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THE DESIGN AND OPTIMIZING THE HYDRAULIC EQUIPMENT PROVIDING A STABLE POSITION CARRIER

Summary. This paper presents the design of a hydraulic device, which ensures stable contact of the working member with transported material – pile of metal chips formed during machining of oversized bearing rings. Virtual prototype of the conveyor is modeled in the working environment of MSC.ADAMS.
Keywords: mechanism, kinematics, hydraulics, stability, ADAMS.

PROJEKT KONSTRUKCYJNY OPTYMALIZACJI URZĄDZENIA HYDRAULICZNEGO ZAPEWNIAJĄCEGO STABILNĄ POZYCJĘ DŹWIGNIKA

Streszczenie. Artykuł przedstawia projekt urządzenia hydraulicznego, które zapewnia stabilny kontakt członu roboczego mechanizmu – dźwignika – z przenoszonym materiałem, tj. ładunkiem wiórów metalowych, które powstają podczas obrabiania wielkogabarytowych pierścieni łożysk. Wirtualny prototyp podajnika jest modelowany w środowisku programu MSC.ADAMS.
Słowa kluczowe: mechanizm, kinematyka, hydraulika, stabilność, ADAMS.

1. INTRODUCTION

Designing of lines for machining of bearing rings requires development of a chip conveyor with specific parameters. In a normal belt conveyor the center of gravity of chips is unstable, causing problems with their transport. Therefore chip conveyor carriages were developed to fulfill the following requirements:

a) to have higher power and an ability to carry particles to larger distances than other transporters are capable,

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b) to transport not only flexible, long, and turning chips, but with them also larger amount of short and small chips with greater weight per volume unit,

c) to work under the floor of the production hall and to be filled by other conveyors or workers according to the operation manual.

Already conducted tests and experience show, that if the conveyor is supposed to satisfy given requirements, optimal design parameters have to be chosen. In effort to extend the application of this conveyor in industry, were proposed design modifications, which were preceded by several types of analysis [2].

One of the innovations of the conveyor mechanism is structural design of a hydraulic system, which ensures stability of the lever mechanism and increases lifetime of the coupled mechanical system.

2. FUNCTION OF THE TROLLEY CONVEYOR OF CHIPS

The conveyor is designed in a such way, that on the length of 126m 63 trolleys are arranged one by another with carriers on which are attached the rakes (4) (fig. 1). The principle of its operation is based on the chips being pushed by weight of the carrier down to the bottom of the canal (1) and simultaneously moved in the direction of movement of the conveyor. The trolley conveyor is powered by two hydraulic cylinders (7) and (8) via lower (2) and upper rod (3). On the figure 1 is displayed a carrier with rake in the the lowest position, burried in metal chips and the second rake is partially lifted and tearing a pile of metal chips, what indicates that one piece of rake with equipment does not interfere with other rakes and equipment.

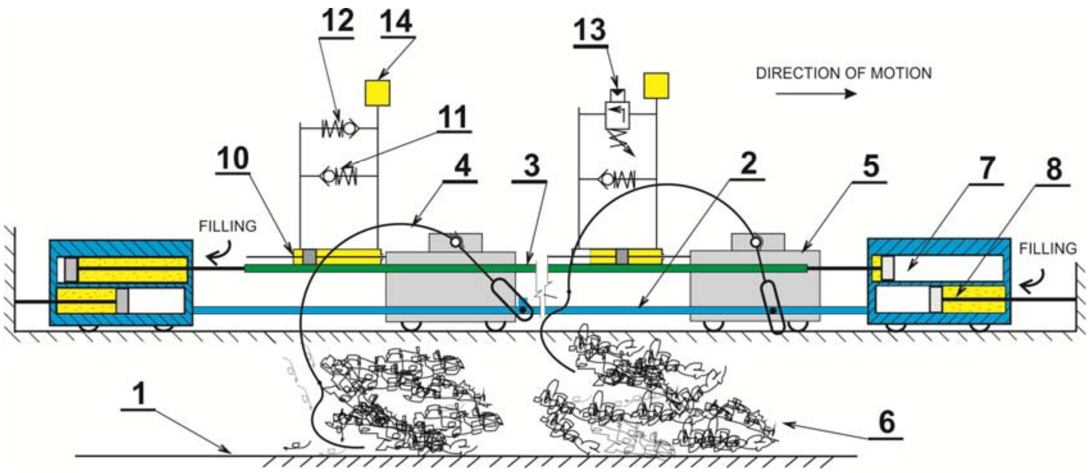


Fig. 1. Schematics of the trolley conveyor of metal chips with the hydraulic equipment
Rys. 1. Schemat wózkowego podajnika wiórów z urządzeniem hydraulicznym

