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ANALYSIS OF THE CONSTRUCTIVE AND WORKING ELEMENTS OF THE MECHANISMS FOR SOLID MUNICIPAL WASTE LOADING IN THE DUSTCART

In cities and town settlements of Ukraine approximately 54 mils. m^3 of solid municipal waste is formed annually, 93.8 % of this volume is transported to the landfills and dumps, 2 % are burnt at the incineration plants and 4.2 % are directed to the recycling stations and waste recycling plants. That is why, one of the most important measures, aimed at the protection of the environment is timely collection, transportation, recycling and disposal of SMW. Growing requirements, regarding the quality of services provided to the population, including the sphere of the sanitation of the territories, stipulate high requirement to the equipment, used for these purposes.

Paper analysis the constructions and working elements of the mechanisms for solid municipal waste in the dustcart to determine the ways of their improvement. It is necessary for the provision of the municipal service of Ukraine with highly-productive multifunctional dustcarts of the manipulator type for the collection of solid municipal waste. The drive of the working organs of the mechanisms of solid municipal waste loading in the dustcart is hydraulic with the source of supply from the pumping station of the dustcart. The schemes of the domestic and foreign mechanisms for solid municipal waste loading are presented. It is noted that the general drawback of this class of machines is that they are equipped with the hydraulic drive on the base of one nonregulated pump. As a result, if it is necessary to regulate the speed of the working organs motion, part of the working fluid of the pump under high pressure will enter the hydraulic tank across the security valve, causing large unproductive power losses.

It has been established that one of the ways of improving the mechanism for solid municipal waste loading into the dustcart is the usage of the scheme, sensitive to loading. This scheme enables to minimize the power losses during hydraulic drive operation, will increase the efficiency factor indices of the control system of the working organs hydraulic drive in different operation modes.

Key words: *construction, working organ, loading mechanism, manipulator, dustcart, solid municipal waste.*

Introduction

Sphere of municipal service of Ukraine requires high productive multifunctional specialized motor-vehicles (dustcarts) of the manipulator type [1 – 6] for the collection of solid municipal waste (SMW). In cities and town settlements of Ukraine approximately 54 mils. m^3 of solid municipal waste is formed annually, 93.8 % of this volume is transported to the landfills and dumps, 2 % of this volume are burnt at the incineration plants and 4.2% are directed to the recycling stations and waste recycling plants [7]. Annual growth of solid municipal waste (SMW) is 0.5 % [8]. That is why, one of the most important measures, aimed at the protection of the environment is timely collection, transportation, recycling and disposal of SMW. Growing requirements, regarding the quality of services provided to the population, including the sphere of the sanitation of the territories, stipulate high requirement to the equipment, used for these purposes. For the transportation of the waste to the place of the disposal outside the 30 km sanitary zone more than 45 thousand tons of fuel is consumed annually [9].

Problem setting

According to the resolution of the Cabinet of Ministers of Ukraine № 265 [10] one of the priority directions of SMW management in Ukraine is to provide to usage of modern highly efficient dustcarts. That is why, the survey of the constructions and working organs of the mechanisms of solid municipal waste loading in the dustcart in order to determine the ways of their improvement is relevant scientific technical task.

Objective and task of the research

Objective of the paper is the analysis of the constructions and working mechanisms of solid municipal waste loading in the dustcart to determine the ways of their improvement.

Methods and materials

The research contains the analysis of the constructions and working mechanisms for solid municipal waste loading into the dustcart.

Main part

Three basic schemes of SMW loading into the body of the dustcart are known: side loading, front loading and rear loading [9].

Fig. 1 shows the scheme of the side loading of SMW into the body of the dustcart [11]. The body of the dustcart contains the beam 2, mounted on the frame 1 of the dustcart, the bean can be turned, and the gripper, fixed on the beam by means of the axle 3, the gripper rotates relatively the axle by the hydraulic cylinder 4. The gripper consists of the pad, made in the form of the longitudinal bar 13 and housing 5, fixed jaw 6 and Г-like clamp pressure, consisting of the plate 7 and grab 8. Hydraulic cylinder 11 is installed between the housing 5 and Г-like clamp pressure on the axles 9 and 10. Axles 9 and 10 are mounted in the ears 12 of the housing 5 and Г-like clamp pressure. Hydraulic cylinder 15 with hydraulic lock is installed between Г-like clamp pressure and longitudinal beam 13 on the axles 10 and 14.

