission and transitional mode at second transmission [Bosch Rexroth Groupe, RE98071, 2002].

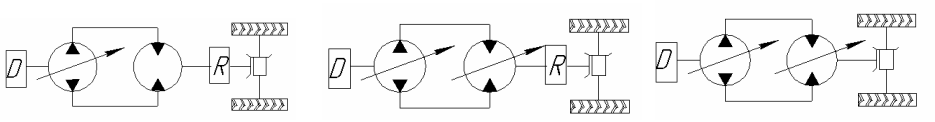

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Fig. 1. Charts of separately-aggregate transmission [Petrov 1988]: a – the variable displaced pump and fixed displaced hydromotor with gearbox; b – the variable pump and hydromotor with gearbox; c – the variable pump and hydromotor, D – engine, R – gearbox

For variable axial piston hydromachine (VAPH) with a sloping disc pump its range of variable is D_p = 2.6...2.8. To provide all the necessary operating condition the optimal range of adjusting transmission is D = 20...25. That's why in such transmissions the three-speed gearbox with the range of variablility D_b = 7.1…9.6. Is set application of two variable hydromachines with sloping discs (Fig. 1b) gives the total range of variability of hydromachine $D_h = D_p \cdot D_m$ = 6.8...7.8, and transmission D_{gb} = 2.6…3.7 that is provided with a two-speed gearbox (Fig. 2b). At low gear an operating condition is provided, at the second transmission speed mode of movement of agricultural machine is provided. Thus, an operating condition is regulated by change of pump swept volume at maximal hydromotor swept volume. The speed mode at the second speed is regulated by motor swept volume at the maximal pump swept volume.

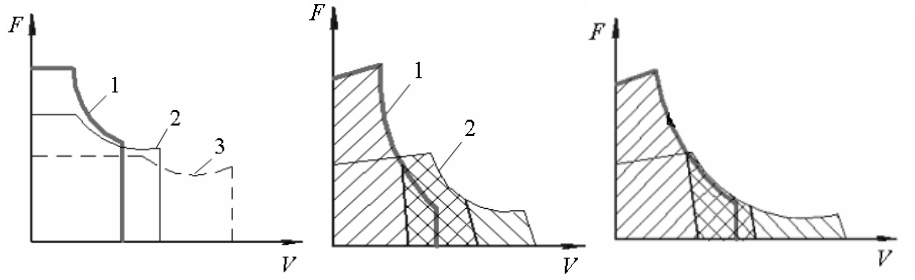

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Fig. 2. Descriptions of tractive -speeds: a – at the variable displaced pump and fixdisplaced hydromotor; b – variable displaced pump and hydromotor with a gearbox; c – the variable displaced pump and hydromotor. 1, 2, 3th transmissions of a gearbox

– regulation by variable displacement with a pump;
– regulation by variable displacement with a hydromotor;
– regulation by variable displacement with pump and hydromotor.

For the last few years there became obvious a tendency of all leading producers of mobile technique to waiver application of hydromotors with a sloping puck in hydrotransmissions, with their substituting with variable hydromotors with sloping block of cylinders (BC) (Fig. 3a). It should be noted that a hydromachine with the sloping BC possesses more intensive characteristics of motors, ten time lower minimal frequency of rotation, it assumes work with working liquid of 25 mkm fineness of filtration. That

provides an additional the increase of reliability and longevity of hydrotransmissions in general.

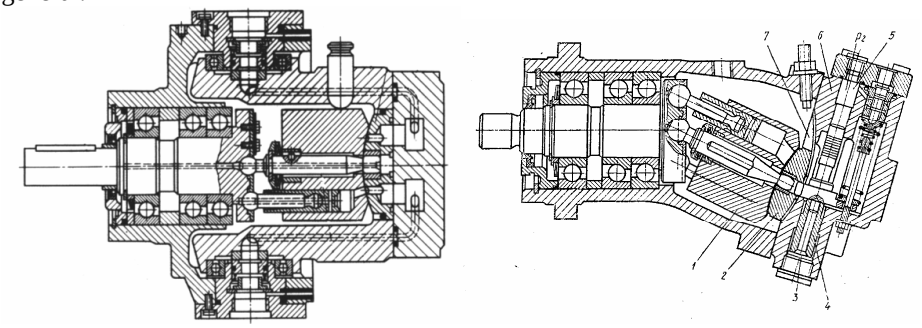

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Fig. 3. VAPH with sloping BC: a – VP in a turning cradle, b – VP is a chart „Trimot"

