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ADAPTIVE HYDRAULIC CIRCUIT FOR MOBILE MACHINES

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Abstract

Hydraulic systems based on adjustable pumps, proportional electrohydraulic equipment and controllers are used in mobile machines. The authors propose a new scheme of the hydraulic system for mobile machines, which provides the auger drilling operation. A number of studies have shown that a certain ratio should be maintained between the frequency of auger rotation and its feed during operation, where the productivity of soil disruption should not exceed the productivity of transporting loose soil from the drilling zone. Ensuring the required ratio between the speed of the auger rotation and its feed is implemented by a controller that works according to a certain algorithm. The algorithm for controlling the auger feed value is formed. This c provides the necessary ratio between the auger feed and speed, as well as reducing the feed rate in the case of soil hardness increases. This creates the conditions for uninterrupted pit drilling at full depth and protection of the hydraulic system from overload.

Key words. adaptive hydraulic circuit, mobile machines, controller, algorithm.

Introduction

Mobile machines have hydraulic systems based on controlled pumps and modulated hydraulics. Such hydraulic circuits become more efficient if they are equipped with electrohydraulics, sensors and controllers. Controllers allow adapting the hydraulic circuit operating modes to the changes of external conditions of the machine operation.

The authors have proposed a new pattern of a mobile machine hydraulic circuit that provides auger drilling of shot holes with diameter up to 600 mm and up to 3 m deep in soil without rock. The proposed hydraulic circuit involves two controlled pumps, a partitioned distributor with modulated electrohydraulics, sensor system and a controller with analogue inputs and outputs. The hydraulic circuit provides the auger rotation and its supply during the shot hole drilling. Some known researches have proven that a certain ratio should be maintained between the auger rotation frequency and its supply during operation; such ratio should provide that the soil destruction productivity does not exceed the productivity of transporting the unconsolidated soil from the drilling area. The required ratio between the auger rotation frequency and its supply is provided by the controller operating according to a certain algorithm.

Results

In Fig. 1, the scheme of the adaptive hydraulic system developed by the authors is presented. The adaptive hydraulic system includes: adjustable pumps 1 and 2, distributors 3, 4, hydraulic cylinder 5, hydraulic motor 6, adjustable throttles 7, 16, differential pressure valves 8, 17, controller 9, amplifiers 10, 11, pressure sensor 12 and tank 19. The hydraulic cylinder 5, which moves the handle 14 is mounted on the boom 13 of the excavator. On the handle 14, the hydraulic motor 6 is installed, which actuates the auger 15.

The hydraulic system uses an adaptive regulator (Fig. 2), which has the unit 1 for switching modes, units 2, 3 for adjusting the flow rates for hydraulic motors, mode switch 4, signal delay units 5, 6, unit 7 for forming the pattern of the ratio change between the flow rates to hydraulic motors, unit 8 for forming the transfer coefficient of the adjusting component, unit 9 for forming the derivative.