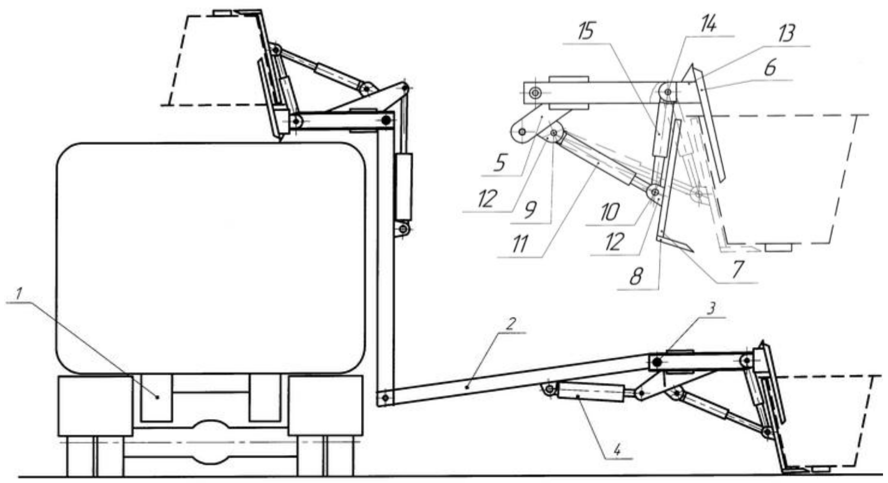
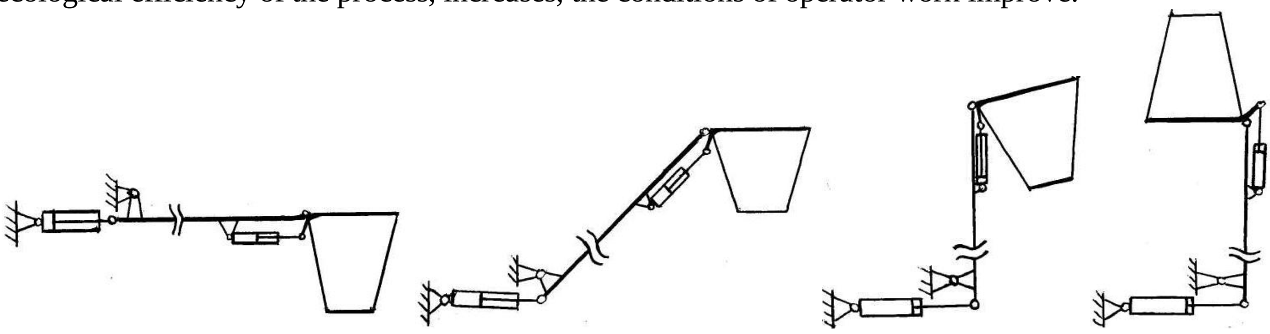


Fig. 1. Scheme of SMW side loading into the body of the dustcart

The device operates in the following way. Dustcart drives to the container on the side distance of 1.6...2 m, the gripper is put into the operation position by means of the hydraulic cylinder 4. After that the boom 2 lowers. Г-like clamp, consisting of the stand 7 , grip 8, and fixed jaw 6 are in the open state and fixed gap is formed between them. The gap is formed as a result of the rod retraction of the hydraulic cylinder 11 Г-like clamp deviates. Boom 2 lowers until the stationary jaw 6 enters the container till the stop of its flange in the tank of the container. It moves Г-like clamp to the stationary jaw 6 and grips the wall of the container between the jaw 6 and rack 7. Hydraulic cylinder 15 with hydraulic lock of the grip 8 presses down the rack to the bottom of the container. Container is lifted by the boom 2 with the help of hydraulic cylinder 4 to the unloading window of the dustcart. Being lifted container is leaned on the grip 8. After unloading the container is lowered on the platform. When the rod of the hydraulic cylinder 15 is put forward, the grip 8 is taken away from the bottom of the container and when the rod of hydraulic cylinder 11 is retracted Г-like clamp deflects from the container, lifts and returns into the initial position.