The main advantage of all APH is simplicity of adjusting of the swept volume. The sphere of VAPH with sloping BC of structural chart „Trimot" as hydromotors was especially broadened, due to the above-indicated advantages (Fig. 1a). This adjustment chart provides the range of adjusting of the swept volume D_m= 5…6,5 and allows for multiple angle of BC slope to 40…45° [Thomson and Bretz 1991]. Application of such hyomotors in hydrotransmissions enables exceptionaly efficient mechanical gearbox, which promotes efficiency and reliability of the system as a whole.

TASK RAISING

An important direction of further development of mobile technique of APH drives is an improvement of methods of constructions calculation and modernization that allow to realize advantages of this type hydromachine at maximal degree [Nikolenko *et al.* 2004].

Capacity and operating qualities of APH substantially depend on the method of working liquid distribution in swinging unit (SU). The main problems solved by development of valve plate (VP) devices are: providing of durability, rigidity and longevity of details; stabilization of gap between BC and VP; decline of radiated noise level. The valve plate of working liquid is used in a great number of constructions of SU of modern APH. The VP of butt ends in SU APH differ in form and number of distributing windows, and in form of surface which BC leans against. The VP with two c-type distributing windows of high and low pressure turned to BC have got the widest spread. In trimot-type APH in VP there are rectangular windows, turned to the lid of case. Sizes of windows are determined from the terms of assured clamp of turning VP to the lid of corps, and also from hydraulic calculations of communicating sections at the minimum and maximal swept volume. Application of VP with a spherical butt end surface provides an influence of additional moment at BC that hinders opening of joint.

There are few recommendations on the choice of geometrical parameters of SU depending on descriptions of APH in technical literature. That is why VP development of their sizes is adopted structurally and oriented mainly on the experience of previous developments. For ground and development of optimum SU constructions modern

methods of details calculation are needed, that allow to determine rational structural sizes of SU details on the stages of calculations and checking by set technical recommendations of APH. With development of computer technique numeral methods theories of resiliency have got wide distribution, among which finite element method is used effectively for engineering calculations [Chigarev 2004]. According to this method a construction appears as an aggregate of resilient eventual elements of stand forms, linked in key points.

BASIC RESULTS OF CALCULATIONS

Researches were executed for VAPH of series 400 size 112. According to the working drawing of VP 403.112.1.30 its model was created. It is a three-dimensional figure, built with characteristic volumes (Fig. 4). Model with the use of cone in a butt end surface, facing to back lid is examined (Fig. 5). The cone gives possibility to multiply durability and rigidity of construction.

For laying out the element SOLID92, is applied, suitable for design of irregular nets. An element SOLID92 is a pyramid determined by ten knots which have three degrees of freedom in every knot: movement in directions of axes X, Y, Z of key of coordinate system.

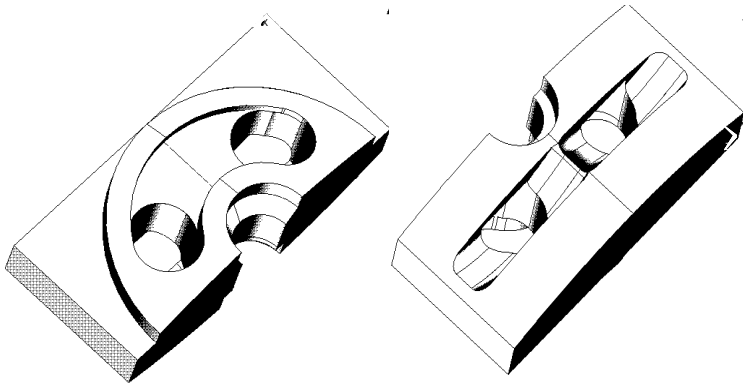

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Fig. 4. Model of VP: a – surface turned to block; b – surface turned to lid of case.

