Construction hammer mill for grinding peppers

Gheorghe ABRUDAN, Ion Bratu Ion, Tudor MITRAN

University of Oradea

Summary: This hammer mill's main purpose is to grind pepper for the paprika (grounded-pepper), by crushing the peppercorn with the active components of the mill. But we also have to remember the other grinding activities which take place, like chopping, compressing and rubbing.

1. Hammer with one hole

So that the articulation between the hammer and the rotor exists, the hammer has to have a hole with the centre in O and is radius. Consequently, the weight centre of the hammer is no more in the middle of its length.

Using the relations shown in picture no.1, the position of the weight centre is determined by considering the plane plate in which we do the hole.

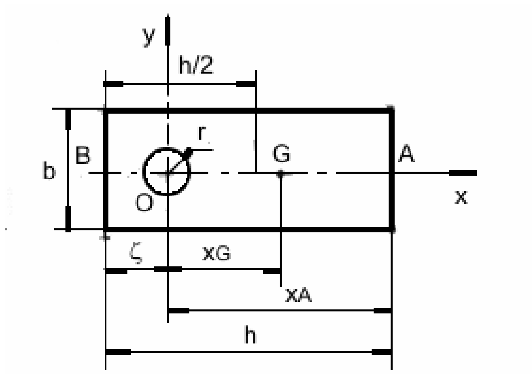

Fig.1

In relation with the origin O, the coordinate x_G of the weight centre in given be the relation:

$$x_G = \frac{hb\left(\frac{h}{2} - \xi\right)}{hb - \pi r^2} \tag{1}$$

From which we can conclude:

$$\xi = \frac{h}{2} - \frac{x_G}{hb}\left(hb - \pi r^2\right) \tag{2}$$

If m_1 and m_2 are the weight of the full plate and the hole taken away, than the ineptness moment of the plate is:

$$J_z^{'} = \frac{m_1\left(h^2+b^2\right)}{12} + m_1\left(\frac{h}{2}-\xi\right)^2 \qquad (3)$$

And the ineptness moment of the hole is:

$$J_z^{''} = \frac{m_2 r^2}{2} \qquad (4$$

Considering that the homogeneous plate weight and the areas are proportional, we have:

$$\frac{m_1}{hb} = \frac{m_2}{\pi r^2} = \frac{m}{hb-\pi r^2} \qquad (5)$$

-where:

m is the weight of the plate with;

r radius hole;

But, the moment de inertia of the hammer considered to be a plate with a hole is:

$$J_z = J_z^{'} - J_z^{''} \qquad (6$$

And so the moment of inertia of the plate is:

$$J_z = \frac{mhb}{\left(hb-\pi r^2\right)}\left[\frac{h^2+b^2}{12} + \frac{x_G^2}{h^2 b^2} - \left(hb-\pi r^2\right)^2\right] - \frac{m\pi r^4}{2\left(hb-\pi r^2\right)} \qquad (7)$$

Because we have:

x_A=h-ξ (8)

So, considering relation (2), we get:

$$x_A = \frac{h}{2} + \frac{x_G}{hb}\left(hb-\pi r^2\right) \qquad (9)$$

On the other hand, using (7) and both of them in the expression (9), we obtain:

$$\frac{1}{2}x_G h\left(hb-\pi r^2\right) + \frac{x_G^2}{hb}\left(hb-\pi r^2\right)^2 = \frac{hb\left(h^2+b^2\right)}{12} + \frac{x_G^2}{hb}\left(hb-\pi r^2\right)^2 - \frac{\pi r^4}{2} \qquad (10)$$

This result:

$$x_G = \frac{\frac{hb\left(h^2+b^2\right)}{6} - \pi r^4}{h\left(hb-\pi r^2\right)} \qquad (11)$$

And from relation (2) we get:

$$\xi = \frac{2h^2-h^2}{6h} - \frac{\pi r^4}{h^2 b} \qquad (12)$$

And then from relation (8) it concludes:

$$x_A = h - \xi = \frac{4h^2+b^2}{6h} - \frac{\pi r^4}{h^2 b} \qquad (13)$$

2. Hammer with two holes

For increasing the functioning period for a hammer, in the case of the hammer mill for grinding pepper, we use plates of steel with two holes symmetrically positioned in relation with the centre. So, the hammer can be set in turns through the two holes in order to get all its segments active.

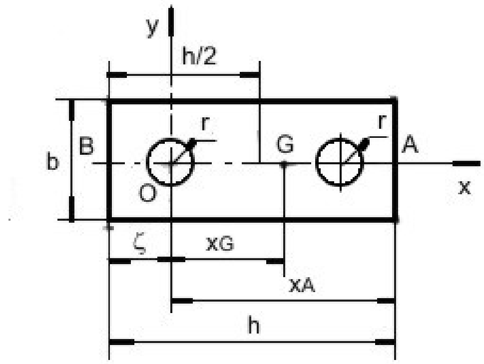

Fig.2

This time the hammer's weight centre is the same as the plate's symmetry centre. Considering that the weight of the plate is proportional with the areas, we have:

$$\frac{m_1}{hb} = \frac{m_2}{2\pi r^2} = \frac{m}{hb - 2\pi r^2} \tag{14}$$

Where:

m_1 , m_2 are the weights of the plate and the refilled holes

$m = m_1 - 2m_2$

Momentum de inertia of the plate is:

$$J_z = J_0 = m_1 \frac{h^2 + b^2}{12} + m_1 x_G^2 - m_2 r^4 - 4\pi r^2 x_G^2 \tag{15}$$

And from relation (14) we get:

$$J_z = \frac{m}{hb - 2\pi r^2}\left[\frac{hb\left(h^2 + b^2\right)}{12} + hbx_G^2 - \pi r^2 - 4m_2 x_G^2\right] \tag{16}$$

If we use relation (16) and also remembering that:

$$x_A = x_G + \frac{h}{2} \tag{17}$$

We get:

$$x_G^2 + \frac{h}{4\pi r^2}\left(hb - 2\pi r^2\right)x_G - \frac{hb\left(h^2 + b^2\right)}{24\pi r^2} + \frac{r^2}{2} = 0 \tag{18}$$

This last relation positions the weight centre, so that the demands for the existence of the percussion centre to be accomplished (the O percussion to be null).

If we notice that $hb >> 2\pi r^2$, so the areas of the holes are totally neglect able in relation to the area of the whole plate, that is valid for the initial ideal case

It is important that we position O at ξ distance in relation to the segment. So we have:

$$x_G = \frac{h}{2} - \xi \tag{19}$$

From relation (18) we get:

$$\xi^2 - \frac{h}{4\pi r^2}\left(hb + 2\pi r^2\right)x\xi + \frac{hb\left(2h^2 - b^2\right)}{24\pi r^2} + \frac{r^2}{2} = 0 \tag{20}$$

It is easy to check that in this case, for $hb >> 2\pi r^2$ we also get for ξ the value from relation.

Bibliography:

1. **B uzzi, L.,** Technical elements of rotor balancing, Technical booklet, $N^0$3, Italy, 1988**;**
2. **B uzzi, L.,** Balancing accuracy of rigid rotors, Technical booklet, $n^0$8, Italy, 1989;
3. **Căproiu**, M., Contribuții teoretice şi experimentale privind construcția ciocanelor morilor cu ciocane, I.P.Gh. Asachi, Iaşi, 1974;
4. **Childs, D.,** Turbo machinery otordynamics, J. Wiley&Sons, New York, 1993.