Such execution of the gripper enables to decrease the efforts, acting on it, increase the reliability of its operation and avoid the deformation of the walls of the container.

Author of the research [12] established that in the standard dustcarts losses of SMW are connected with the complex path route of the manipulator. That is why, for the improvement of the productivity and reduction of SMW losses in each cycle of loading the construction of the manipulator is developed, which increases the loading process productivity as a result of the reduction of SMW losses and reduction the cycle duration by changing the path of the container motion (Fig. 2). Simultaneously, the ecological efficiency of the process, increases, the conditions of operator work improve.



a) b) c) d)

Fig. 2. Positional diagrams of the manipulator: a) container grip; b) lifting of the boom; c) container overturn ; d) unloading of SMW

Scheme and technique of SMW loading mass in the dustcart determination in case of side loading (Fig. 3), is presented in the research [13]. Weighting of the containers, loaded in the dustcarts in the sites of collection, is realized by means of the device for determining the mass of the loaded weight in the transport vehicle. For the correct determination of the mass of the container with SMW it is necessary that the weighting equipment always remain in the same position.

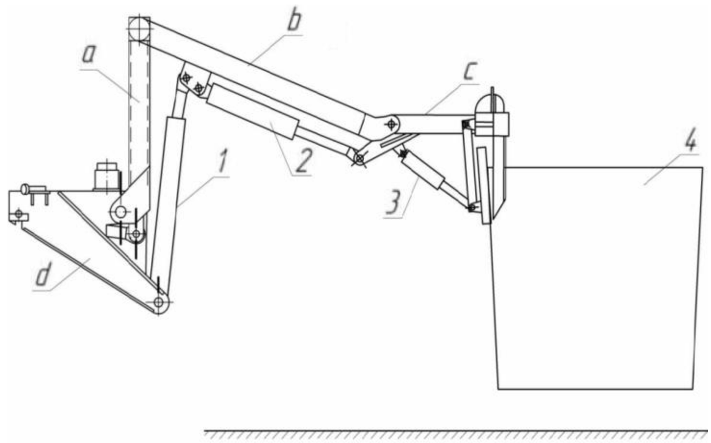


Fig. 3. Space position of the loading equipment in the process of the container with SMW weighting: 1 – hydraulic cylinder of the boom bend, 2 – hydraulic cylinder of the container overturn, 3 – gripping hydraulic cylinder, 4 – container; a, b, c, d – manipulator links

Usage of the side method of SMW loading is 25 % it is caused by the availability on the territory of Ukraine since the time of the USSR large amount of stationary (without wheels) waste containers of 0.75 and 0.8 m^3.

Main drawback of the side scheme of SMW loading in the body of the dustcart is nonuniform wear of springs, this leads to the roll of the body to the side of the manipulator, shown in Fig. 4 [12], as a result of the asymmetry of the applied loading.

Fig. 4. Roll of the dustcart in the direction of the manipulator in case of the side loading of SMW in the body of the dustcart

Dustcarts with frontal loading of SMW are the combination of frontal loader and transport dustcart (Fig. 5 [14]). Loading of the container with waste is carried out by means of the tilting through the trapdoor in the upper part of the body.