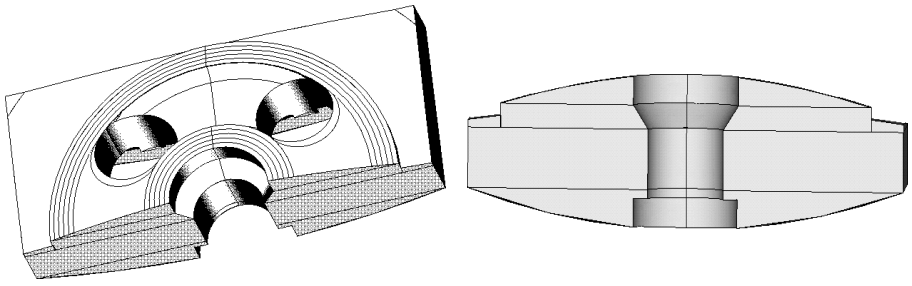

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Fig. 5. Model of VP with a cone: a – a surface is turned to the block; b – is a section of VP with a cone

Models of VP were broken into more than into 160000 eventual elements. When constructing the net, algorithm of rational choice of layout element is used. That allows to build the net of elements taking into account curvature of model surface as well as to describe its real geometry.

As a result of the carried out researches of the tensely deformed state of the allocator of the hydromachine, fields of pressure and deformations are determined at different kinds of loadings for different models. In Fig. 6 fields of intensity pressure for model without a cone, and in Fig. 7 – with a cone, are shown. Total movings of a surface of the allocator without a cone in Fig. 8, and in Fig. 9 – with a cone, are submitted. Sizes of the maximal intensity of pressure which arise in crosspieces of the allocator have allowed to define the analysis of the received results.

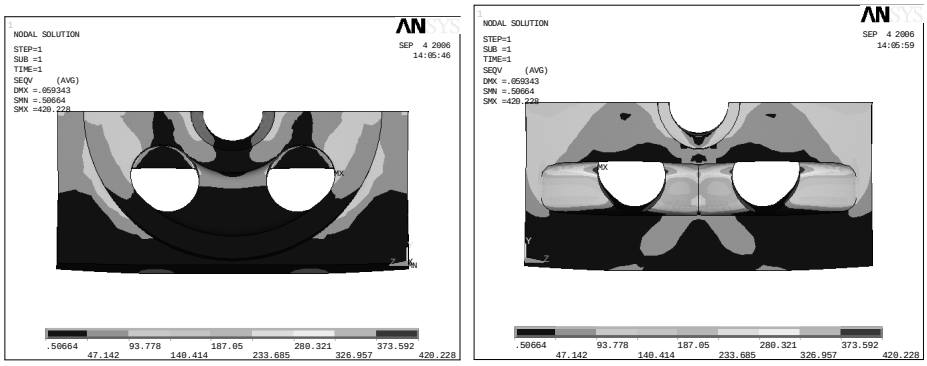

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Fig. 6. Fields of intense pressure in VP: a – the surface is inverted to the block; b – the surface is inverted to a cover of the case

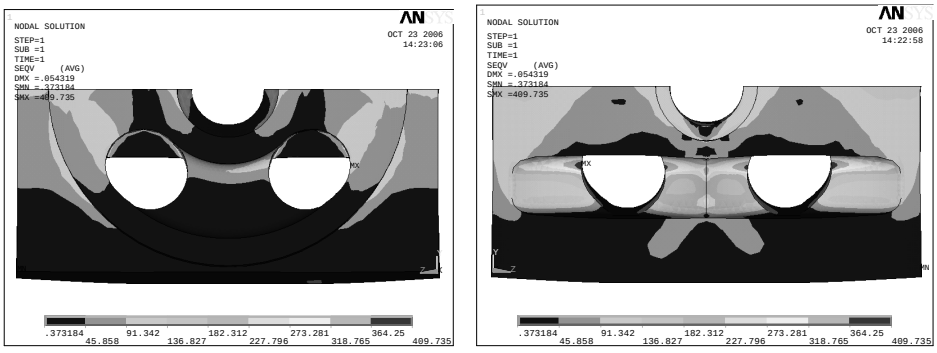

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Fig. 7. Fields of intense pressure in VP with a cone: a – the surface is inverted to the block; b – the surface is inverted to a cover of the case