Working mode of the conveyor can be divided into four phases:

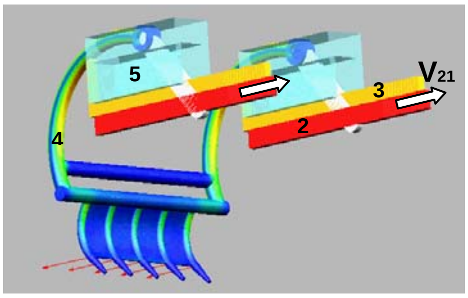
1. Transportation (fig. 2a)

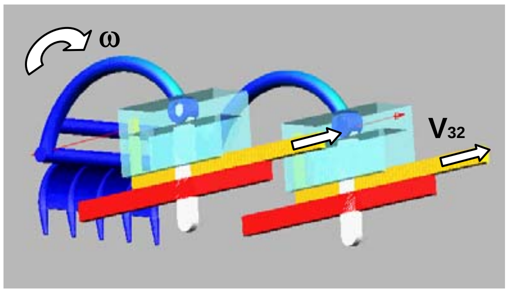
During transportation of chips in the canal is the lower rod moving by velocity v_{21}. The upper rod is drifted by the lower rod. During motion of the lower rod in the direction of the indicated velocity, is the carrier with rake moved by means of a pivot-groove joint and the carrier is also pulling a trolley (5) connected by a rotational joint. Mobility of the mechanism is for this phase of working mode calculated by formula (1) [1]:

$$n = 3(i-1) - \sum_{j=1}^{2} j d_j = 3(4-1) - 2.3 - 1.1 = 2\ ^{\circ}\mathrm{V}. \qquad (1)$$

where:

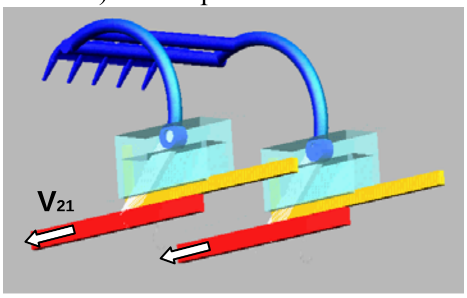
n – number of degrees of freedom;
i – number of members of the system including frame;
$3(i\text{-}1)$ – mobility of a group of free bodies;
j – class of geometrical constraints, removes exactly j degrees of freedom;
d_j – number of connections of class j of all pairs of connected bodies in CMS.

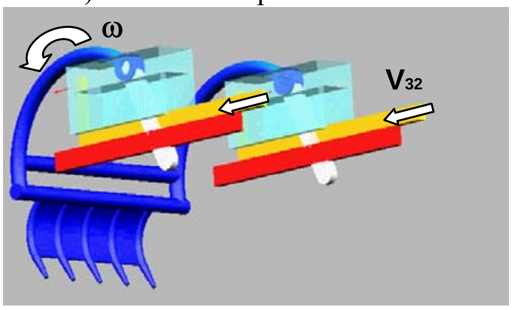




a) Transportation
a) Transportowanie

b) Lifting of the carrier
b) Podnoszenie podkładki





c) Displacement of the system
c) Przemieszczenie układu

d) Descent of the carrier
d) Włączenie dźwignika

Fig. 2. Working modes of the conveyor of chips
Rys. 2. Tryby pracy podajnika wiórów

2. Lifting of the carrier

The next working mode is lifting of the carrier over the transported chips. The lower rod stays stopped. The upper rod continues in motion, presses against the trolley and the carrier is elevated over the transported chips by rotational joint and pivot-groove joint (fig. 2b). During lifting of the carrier the lower rod stands still, i.e. we consider it as a frame, thus in this phase of working mode is the mobility: $n = 3(4-1) - 2.3 - 1.2 = 1$ ^{o}V

3. Displacement of the system

Displacement of the system is done by the upper rod standing still and the lower rod moving backwards, so the system moves back to the start of a working cycle (fig. 2c).

4. Lowering of the carrier

Lowering of the carrier to its initial position is done by the upper rod being pulled by the hydraulic cylinder (7) back, while the lower rod is standing still. During this motion a bumper releases the trolley and the carrier returns to the lower position by its own weight. After the carrier descends to the initial position the working cycle repeats.