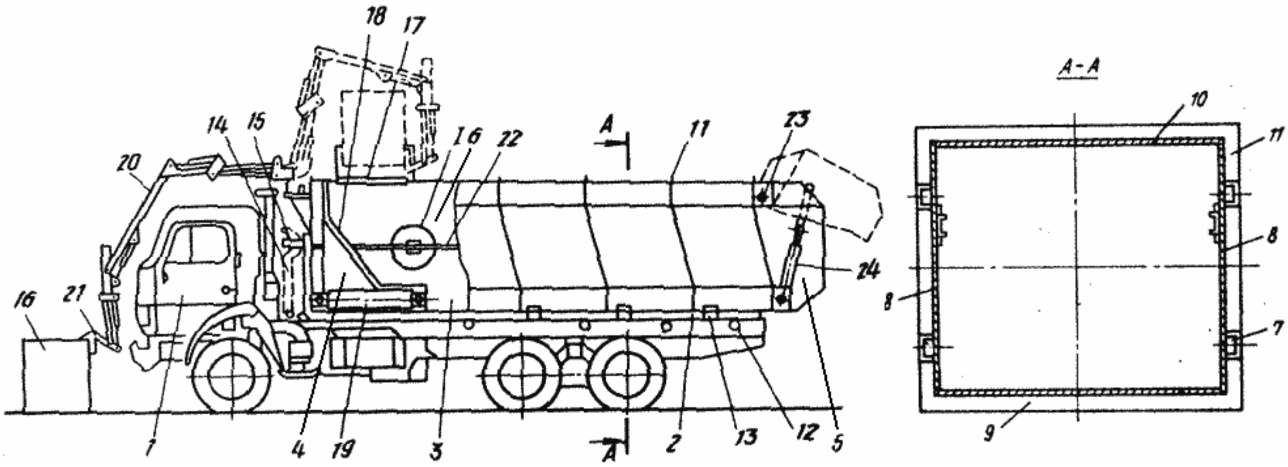


Fig. 5. Diagram of the body-type dustcart with frontal loading: 1 – undercarriage, 2 – carrying frame, 3 – body, 4 – loading module, 5 – unloading module, 6 – intermediate modules, 7 – framework, 8 – side walls, 9 – bottom, 10 – roof, 11 – flanges, 12 – support rollers, 13 – blocking locks, 14 – hook grip, 15 - trap, 16 – container, 17 – loading window, 18 – pushing plate, 19 – hydraulic cylinder, 20 - moving-rotational beam, 21 – grip, 22 – guides, 23-- joint , 24 – hydraulic drive,

Dustcart with frontal loading can be used for emptying euro containers of 2.0…5.0 m^3. But large dimensions of the dustcart and frontal location of the turning device require large space for handling, that is why this method of SMW loading in the dustcart is not widely used (5 %).

Most widely used method of SMW loading (70 %) is the dustcart with rear loading (Fig. 6). These dustcarts are well adjusted for the operation in limited conditions and can be used in the places, where the container system of SMW collection is missing. Greater part of this type of motor vehicles have truck chassis 1, where the box-shaped body 2 is mounted with a tailgate connected with the body by means of the joint.

In its lower part the receiving bucket 3 (loading bucket), is installed, it is the base for fixing the lifting (upper) plate of the compaction mechanism, with which the rotary compaction (lower) plate is connected by means of joints .

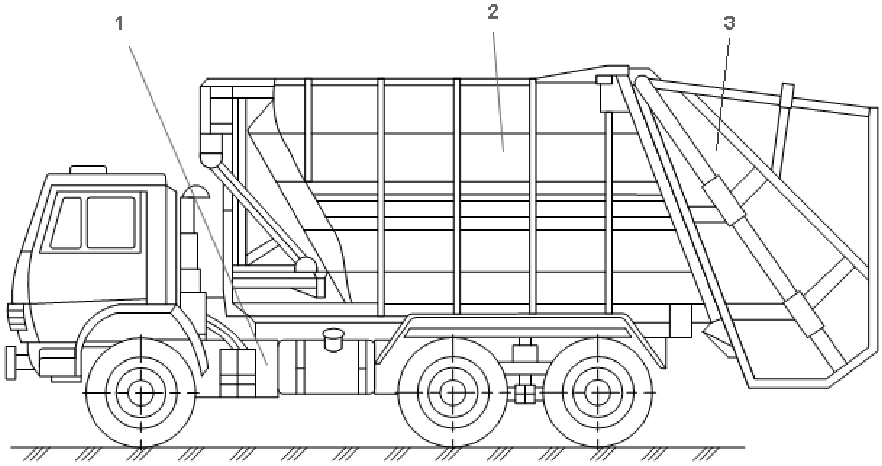


Fig. 6. Scheme of the dustcart with rear loading of SMW

Fig. 7 presents the scheme of SMW loading into the dustcart with rear loading.

