Adaptive drive of the technological machine with two working movements of the executive body

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Abstract. The article deals with the machines schemes, having an executive body making two movements and establishing a relationship between them. The ratio of the moving velocities, or the ratio of the two displacements of these movements, or the ratio of the applied powers to each of these movements, determines the indices of the working process, and often has an optimal value. A typical example of this type of machine is a drilling machine. The ratio of rotation speed and the feed rate determines both the specific power intensity of the cutting process, the intensity of the wear out and drilling capacity. The structural schemes of the drive of some other technological machines are considered. On the example of a device used for processing curved surfaces in metalworking, a process of automatically adjusting chip thickness with a hydraulic drive having an adaptive structure is described. The efficiency of self-regulation is shown by means of using relatively simple circuit solutions.

1 Introduction

Technological machines can be described as the working process determined by the relationship of two related movements, for example, translational and rotational motion. Classical drilling machines for construction, mining industry and geological exploration are known to be an extensive class of machines of different capacities, different performances oriented for different drilling conditions. Such technological machines are added by metal working machines in which the working process is provided by at least two interlocking movements. Moreover, two working movements are the main ones and their ratio determines the indicators of metal working processes. In some machines, for example, milling or drilling, the working process is provided by two movements: rotational and translational. The ratio and velocities of these movements determine the productivity and specific energy consumption, the temperature modes of cutting, the purity of the processed surface and the life cycle of the cutting tools. The theory of cutting determines the optimal conditions for metalworking process of various materials, and the operating conditions of the machines. There are a lot of other numerous technological machines in which the executive body performs two interconnected movements, so it necessary to maintain some rational relationships between them.

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2 Topicality

The process of automatic maintaining the rational relationships without using automation and computer technology is of great interest. This method is known, as it was developed by a number of researchers under the scientific guidance of professors G.M., Vodianik. and A.N. Drovnikov [1,2,3]. This paper presents some results of some well-known studies.

Let us consider the example of a loading machine (Fig. 1) with two related movements, in which a mechanical differential (2) is used. The usage of the planetary differential, allowed providing a rational ratio of the torque on the loading body (5) with the moment of resistance of the mechanism of moving the loading machine (3) on the loading material. When the loading mechanism (5) is overloaded, the speed of the moving machine to the stack of the loaded material is automatically reduced.

Fig. 1. Loading machine by A.S. USSR №404949.

Similar functions of the automated drive are provided by means of two differentials for another loading machine (Fig. 2). The drive of such loading machine includes two hydraulic and mechanical differentials. The first is formed by means of the parallel inclusion of the hydraulic motors *HMI* and *HM2*. The second differential is formed by a planetary adder (1) (see Fig. 2). Due to the sequential activation of the hydraulic motors *G2* and *G3*, automatic speed control of the machine body movement on the loaded material from the moment of resistance on the loading body is provided. When the resistance on the shaft of the motor *G3* is less than the settled one, the speed of sliding machine is increased. At the critical torque of rotation on the shaft of this hydraulic motor, the machine moves (mechanism 2) away from the material being loaded. Details of the work of the machine are given in the description of the author's certificate.

Fig. 2. Hydraulic drive of the loading machine according to A.S. USSR № 420793

Figure 3 shows a scheme of a hydraulic loading machine with two hydraulic differentials [4]. The first differential is formed by dividing the hydraulic pump flow rate (3) into two arms: the hydraulic motor (4) and the hydraulic motor (6). It is obvious that the costs over the shoulders of this hydraulic differential can be redistributed.

Fig. 3. The scheme of hydraulic loading machine.

On the drain line (15) of the hydraulic motor (4), a reversible hydraulic motor (5) is included, which is the drive of the machine moving mechanism (7) to the loading material. The hydraulic motor (5) forms the second hydraulic differential. Indeed, a drain line of the hydraulic motor is connected to its drain line (6). And the direction of rotation and the speed of rotation of the hydraulic motor (5) depends both on the loading mechanism (1), on the conveyor overload (8) and resistance to the machine moving on the loaded material. In a critical case, if the loading “paws “are jammed and the hydraulic motor is stopped, the hydraulic fluid under pressure through the hydraulic motor (6) can lead to a reverse rotation of the hydraulic motor (5). The machine will move away from the immersed material.

The flow through the hydraulic motor (4) depends on the moment of resistance to the rotation of the loading “paws”, and the flow through the hydraulic motor (6) which is formed with the load on the belt conveyor which depends on the conveyor load.

