ALUMINUM BOX BUNDLING PRESS

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Abstract: *In municipal solid waste, aluminum is the main nonferrous metal, approximately 80-85% of the total nonferrous metals. The income per ton gained from aluminum recuperation is 20 times higher than from glass, steel boxes or paper recuperation. The object of this paper is the design of a 300 kN press for aluminum box bundling.*

Key words: bundling press, aluminum box

INTRODUCTION

Recycling one kilogram aluminum saves up to 8 kg bauxite, 4 kg chemical substances, and 1 kWh energy. One recycled aluminum box is equivalent to electricity for 3 hours of watching TV.

Recyclable wastes, such as paper, carton, and aluminum boxes are bundled to ease maneuvering and reduce transport costs. Bundling equipments compress the material in one or more directions by applying a pressure of 14-25 MPa with a hydraulic cylinder.

The metal construction of a 300 kN press for Al box bundling is the object of this paper. This press will make 600 x 400 mm section, 350-400 mm long, and 40-60 kg bales of boxes. The press funnel allows the takeover of a 1,1 m^3 container.

With the help of MathCAD software, a program of dimensioning and checking metal constructions was drawn up, also applying finite elements.

CONSTRUCTION AND OPERATION OF ALUMINUM BOX BUNDLING PRESS

The press compacts aluminum boxes, compote preserve boxes, 0,8 kg tomato juice boxes in 40-60 kg, 600x400 section, 350-400 mm bales.

The press funnel allows a 1,1 m^3 container to be taken over. The bale is discarded at the end of the pressing cycle with the 140x110x1150 mm pressing hydraulic cylinder, with more than 300 kN pressing force. Bundle pressing and discarding technological parameters, force and speed, are controlled by the control panel, which has a microprocessor included in it.

Fig. 1 shows a 3D model of the Al box bundling press, made up of: 1 – chute; 2 – rammer; 3 – barrier; 4 – funnel; 5 – hydraulic installation; 6 – pressing cylinder 7 – barrier cylinder; 8 – bale discarding chute. Fig. 1,a shows the rammer retracted at the end of the stroke, and Fig. 1,b shows the rammer at its maximum 950 mm pressing stroke.

When the rammer track is between 520 and 570 , and the pressure in the pressing cylinder reached the maximum adjusted value between 20 and 25 MPa, the 600x400x(350 … 400) mm bale forming operation is considered concluded; the barrier is raised and the formed bale discarded, the pressing cylinder having been done the maximum 1150 mm stroke.

Fig. 1. 3D model of Al box bundling press

Fig. 2 shows the metal construction of the Al box bundling press chute, where: *1* – collar plate; *2* – lower ledge; *3* – lower side doubling; *4* – U shaped side doubling I; *5* – upper ledge; *6* – upper side doubling; *7* –lower doubling I; *8* - lower doubling II; *9* - U shaped side doubling II; *10* – cutter supporting collar plate; *11* – U shaped side doubling III; *12* – lower doubling III; *13* – lower support plate; *14* – leg; *15* – lower gusset plate; *16* –intermediary gusset plate; *17* – upper gusset plate; *18* – guide distance plate; *19* – front guide plate; *20* – bolt arrester; *21* – bolt; *22* – cylinder support traverse *23* – back guide plate; *24* – upper distance plate; *25* –upper doubling; *26* – vertical cutter support plate; *27* – scraper support plate; *28* – funnel support transversal band; *29* – bridle for barrier cylinder pipes; *30* – transversal support band for hydraulic installation; *31* – end plate; *32* – upper transversal plate to support pressing cylinder; *33* – lower transversal plate to support pressing cylinder; *34* – support plate for pressing cylinder; *a* – pipe Dn 10 to supply annular surface of the barrier cylinder; b - pipe Dn 16 to supply full surface of barrier cylinder.