Tailgate of the greater part of such motor vehicles is equipped with the universal grip, that operates with any type of trash containers, having the volume up to 1.1 m^3. Such dustcart grips, lifts and empties any tanks, having the mass of up to 500 kg. Only two conditions are needed: the tank must be equipped with the wheels, which provide the possibility to move it to the grip; the surface of the area must be smooth. Characteristic features of the rear loading enable to accelerate the handing of one waste collection area.

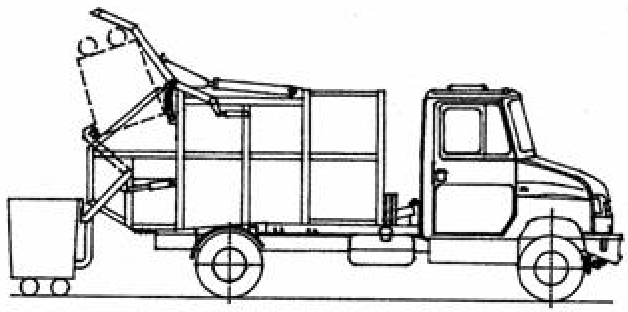


Fig. 7. Scheme of SMW loading into the dustcart with rear loading

Common drawback of the known SMW loading in the body of dustcart schemes is the possibility of incomplete empting of the container, caused by self- compaction of the waste during filling the waste container and mechanical (structural) binding of SMW and ability to stick to the walls of the container with the angle of inclination to the horizon up to 65...70°.

That is why, the construction of vibration container emptyer of the waste into the body of the dustcart was elaborated. In the given construction as a result of the introduction of new elements and links the vibration shaking of the waste into the body of the dustcart from the container in case of its incomplete emptying takes place during the reverse stroke of the twin hydraulic cylinders, this improves the operation quality of the dustcart due to elimination of the probability of incomplete empting of the container with SMW. The construction of the vibration emptyer is protected by the patent of Ukraine for utility model 91672 U [15].

The problem put forward is solved as a result of the introduction of pressure pulses generator into the hydraulic drive for SMW container overturn into the body of the dustcart. Its input is connected via two position hydraulic distributor with the rod line of the twin hydraulic cylinders and the output – via two position hydraulic distributor with piston line of the twin hydraulic cylinders.

Fig. 8 presents the scheme of the vibration emptier of SMW container into the body of the dustcart [16]. Hydraulic drive of SMW container overturn into the body of the dustcart contains hydraulic pump 2, connected with the oil tank 7 by means of the supply line via the filter 6. Safety valve 4 and three-position hydraulic distributor 3 is installed on the piston line. Twin hydraulic cylinders 1 are connected with three- position hydraulic distributor 3 by means of the main lines. Input of the pressure pulses generator 5 is connected via two position hydraulic distributor 13 with the rod line 11 of the twin hydraulic cylinders 1, and the output – via two position hydraulic distributor 13 with piston line 10 of the twin hydraulic cylinders 1. Safety valve 4 via rod line 11 is connected with the oil tank 7 through the filter 6. Levers 8, grip 9 and container 12 are also shown in the scheme.