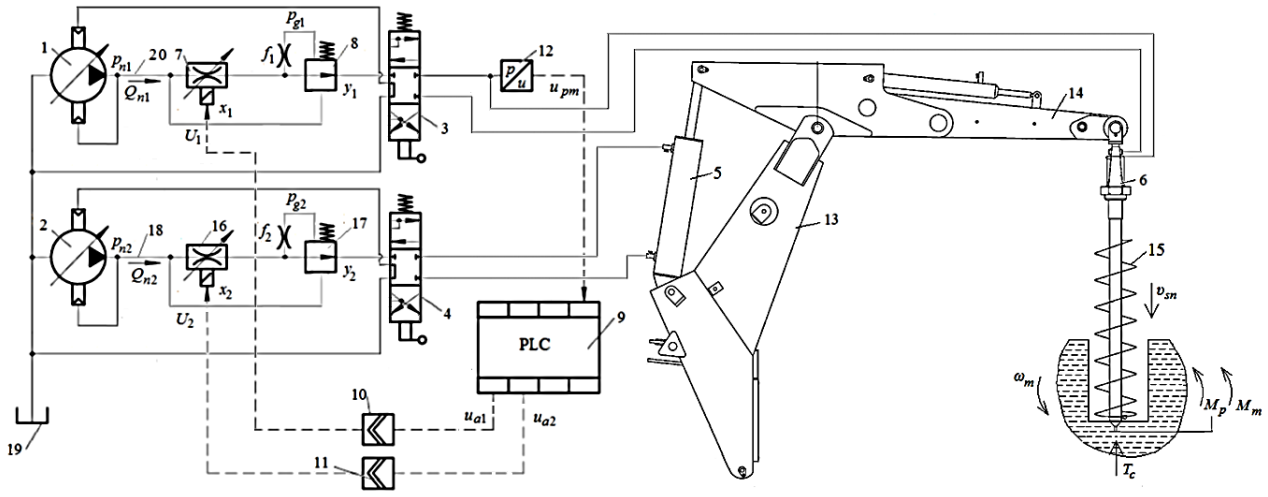

Fig. 1 Scheme of the adaptive hydraulic system

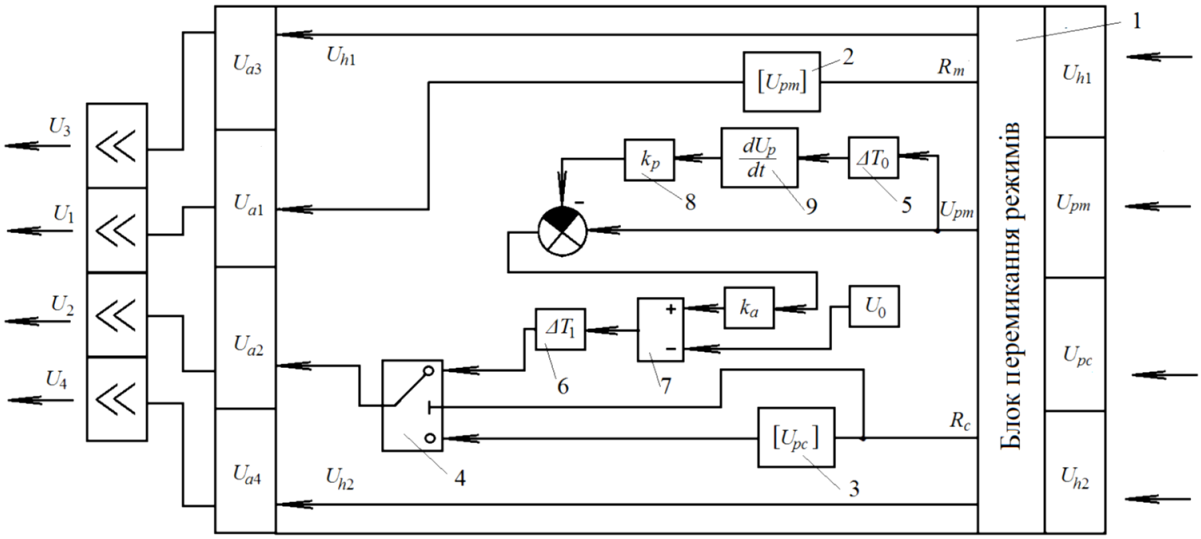

Fig. 2 Adaptive regulator

The adaptive regulator provides adjustment of the cross-connection signal between circuits which provide auger rotation and feed in order to improve the dynamic characteristics of the hydraulic system. The adaptive controller provides for possible adjustment of the parameter k_p – the transfer ratio of the adjustment component and ΔT_0 – the time delay of the cross-connection signal.

A mathematical model was developed for the presented adaptive hydraulic system. According to the mathematical model, the characteristics of the adaptive hydraulic system were calculated.

During the operation of the adaptive hydraulic system for pit drilling operations, it is necessary to maintain a stable rotation speed ω_m of the hydraulic motor shaft, which actuates the auger. This is ensured by the presence of the throttle 7 and the differential pressure valve 8 in the adaptive hydraulic system (see Fig.1). The controller 9 provides a change in the feed rate v_c according to a certain dependence, which is implemented in the program. The program uses the dependence of type $U_{a2} = U_0 - k_0 U_{pm}$, where U_0 and k_0 are rates that vary depending on the mode of operation of the adaptive hydraulic system and the value of loads on the auger.

The algorithm provides automatic adjustment of two parameters for setting the adaptive hydraulic system:

Ensuring the ratio between the rotation speed of the auger ω_m and the feed of the auger v_c, at which the productivity of loose rock transportation exceeds the productivity of drilling. This ratio eliminates pinching of the auger during drilling.

Active pressure control of p_m at the inlet to the hydraulic motor is carried out in order to limit the pressure of p_{n1} at the pump outlet and ensure uninterrupted drilling when soil properties are changed.

Conclusions

The proposed control algorithm of the adaptive hydraulic system provides such a ratio between the rotation speed of the auger and the value of its feed in the drilling process, in which the productivity of soil disruption with the auger does not exceed the productivity of transporting loose soil from the drilled depth, which ensures uninterrupted operation of the machine in the working cycle. Depending on loading, the auger feed value changes under condition of not exceeding admissible pressure value in the hydraulic system.

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Адаптивна гідравлічна схема для мобільних машини

Анотація

У мобільних машинах використовуються гідравлічні системи на основі регульованих насосів, пропорційної електрогідравлічної апаратури та регуляторів. Авторами запропоновано нову схему гідравлічної системи мобільних машин, яка забезпечує роботу шнекового буріння. У ряді досліджень показано, що між частотою обертання шнека та його подачею під час роботи необхідно підтримувати певне співвідношення, при якому продуктивність руйнування ґрунту не повинна перевищувати продуктивність транспортування рихлого ґрунту із зони буріння. Забезпечення необхідного співвідношення між швидкістю обертання шнека та його подачею здійснюється контролером, який працює за певним алгоритмом. Сформовано алгоритм керування величиною шнекової подачі. При цьому забезпечується необхідне співвідношення між подачею шнека та швидкістю, а також зниження швидкості подачі у разі підвищення твердості ґрунту. Це створює умови для безперебійного буріння котловану на всю глибину та захисту гідросистеми від перевантаження.

Ключові слова. адаптивна гідравлічна схема, мобільна машина, контролер, алгоритм.

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