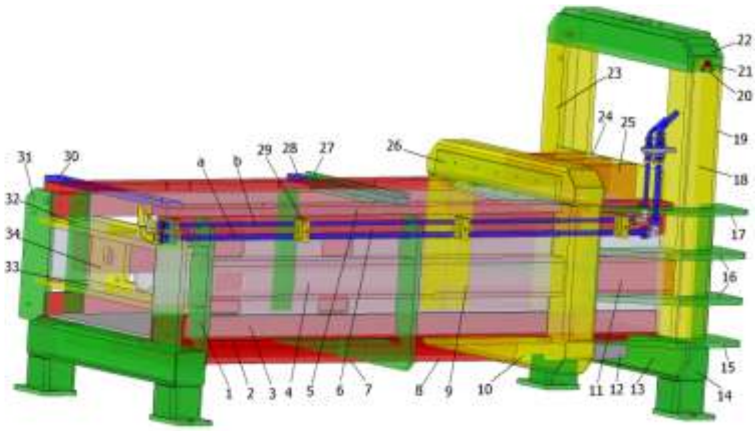

Fig. 2. Press chute metal construction

Fig. 3 shows the press rammer design to bundle Al boxes, where: *1* –lateral wall *2* – vertical transversal plate; *3* – horizontal transversal plate; *4* –M16x60 screw to adjust lower shoes; *5* – M12x60 screw to adjust upper shoes; *6* – transversal doublings for rammer shank; *7* – rammer shank covering plate;*8* – visiting cover; *9* – polyamide shoe; *10* – distance plate to horizontally adjust shoes; *11* – reinforcing gusset plate; *12* –M12x60 screw to horizontally adjust shoes; *13* – right cutter; *14* – ear; *15* – front plate; *16* – vertical doubling; *17* – distance plate; *18* – buffer plate for spherical head of pressing cylinder rod; *19* –Φ50 bolt with tapered ends; *20* – semi-spheres to adjust the free play between the buffer plate and the rod's spherical head; *21* – scraper; *22* –Φ20 bolt; *23* –M12x40 low-head screws.

Fig. 4 shows the press barrier construction for Al box bundling , where: *1* – barrier metal framework; *2* – polyamide pegs for lateral guiding; *3* – polyamide wear plate; *4* – covers; *5* – M36 nut; *6* – special washer; *7* –M24 threaded sleeve for barrier cylinder rod.

Polyamide pegs for lateral guiding are adjusted with M8x40 screws, blocked with back nuts. Threaded sleeves for barrier cylinder rod have the role of allowing oscillation in the barrier plane, to avoid forcing the cylinder rod being bent, in case the barrier is blocked on one side.