3 Practical relevance

To analyze the adaptation properties, the hydraulic drive of this machine can be represented as a closed hydraulic drive with separation of differential groups. Figure 4 shows the structure of this hydraulic drive, identical to the diagram shown in Figure 3. In the actual loading machine, the hydraulic drive is not closed.

Fig. 4. Block diagram of the hydraulic drive of the loading machine.

The working state of the hydraulic circuit is provided by the main flow of hydraulic fluid through the hydraulic motor 4, hydraulic motor 5 and throttle 9.

The ratio of the loads of the hydraulic motors 4 and 5 is adjusted by the throttle 10. When the load on the hydraulic motor 4 increases, the pressure at the inlet to the throttle 11 and then on the hydraulic motor 6, as well as on the throttle 9, also increases. In this case, the speed of the reverse motor decreases, the speed of moving the loading machine on the loading stack also decreases, while the speed of the conveyor drive increases. With the reduction of the load on the hydraulic motor 4, the moving speed (the frequency of motor rotation 5 of the loading machine on the stack increases.

Thus, the loading machine self-regulation is performed. It assumes the method of continuous loading of the loading machine on the slaughtering when the speed of machine sliding is adjusted depending on the moment of resistance to the rotation of the drive of the loading paws.

Cutting metals, drilling rocks, destructing building materials by using executive bodies of cutters, teeth and other cutting tools can be provided by adjusting the ratio of the two speeds in the direction of movement of the cutting tool and in the perpendicular direction to the cutting vector- supply. In this case, the operating modes, their optimality are provided by the regulation of the components efforts in the above-mentioned areas.

The problem of adaptive cutting control is automatic maintenance of the optimum [5] the ratio of these efforts, within the limitations [6].

The peculiarity of controlling working machines with executive body performing two working movements is the consideration of random and systematic external influences, to which the control system must respond as an adequate (adaptive) change in the operating mode, one at a time or in both control channels. In this case, the control criterion can be a rational ratio of working movements and their parameters, and the transition of the drive operation into a special, for example, emergency (protection) mode.

For this purpose it is expedient to use methods of hydro-automatics, and in particular to use an automated hydraulic drive in which hydraulic differentials are used. At the same time, the peculiarity of such control schemes is the realization of feedbacks through force-moment kinematic links. In such an automated drive, it is not necessary to use sensors and meters, comparisons of controllers and control algorithms typical for automated control systems.

Experience of the development, research and application of this type of drives has shown the ability to provide high performance and stability of operating these machines [7]. Similar to the above pointed description, the hydraulic drive of other adaptive machines and devices can operate: the hydraulic drive as the "Method of intensification of the cutting process" [8], the hydraulic drive as "Devices for stabilizing the thickness of the layer to be removed during machining curvilinear surfaces" [9], as the hydraulic drive of the robot module [10], as the hydraulic drive of adaptive drilling machine [11] and other adaptive

machines and mechanisms pointed out in the works by G.M. Vodianik , and A.N. Drovnikov [3].

Let us consider another device that can be used for rough machining of various parts with a complex profile (Fig. 5). This device can be used for stabilizing the thickness of the removable layer during machining of curvilinear surfaces [9].

Fig. 5. Schematic diagram of the device for stabilizing the thickness of the removable layer during machining of curvilinear surfaces. (A. S. SU № 483224).

Below (Fig. 6) the block diagram of this device is given.

Fig. 6. Scheme diagram of the device for stabilizing the thickness of the removable layer during machining of curvilinear surfaces.

Fig. 7 shows the hydraulic circuit of the drilling machine [9], in which two hydraulic differentials are used. The first differential is the output of the hydraulic fluid from the hydraulic pump and dividing the flow into two lines through the throttle 1 and the hydraulic motor. The second differential is the hydraulic cylinder.

Fig. 7. The adaptive drilling machine "UBG-1A"

As can be seen from the comparison of the above pointed schemes, the drive of the drill, tunneling machine and drilling machine can be represented by bridge switching of the hydraulic motor or hydraulic cylinder in the bridge diagonal. Obviously, depending on the ratio of the bridge arms, the flow direction into the diagonal can be direct or reverse.

4 Conclusion

1. The performed research allowed to develop a generalized structure of these machines on the basis of generalization of a number of known and investigated adaptive machines applicable for the analysis and simulation of the automated drive made on the basis of hydraulic differentials.

2. For the analysis of specific hydraulic circuits of the adaptive drive, the approach of conversion of open hydraulic circuits into closed ones was used. This transformation allows the calculation of these hydraulic circuits using the method of electro-hydraulic analogies.

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