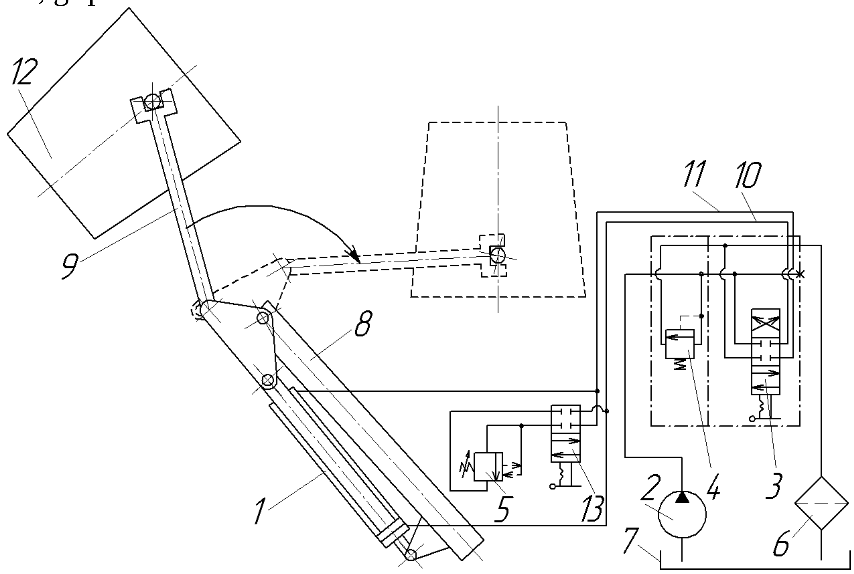


Fig. 8. Diagram of vibration emptier of SMW container into the body of the dustcart

Main characteristics of pressure pulses generator of the vibration emptier are presented in the study [17].

Loading of SMW into the bucket of the dustcart consists of two sequential technological operations: turn of the manipulator lever and overturn of the container grip. From the total duration of the technological operation of SMW loading into the dustcart turn of the manipulator lever takes greater part (75 %).

Materials of the paper [18] contain nonlinear mathematical model of the dynamics of the hydraulic drive turn of the manipulator lever during execution of the technological operation of SMW loading in the dustcart, this model enabled to study the dynamics of the given drive [19] and perform the optimization of its basic parameters [20].

In the study [21] linearized mathematical model of the hydraulic drive of the manipulator lever turn in the technological operation of SMW loading into the dustcart is suggested. It enabled to obtain the approximated analytical dependences: pressure in the delivery line, angular velocity and manipulator lever rotation angle on time.

Nonlinear mathematical model of the dynamics of the container overturn hydraulic drive during the execution of the technological operation of SMW loading into the dustcart is published in the paper [22] it allowed to study the dynamics of the given drive.

Paper [23] contains the linearized mathematical model of the hydraulic drive of the container overturn. The model allowed to obtain approximate analytical dependences: pressure in the delivery line of hydraulic cylinder, angular velocity and angle of the container overturn on the time.

General drawback of is class of machines is that they are equipped with the hydraulic drive on the base of one fixed pump. Thus, if it is necessary to regulate the speed of the working elements motion, part of the working fluid of the pump under high pressure will pass via the safety valve to the hydraulic tank, causing considerable unproductive losses of power. Unproductive losses of power during speed modes regulation of the working elements of the machines, decrease in the hydraulic drives, constructed on the principle «sensitive to loading» [24].

In the paper [25] the improvement of the hydraulic drive of the support-rotational device with the hydraulic motor of the rotational type on the base of the scheme, sensitive to loading has been suggested. Application of the scheme enables to minimize power losses in the process of the hydraulic drive operation, it provides the increase of the efficiency factor values of the hydraulic drive control system in different operation modes.

In our opinion, one of the ways for the improvement of the mechanisms for SMW loading into the dustcart is the application of the scheme, sensitive to loading, which will enable to minimize power losses as a result of the hydraulic drive operation. This scheme provides the improvement of the efficiency factor indices of the hydraulic drive control system of the working elements at different operation modes.

Conclusions

The analysis of the constructions and working elements of solid municipal waste loading mechanisms in the dustcart in order to determine the ways of their improvement has been carried out. It is established that one of the ways of loading mechanisms improvement is the application of the scheme, sensitive to loading, which will enable to minimize power losses during the hydraulic drive operation. This scheme provides the improvement of the efficiency factor indices of the control system of the working elements hydraulic drive in different operation modes.

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