THE ANNALS OF "DUNAREA DE JOS" UNIVERSITY OF GALATI
FASCICLE XIV MECHANICHAL ENGINEERING, ISSN 1224-5615
2012

ROTARY SCREENING BUCKET EQUIPMENT ATTACHABLE TO THE EXCAVATOR ARM

PhD. Assoc. Prof. Dorin EFTIMIE
"Dunarea de Jos" University of Galati,Romania
Eng. Anamaria BAJAN

ABSTRACT

This paper aims to find a new solution of an equipment with rotary screening bucket attachable to the excavator arm. This equipment is used on a large scale for selecting the building material used on small and medium building worksites.

KEYWORDS: screening equipment, 3D modeling, analysis of the screening capacity

1. INTRODUCTION

Screening of the recyclable building materials directly on worksites represents a modern technology very used nowadays. The advantages are several:

- there is no need for trucks for transportation on long distances of the material resulted from demolitions or uncovering.
- the screened material is often used directly on the building worksite.

In figure 1, it is presented a type of rotary screening bucket [1] attachable to the excavator arm.

Fig.1. Equipment - rotary screening bucket attachable to the excavator arm

2. HYDRAULIC KINEMATIC DIAGRAM

In fig. 2, it is presented a kinematic diagram of the equipment.

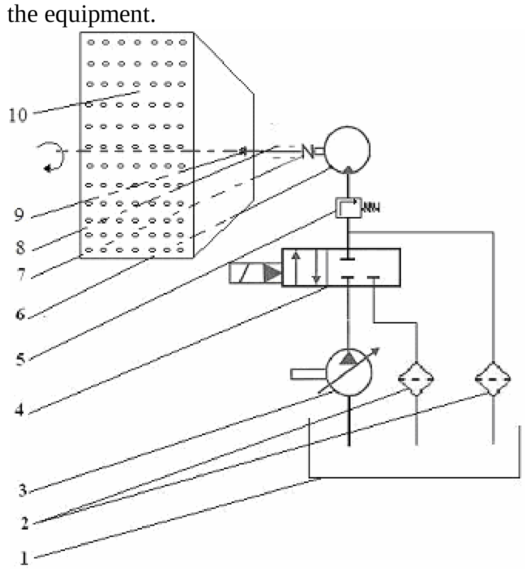

Fig.2. Hydraulic Kinematic Diagram
1-tank; 2-filters; 3- variable-delivery pump; 4-distribuitor; 5-safety valve; 6- rotary hydraulic engine; 7-safety clutch; 8-shaft; 9-bearings; 10-bucket

Hydraulic pressure is obtained from a hydraulic pump with variable delivery which by means of a distributor activates a rotary hydraulic engine. This, on its turn, transmits further on the rotary movement of the rotary screen shaft.

In figures 3 and 4 it is presented the assembly drawing of a rotary screening bucket equipment in different sections whose production capacity is between 7-14 m^3/h.

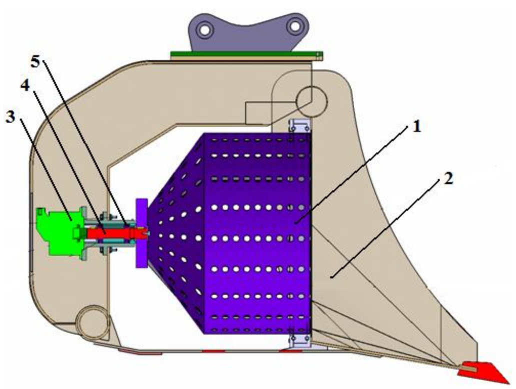

Figure 3. Equipment with
rotary screening bucket – side view
1-screen, 2- bucket, 3-rotary hydro-static engine,
4-turning shaft, 5-bearing

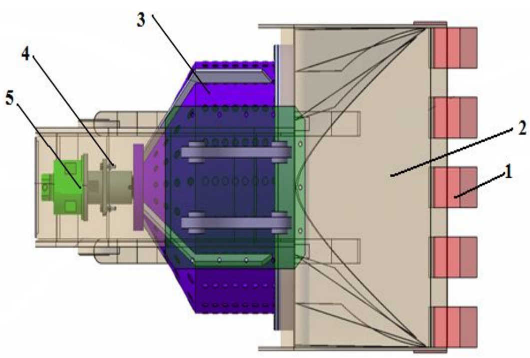

Figure 4. Equipment with
rotary screening bucket – top view
1-tooth, 2-bucket, 3-screen, 4-engine, 5-bolt

Mainly, the equipment is actually a rotary screening bucket framed in an excavator bucket (position no. 1). The size of the selection is established by changing the drum (position no. 2) with the sizes of the openings according to the need. Driving of the box is done by means of a rotary hydraulic engine (position no. 6), as well as of a turning shaft (position no. 8), designed with the afferent axle bearings (position no. 5). The necessary hydrostatic pressure is taken from the hydraulic pressure engine of the excavator.

