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TRANSLATION COMPACTION SYSTEMS USED IN WASTE COLLECTION AND TRANSPORTATION

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Abstract: Solid municipal waste (MSW) management is solved differently in many countries around the world, given their degree of development. There are countless systems for collecting, transporting and storing collected waste. Most machines for MSW collection are equipped with pre-compaction and compaction systems to reduce the volume of waste and transport a larger quantity over distances that often do reach several tens of kilometers. Vehicles for the collection and transport of waste are equipped with complex systems comprising: loading of containers, taking over and precompacting the material, compacting in the body of the structure and finally unloading in warehouses of the collected waste. Compacting is the process by which the volume of waste is reduced and this occurs through movements of the active organs and waste, in a complex structure located on the autochassis. The equipment is designed to collect / compact and transport in an economical and sanitary safety, pre-collected waste in generators.
Keywords: municipal solid waste, compaction force, exhaust plate, compaction plate, FEM simulation

INTRODUCTION

Solid municipal waste (MSW) management is solved differently in many countries around the world, given their degree of development. There are countless systems for collecting, transporting and storing collected waste. Most machines for MSW collection are equipped with pre-compaction and compaction systems to reduce the volume of waste and transport a larger quantity over distances that often do reach several tens of kilometers [1-5].

In figure 1 we have the scheme of a garbage truck, intended for collection and transport of municipal solid waste and the following we expose the operation, calculation of precompaction and evacuation systems and simulation of efforts in a precompaction plate.

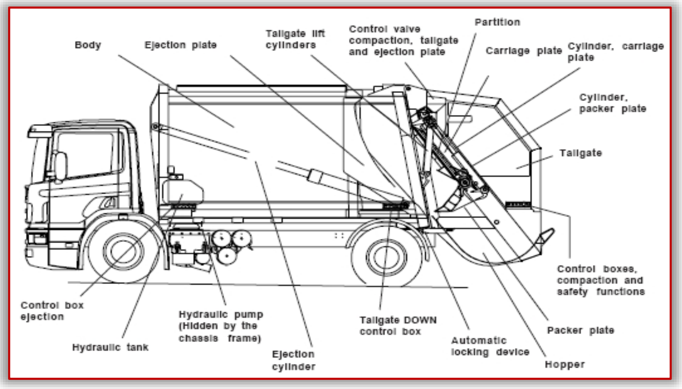

Figure 1 - Auto-chassis scheme with translation compaction system, [11]

The loading of the waste is done through the back of the compaction system, are taken from the camera, with a pickup and precompaction plate, which raises the waste in the compaction room. The compaction plate/exhaust, is the furniture and moves to each waste supply made by the precompaction plate.

The compaction plate is operated with a hydraulic cylinder with double effect and performs the role of counter pressure but also exhaust the waste from the pressing chamber.

Analyzing comparatively two types of pickup and precompaction systems presented in figures 2 and 3 (Norba), we observe that precompaction mechanisms have different operating principles [8,9,10]:

≡ Precompaction system with translation movement in Figure 2 (a,b)

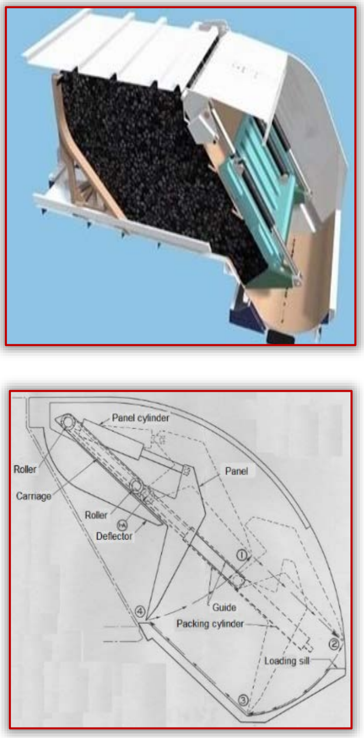

Figure 2 - a) Draw section in compaction system Pickup system – precompaction

≡ Precompaction system with portal (poka yoke) [8,9,10], in Figure 3 (a,b)