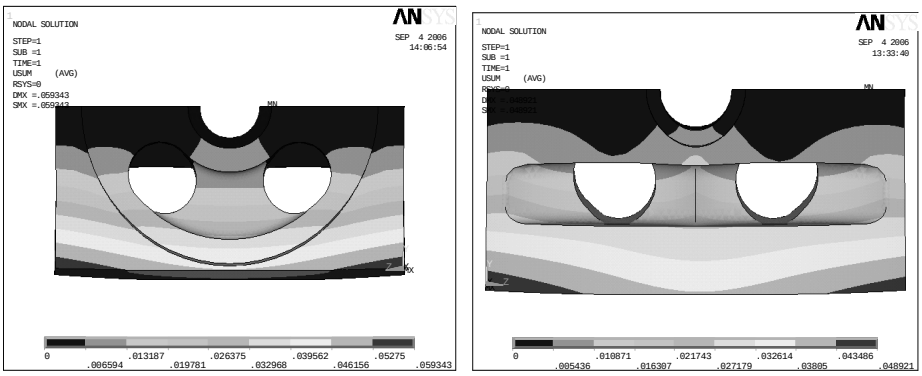

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Fig. 8. Total movings in VP: a – the surface is inverted to the block;
b – the surface is inverted to a cover of the case

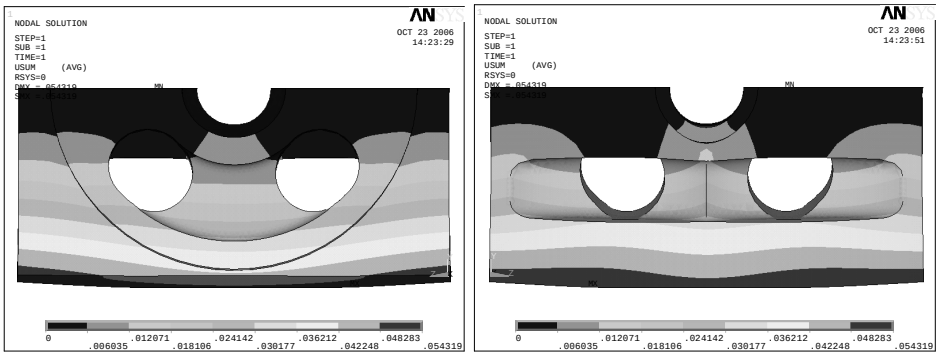

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Fig. 9. Total movings in VP with a cone: a – the surface is inverted to the block;
b – the surface is inverted to a cover of the case

Time of calculation of one decision has taken 80 minutes on a computer with such characteristics: operative memory 2 Gb, the processor 3GH. Some variants of designs that have enabled to develop recommendations for a choice of the rational geometrical sizes of allocators are considered. There was chosen the pressure p = 25 MPa in accounts. Material of VP is steel of P25.

The analysis of results allowed to determine the value of maximal intensity of tensions which arise up in the bridges of VP. At pressure p = 25 MPa maximal tensions in VP without a cone at symmetric position were 420 MPa, and at not symmetric position were 320 MPa. The maximal moving arise up on the lateral sides of VP without a cone. They increase from butt end surface turned to BC to butt end surface turned to the lid of corps and they reach 59 mkm. At the pressure p = 25 MPa maximal tensions in VP with a cone at symmetric position were 409 MPa. The maximal moving in a VP with a cone were 54 mkm.

CONCLUSIONS

Technological simplifications of VP VAPH type 403.112, areas with maximal deformations and tension at action of nominal and maximal pressure are found out and developed. Research of tense deformed condition VP.

As a result of the executed analysis of VP a tensely deformed state with the programm complex ANSYS recommendation on modernization of construction are developed. The purpose of recommendations is an increase of working pressure up to 40 MPa in VAPH with structural chart „Trimot" Application of cone decreased the size of tensions to 5–10%, it provided multiplying descriptions of outputs: pressure and long life.

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