It is worth noting that the grid basket is interchangeable according to the needs and to the size of the sorts which can vary between 20-80mm.

In figure 5. it is presented the diagram of the equipment productivity according to the size of the classified granulation.

For example, at the same size of granulation, the productivity differs according to the typo-dimension of the screening bucket.

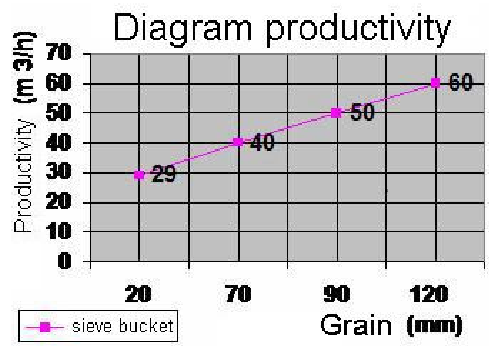

Fig.5. Diagram of the equipment productivity expressed in m^3/h

3. CHARACTERISTICS OF THE PARTICLE MOVEMENTS

In figure 6. it is illustrated the characteristics of the material particle movements along the drum. Particle from point 1 is lifted along with the rotation of the drum and arrives at point B_1 where it is situated in the equilibrium limit position. From B_1 to B_2 the particle arrives, being supported on the interior surface of the drum by the friction forces. Radius OB_2 makes angle β with the initial one O. In point B_2, the equilibrium is destroyed and particularly it slides down on the interior surface of the screen after the maximum inclination line B_2B_3.

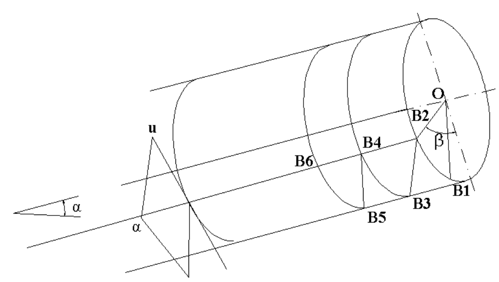

Fig.6. Diagram for studying the material particle trajectory along the screen

Consuming its own energy, the particle stops in point B_3, from where it rises again, simultaneously with the rotation of the screen till point B_4 and from now on the action is repeated. Portions B_2B_3,B_4B_5 etc . are very small. Axial velocity *v* of the particle is equal to the geometric sum between the tangential velocity *u* and the relative one *w*.

As the direction of the relative velocity ***w*** in comparison with the direction of the tangential velocity ***u*** is:

180-ψ =180-2α , it results :

$$v = u \cdot tg 2\alpha = \frac{R \cdot n}{30} tg 2\alpha \left[\frac{m}{s}\right] \qquad (1)$$

4. DETERMINATION OF THE BARREL ROTATIONS

Rotation of the barrel must not exceed a certain limit value. If not, the material rotates along with the barrel and the screening ends as a result of stopping the relative movement between material and screen.

At a certain moment, on a material particle with mass m, situated inside the barrel, the following forces will act (fig.7):

- on radial direction: $F_c = m \cdot R \cdot \omega^2$ and radial component of the particle weight $m \cdot g \cdot \cos\beta$;
- on tangential direction: tangential component of the particle weight $m \cdot g \cdot \sin\beta$ and friction force F_f.

$$F_f = (mg \cos\beta + m R\, \omega^2)\, f \qquad (2)$$

where: f is the friction coefficient between material and barrel.

In point *A*, where the rising of the material particle is maximum, the tangential component of its weight equals the friction force, and next to the top of point *A*, the tangential component of the particle weight exceeds friction force, leading to the sliding of the particle on the barrel surface.

In point *A*, we can write:

$$F_1 = mg \sin\beta \ ; \qquad (3)$$

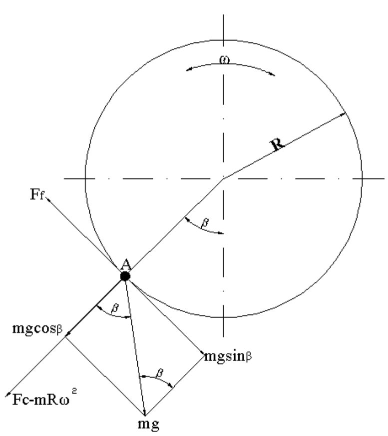

Fig.7. Determination of the barrel rotation diagram

Replacing in relation (3) the friction force according to expression (4), it results the limited angular velocity of the barrel.

$$n = 30\sqrt{\frac{g(\sin\beta - f\cos\beta)}{fR}}\left[\frac{rot}{\min}\right] \qquad (4)$$

It has been determined that, practically, for an operation of the rotary screen under normal conditions, the angle value β is 40...45^0.

Considering β=40^0; f=0,7 and g=9,81 m/s^2 and replacing in relation (4), it is obtained:

$$\omega = 1{,}25\sqrt{R} \quad [s^{-1}], \qquad (5)$$

where *R* is the interior radius of the barrel, m.