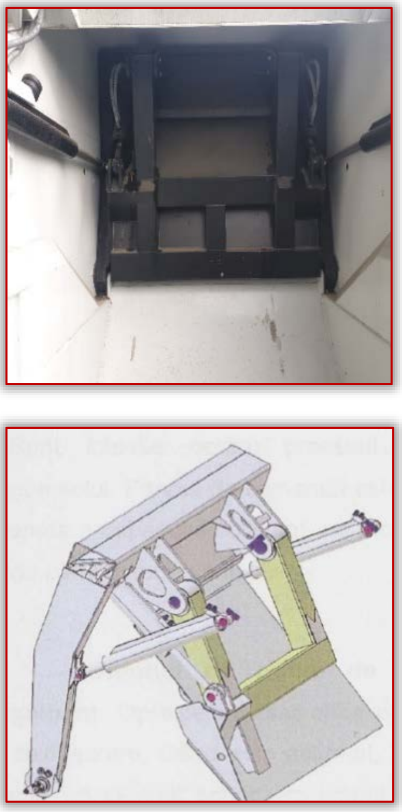

Figure 3 a) Posterior view of the compaction system;
b) View of the portal system and the compression plate

MATERIAL AND METHOD

— The highlighting and determination of the forces that act on the waste in the inclined plane movement

On the inclined plane noted with 3-4 (Figure 2, b), the waste is taken over and pushed by articulated precompaction plate until the discharge into the pressing/compaction chamber where the successive compaction process of the waste volumes is continued.

From the simplified scheme of the waste transfer area, we consider a volume of waste, pushed with a piston (plate), through a channel with rectangular section, inclined plane towards the horizontal with the angle (open to the upper part).

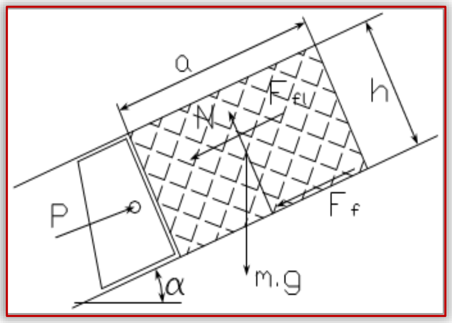

Figure 4 – Diagram of the arrangement of forces, [7]

On the material acts the forces:

≡ $m \cdot g$ – own weight; N – reaction force; F_f – friction force on the lower surface;

≡ F_{fl} – friction force on lateral walls; P – force required to push the material.

The force required to push the plunger (precompaction plate) is neglected, which is mounted on devices that reduce friction.

≡ **Resistance force due to friction** with lateral walls the expression:

$$F_f = 2\,\mu \cdot a \cdot h \cdot q_m$$

where: h – average height of the material layer;
μ - coefficient of friction between material and gutter;
q_m – average pressure on lateral walls.

≡ **Pressure on the side walls** of the gutter can be determined with the relation, [7]:

$$q_m = \frac{k_m \rho \cdot g \cdot h}{2}$$

in which: k_m is the mobility coefficient of the material; ρ - its volumetric mass; g – gravitational acceleration.

Knowing the angle of internal friction of the material ψ (or natural slope angle) the mobility coefficient may be determined k_m:

$$k_m = \frac{1 - \sin\psi}{1 + \sin\psi}$$

To push the material, it is necessary to fulfill the relationship:

$$P > mg\sin\alpha + \mu \cdot mg\cos\alpha + 2\mu \cdot ahq_m$$

Replacing relationship:

$$P > mg(\sin\alpha + \mu.\cos\alpha) + ah^2 k_m \rho.g\mu$$

In order for the material to be trained in motion on the gutter must:

$$P' = c_o\left[mg(\sin\alpha + \mu.\cos\alpha) + ah^2 k_m \rho.g\mu\right]$$

where: c_o it is correction coefficient that takes into account the resistance due to piston friction with the walls and is vertical lifting, as well as the overload appearing in operation (c_o=1,5-1,8).

— Simulation of requests in the component bodies of translation compaction systems

The manufacture of the working bodies of waste trucks in optimal conditions, implies that the model made by the designers engineers to go through the modeling, simulation and analysis processes using CAD software (Computer Aided Design), before sending them to the proper execution.

The purpose of this finite element 3D numerical simulation study was to simulate the behavior of the structure of the compression plate of a garbage truck Valu€ Pak Lift 1000, subject to request incurred during the process of compacting of the household, considering that the plate is performed from there different materials (steels Hardox 400, Hardox 450 and S355J2).

Simplified models of precompaction and counter pressure plates (for the disposal of compact wastes) where made, and the mass of the compact waste was simulated by the choice of springs, which can be arranged between the two parallel faces – Figure 5.