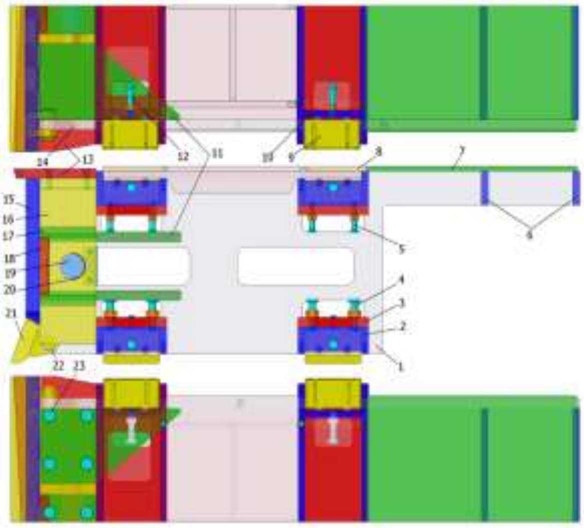

Fig. 3. Press rammer construction

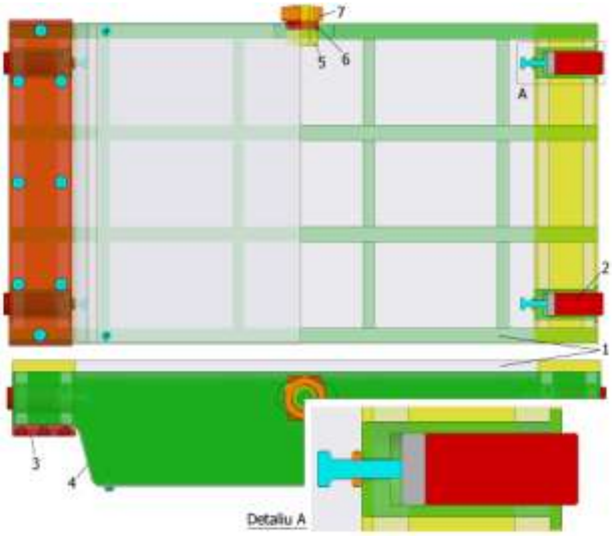

Fig. 4. Barrier construction

Fig. 5 shows the supply funnel construction for Al box bundling, where: *1* – funnel metal construction; *2* – door; *3* - M10x20 screw; *4* –M10x80 screw with Grower washer and nut.

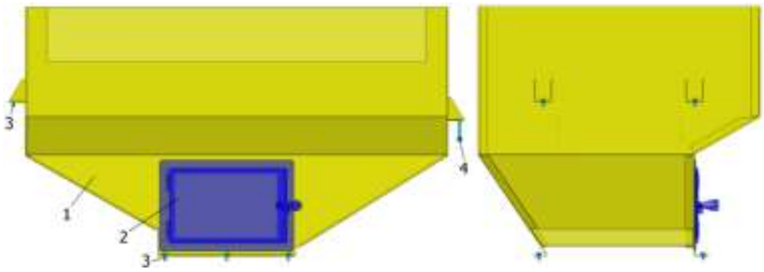

Fig. 5. Supply funnel construction

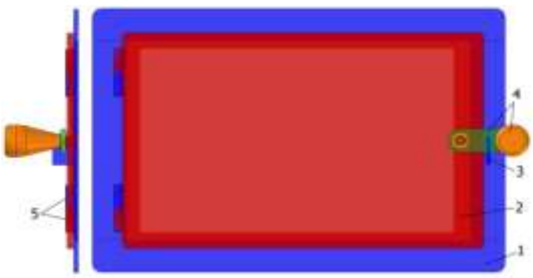

Fig. 6. Funnel door construction

Metal funnel construction is of 3 mm sheet, with two front faces, supported by the upper frame of the chute, allowing fixing with six M10x20 screws. Lateral faces keep frontal faces at a distance and each of them has two 3 mm sheet ears to additionally support the barrier cylinder to the support traverse and to the support framework of the hydraulic control unit. The funnel will take over the load of a m^3 container. The design of the visiting door is shown in Fig. 6, where: 1 – frame 2 – door; 3 – barrier; 4 – lock; 5 – hinge.

METAL PRESS FRAMEWORK ANALYSIS WITH FINITE ELEMENTS

Structural analysis with finite element with Cosmos Design Star program allows the following types of analyses: linear and nonlinear static analysis; modal analysis, own frequencies and vibration modes; crinkling calculus; linear and nonlinear heat transfer in permanent and transitory regime; fluid flows; electromagnetic analysis.

Static linear analysis operates with the following hypotheses:

- static character of load application;
- linearity hypothesis between loads and answer produced in the body($\sigma = E \cdot \varepsilon$)i.

Inside stress induced in the body by external loads vary from one point to another and reflect the behavior of the body structure to external strains.

Von Mises stress or equivalent stress is determined with the formula,

$$VON = \sqrt{\frac{1}{2}\left[(SX - SY)^2 + (SX - SZ)^2 + (SY - SZ)^2\right] + 3\left(TXY^2 + TXZ^2 + TYZ^2\right)} \qquad (1)$$

where: *SX* is normal stress along *X* direction; *SY* – normal stress along *Y* direction ; *SZ* – normal stress along *Z* direction; ; *TXY* – tangential stress *XY* in plane; *TXZ* – tangential stress in *XZ* plane; *TYZ* – tangential stress in *YZ* plane.