Practically, it is adopted:

$$\omega = 0{,}84\sqrt{R}...1{,}47\sqrt{R} \quad [s^{-1}],$$

meaning: $n=8\sqrt{R}...14\sqrt{R}$ [rot/min];

n =(8,3...14,6) [rot/min]. (6)

Peripheral velocity of the barrel is v= (0,95..1,6)m/s .

5. CALCULATION OF THE CLASSIFICATION CAPACITY

Classification capacity of the rotary screens is influenced mostly by the travelling speed of the material on the screening surface.

For the rotary screens, the speed of the material is determined by the following relation:

$$V = \frac{k \cdot N}{1000} \cdot \frac{n^2 \cdot r}{g}\left(1 + 22\sqrt{tg^3\alpha}\right) \cdot \frac{\alpha}{18} \ [m/s] \qquad (7)$$

where: K – correction coefficient according to the specific volumetric productivity:

q [m^3/ h]
k=1,7
N – constant;
n – barrel rotation
n = $n_{ME}/i_{red}/i_{trans}$ [rot/min]
g – gravitational acceleration
r – medium radius of the conic screen; [mm]

According to Allis-Chalmers (SUA) method, classification capacity is determined by relation:

Q=Q'·V·H·K·W[t/h] (8)

where: Q' – basic classification capacity [t/h]
V, H – correction coefficients
K – condition factor (for the material with apparent density)
W – weight factor

- For the screen of 1 [mm]
  Q' = 6,5 [t/h]
  V = 1,09
  H = 1,00
  K – for the dry coarse material which does not exceed 4% humidity, K = 1
  W = 0,65
- For the screen of 5 [mm]
  Q' = 15 [t/h]

V = 0,95

H = 0,50

K – for the dry coarse material which does not exceed 4% humidity, K = 1

6. SIZE DETERMINATION OF THE SIEVE MESHES

If a particle moving over the sieve mesh succeeds in passing through, than it falls freely from a height equal to its half diameter. According to figure 8, we can write:

$x=v \cdot t=D-d/2;$ (9)

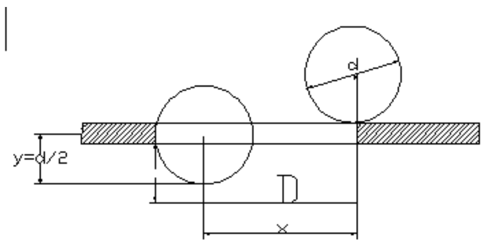

Fig.8 Determination of the sieve mesh diagram

$$t=\sqrt{\frac{\cdot y}{g}}=\sqrt{\frac{d_p}{g}} \quad [s] \qquad (10)$$

$$v=\frac{D-d_p}{\sqrt{\frac{d_p}{g}}}=\left(D-d_p\right)\sqrt{\frac{g}{d_p}}, \quad [m/s] \qquad (11)$$

$$D=v\cdot\sqrt{\frac{d_p}{g}}+d_p\left[m\right] \qquad (12)$$

where:

d_p – diameter of the particle in *m*;

v - optimum velocity for classification (0,96..1,6) m/s;

D - diameter of the sieve meshes.

7. CALCULATION OF THE OPERATING POWER

The operating power is :

$$P=\frac{G_0^2\cdot n^3\cdot r_1^2}{1{,}73\cdot 10^5\left(G+G_0\right)}[Kw], \qquad (13)$$

where: (4.14)

G_0 – sieve weight [daN];

n – rotation of the rotary sieve;

n = 14, [rot/min];

r_1 – material particles motion amplitude;

$r_1 \geq 0{,}15d+1$[mm];

where:

d – diameter of the openings of the screening surface;

$d = d_{med} = 3$ [mm];

$r_1 \geq 0{,}15 \cdot 3 + 1$, $r_1 \geq 1{,}45$ [mm], $r_1 \geq 1{,}8$[mm];

G –material weight [daN]

To determine G_0 (weight of the conic screen) the following calculations are performed:

Lateral area $S_l = \pi G(R + r)$; [m^2] (14)

According to the specialty literature, the active surface of the screen in case of the circular meshes is about 40% from the total surface, so the effective mass of the screen is 60% from the mass of the semi-manufactured material.

$G_0 = m_{screen} \cdot g$ [daN]

To determine G the volume is calculated first:

$$V=\frac{\pi\cdot h}{3}(R^2+r^2+R\cdot r)=[m^3] \qquad (15)$$

During operating procedure, it is considered that there is a volume of material of 15% from the screen volume in the screen.

The apparent density of the material:

$\varsigma = 866$ [Kg/m^3]

$M = V \cdot \varsigma$ [Kg]

8. CONCLUSIONS

It has been attempted to elaborate a new constructive solution and methodology of designing a rotary screen adaptable to the technological requests taking into account the constructive solutions existing on the market of building equipment.

REFERENCES

[1] www.vtngroup.com
[2] http://www.lloydengineering.co.uk
[3] www.solidedge.com