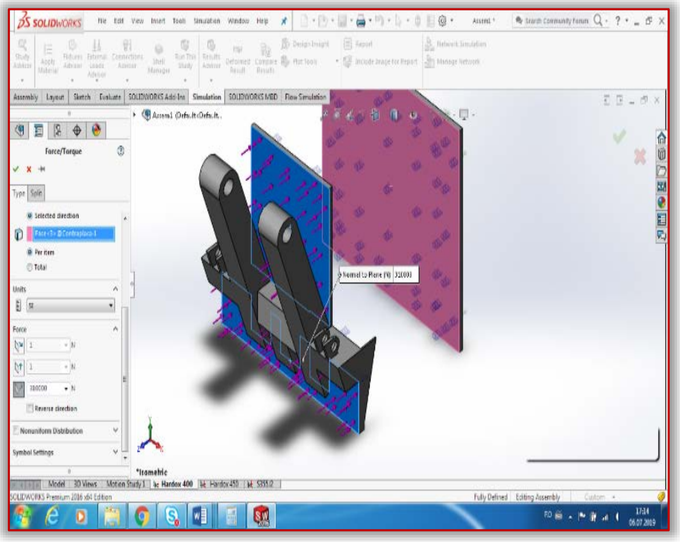

Figure 5 - Isometric view compaction plate assembly – exhaust plate

The next step consisted in introducing the geometric 3D model of the assembly in the "simulation" module of the Solid Works design programed. In this sense, simplifications of the process have been carried out:

- the counter-pressure plate shall be to be fixed to determine the maximum,
- the forced exercised by the hydraulic system was considered uniformly distributed through the surface behind the compression plate (in practice this is: 300 - 320 kN).
- the compressed material was simulated by means of resort whose rigidity value was set to the value of aluminum (it was considered that aluminum is most rigid material in the waste mixture).

According to factory, technical data sheets the materials used most often in the manufacture of compression plates are steels: Hardox 400, Hardox 450 and S355J2.

Following the simulation, the software provided the graphical results, where the model is divided into areas with certain colors. In fig 6are presented the values of the movements appearing in the compression plate during the simulation of the request.

It can simulate and extract specific information on: displacement values, the values of the equivalent tension of the working organelle or the oscillation of the safety coefficient in the compaction plate.

RESULTS

Following the simulation, the design programme provided the results in graphical form. The geometric pattern is divided into areas of a particular color, each area compaction the region of the geometric pattern in which the analyzed size has the value specified in the chromatic legend on the right side of the screen. It should be noted that three simulation have been rolled, one for each of the three selected steels (Hardox 400, Hardox 450 and S355J2).

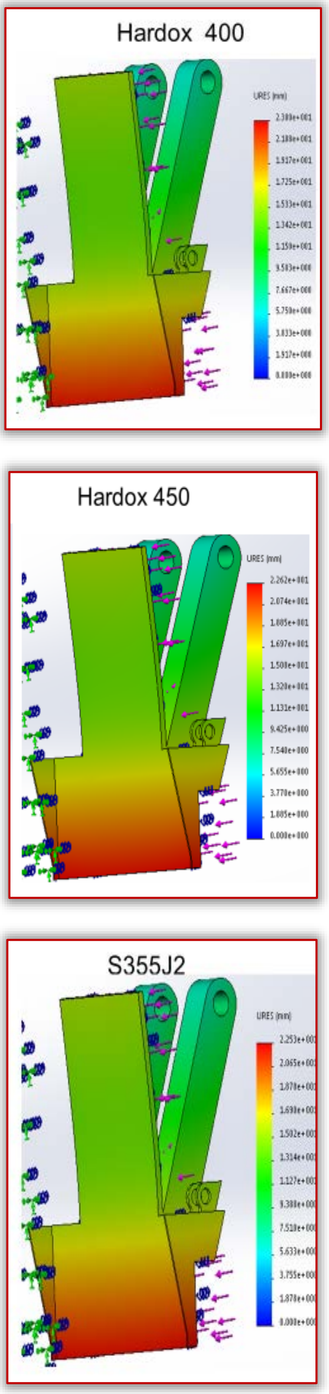

Figure 6 - Displacement values in the compaction plate

The minimum value of the safety coefficient is reached for the S355J2, steel with weaker mechanical properties compared to the other two and the maximum value is reached for Hardox 450, a steel with quite high hardness. The minimum values of safety coefficients are 6.76 for Hardox 400, 8.08 for Hardox 450 and 4.34 for S355J2.

CONCLUSIONS

The movement of the elements of the mechanism must be correlated with the movement of the waste collection plate from the back of the car so that it takes over the material from the cage, lift it up and push it over the previously raised waste in the container collection. Those, the top of the pickup plate follows the preset trajectories that can be determined by the cinematic analysis of the actuator mechanism.

Eluciding the movement of the working bodies of these mechanisms is necessary for the proper understanding of their operation, but especially in order to redesign and improve their functional parameters for a loss-free operation of material and low energy consumption.

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