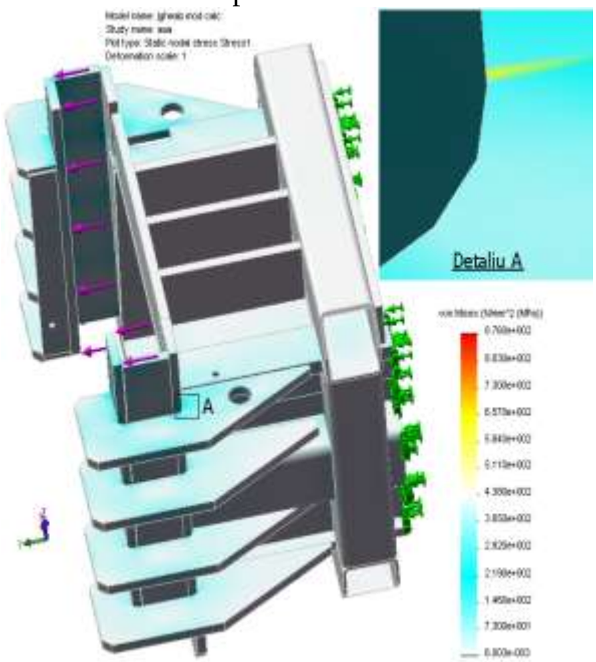

Fig. 7. Verification of the chute's frontal part

Linear static analysis calculates stress, displacements, strains, deformations and reaction forces under the effect of the loads applied to the model.

With the help of COSMOS DesignSTAR 4.0 program, a linear static analysis was made of the press chute at 300 kN force, and the strain of the frontal face of the chute, of the barrier guiding is shown in Fig. 7. It is noticed that equivalent stress in the barrier guide is 250 MPa, close to 252,46 MPa determined by analytic calculation.

Maximum value results in the stress concentrator area, on the connecting of the gusset plate opening, which involved analysis with finite elements of only one gusset plate, loaded with a force of 50 kN, since the center gusset plates are more strained than the exterior ones.Fig. 8 shows the strain of the intermediary gusset plate, it is noticed that maximum equivalent stress is still in the connecting area, of 452,1 MPa, which involves OL 52 steel gusset plates to be used, of 520 MPa breaking resistance.

Fig. 9 shows the strain on the support collar plate of the pressing cylinder flange, resulting a maximum equivalent stress of 141,5 MPa.