3. HYDRAULIC DEVICE ENSURING CONTACT STABILISATION

If the resistance caused by chips rises above acceptable level, the design allows that the carrier begins to rise in order to avoid an overload of the equipment (fig. 3). While the carrier is elevated, the rake divides the transported material, thus the load is decreased and subsequently the rake descends by its own weight. Whether the pack of transported chips will be completely divided to two separate parts depends on compactness of this pack of chips and of magnitude of the moment acting on them [3]. To prevent overload or the state when the rake is not in contact with chips, we performed analysis and proposed designs which were published in [4, 6, 7].

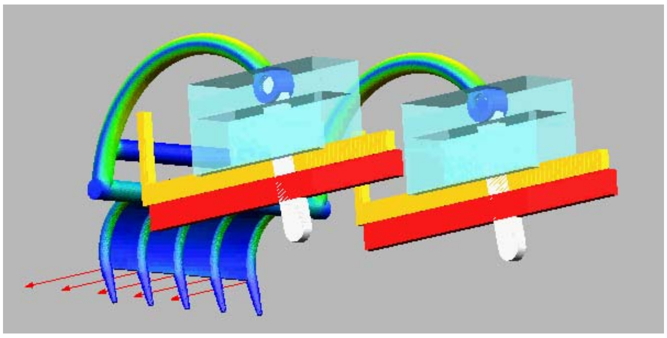


Fig. 3. Position during load from chips
Rys. 3. Tryby pracy podajnika wiórów

This paper presents a solution for the presented problem, which was solved by adding a hydraulic device between the trolley and the upper rod (fig. 1 and fig. 4). This particular device serves to press the rake during transport of chips and also serves to free the rake during overload of the conveyor. This ensures that the rake is in constant contact with the transported material [5, 8, 9].

The hydraulic cylinder (10) is fixed to the upper rod and the piston with the piston rod is connected to the trolley. Two parallel branches of the hydraulic circuit are leading from the cylinder.

In the first branch of the hydraulic circuit is connected the first hydraulic valve (11) and in the second is the second one-way hydraulic valve (12), or the overflow hydraulic valve (13) (fig. 5). To the filling hole of the hydraulic cylinder on the side of a mobile trolley is connected one filling tank (14) with hydraulic fluid.

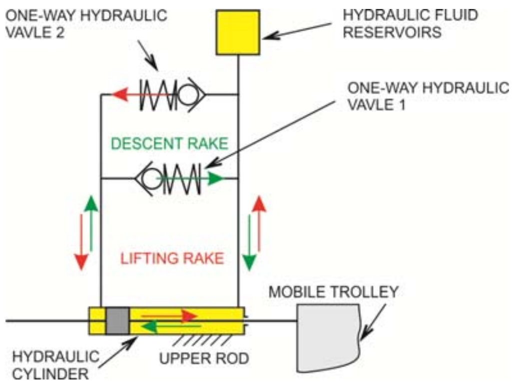


Fig. 4. Hydraulic device
Rys. 4. Pozycja podczas obciążenia wiórami

While raking the chips, pressure in the hydraulic cylinder (10) is rising because the load on the carrier is increasing. If the pressure in the one-way hydraulic valve (12) does not exceed maximal pressure p_{max}, the rake will not rise and will transport chips in given position. If the chips create such strong resistance that the maximal pressure on the one-way hydraulic valveis exceeded, i.e. $p1 \geq p_{max}$, hydraulic fluid starts to flow through the circuit to the opposite side of the piston and the rake starts to elevate (fig. 5). The rake is elevated until the resistance between metal chips and rake does not drop so the rake will separate the chips. After the large pack of chips is divided into several parts, pressure in the cylinder drops below maximal value, the rake descends and by its own mass and pressure in the cylinder pushes the hydraulic fluid to the opposite side of the piston through the first hydraulic valve (11), which has small opening pressure p_2 (fig. 6).