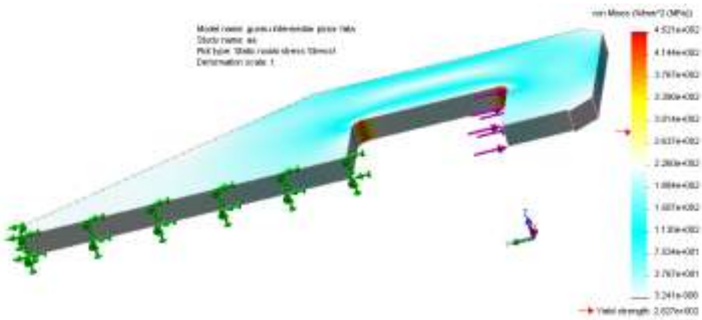

Fig. 8. Verification of the intermediary gusset plate at 50 kN

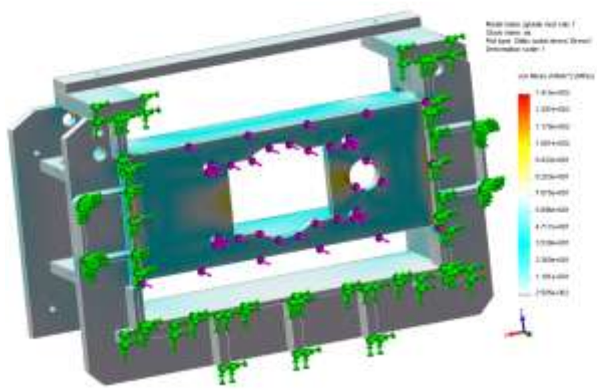

Fig. 9. Verification of the support collar plate of the pressing cylinder

Fig. 10 shows the strain on the barrier at 300 kN, it is noticed that equivalent stress is high, with maximum values in the area of transversal longitudinal beams, therefore the analysis with finite elements of the intermediary longitudinal beam loaded at 100 kN force is required. The strain on the longitudinal beam and its analysis with finite elements is shown in Fig. 11. It is noticed that the equivalent sress in the longitudinal beam is 134,4 MPa, analytically calculated, with 402,8 MPa maximum value in the connection area of the longitudinal beam.

Therefore, OL 52 steel longitudinal beams are required, with 520 MPa breaking resistance.

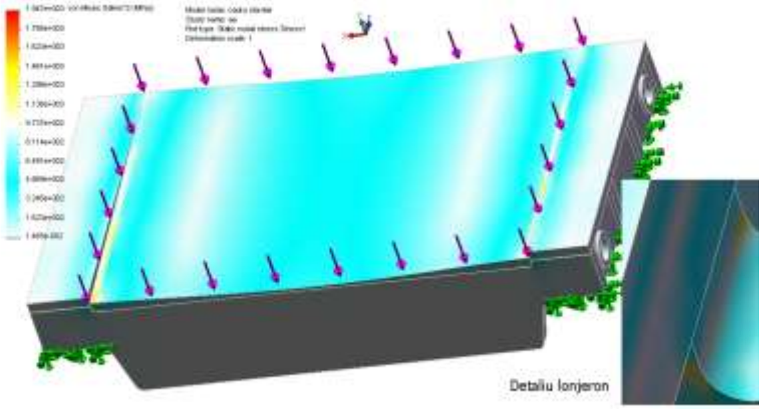

Fig. 10. Verification of the barrier 300 kN

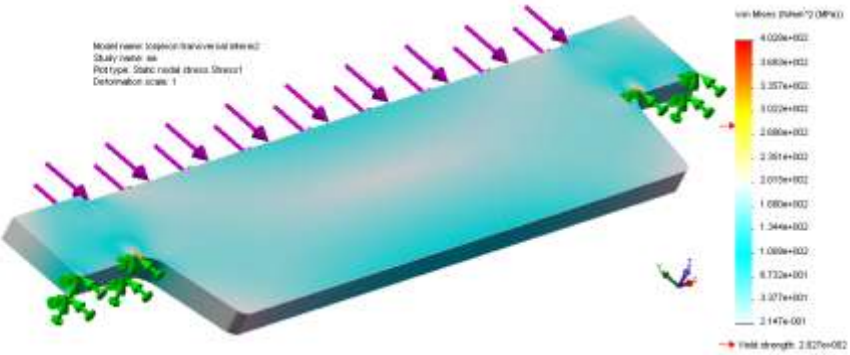

Fig. 11. Verification of barrier intermediary longitudinal beam at 100 kN.

CONCLUSIONS

The verification of the press metal construction with finite element required the construction of frontal gusset plates of the chute and longitudinal beams of the barrier in OL 52 steel.

Based on the technical documentation, an Al box bundling press has been developed in SC Adarco Invest SRL Aninoasa, and Fig. 12 shows the press during functional trials and homologation of technical characteristics.

Fig. 12. Development and trials with Al box bundling press

REFERENCES

[1] * * * - *Documentaţie tehnică de execuţie presă de balotat doze de aluminiu*, SC Adarco Invest SRL Aninoasa