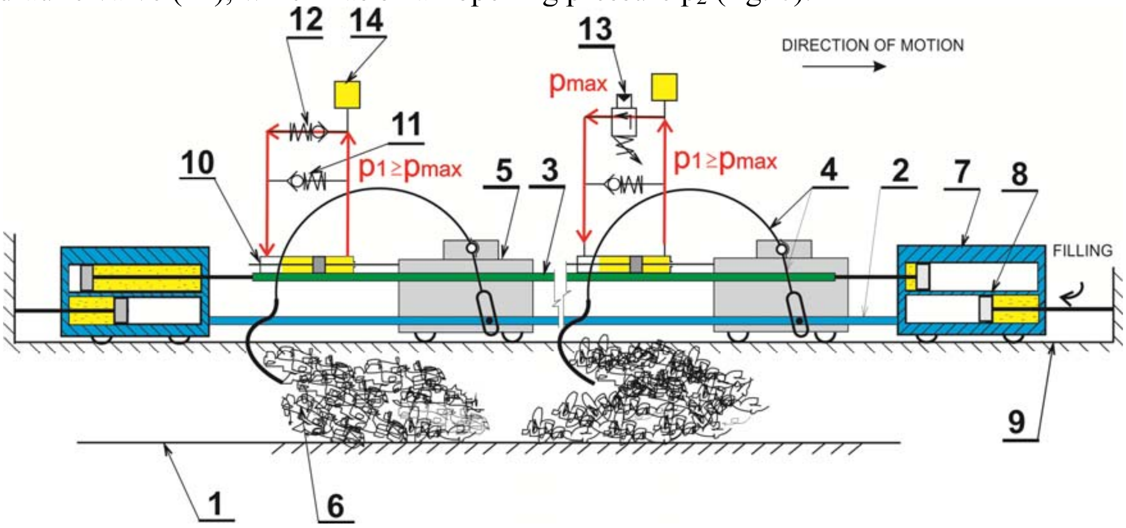


Fig. 5. Hydraulic device – lifting of the rake
Rys. 5. Urządzenie hydrauliczne – podnoszenie ramion

The maximal travel of the rake during raking is limited by maximal travel of the piston of the hydraulic cylinder of the mobile trolley connected by upper rod. While introducing the device against overload of the trolley conveyor into service, one assembly has to be tested to determine if the hydraulic elements are suitable for transport of given type of metal chips (6) [7]. This test can be done by overflow valve (13).

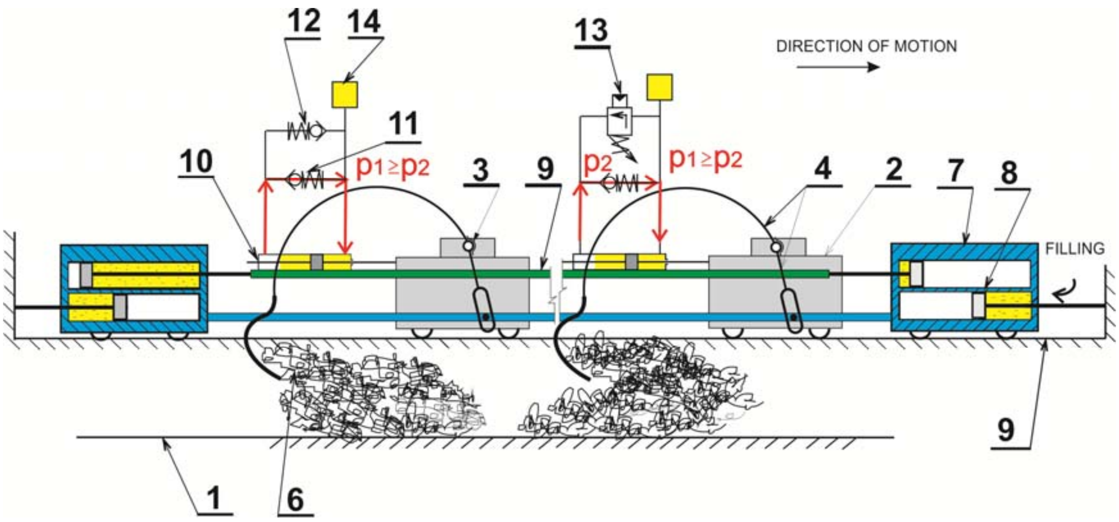


Fig. 6. Hydraulic device – lowering of the rake
Rys. 6. Urządzenie hydrauliczne – opuszczanie ramion

4. CONCLUSION

The device against overload of the trolley conveyor of metal chips can be conveniently used for rake conveyors, which are used mainly in mechanical industry to collect metal chips. After some modifications the conveyor can be used in non-mechanical industry for transport of metal or non-metallic objects. Trolley conveyor with the device against overload is suitable for use in conditions where the risk of overload is present, such as transportation to longer distances or when higher power of conveyor is required. If necessary, the conveyor can be also used for transport over slopes. Mentioned advantages derive from the device against overload, an independant function of individual rakes and the fact that the rakes move over the chips during backward movement.

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