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VIBRATING TUBE MILLS OF CONSTRUCTION MATERIALS ‘ INDUSTRY MODEL MECHANIC APPROACH OF “ DIVIDED MASS IN n BAR“ FOR THE CALCULUS OF VIBRATION AMPLITUDE

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1. INTRODUCTION

Vibrating tube mills are used primarily for producing very fine powders from medium hard to hard materials . The diameter of the grinding tube lies in the range 200 to 6000 mm , where the larger grinding tube diameters are used to achieve greater throughputs . The design of these large grinding tube is related to the following difficulty. Increasing the diameter of the grinding tube will lead to grinding condition being considerably impaired due to increased losses in the transfer of momentum .If losses in grinding results are to be prevented when increasing the size of the grinding chamber , it is necessary to adapt the grinding condition to new geometric condition .This paper attempt to show means and ways to determine the operating range where the most effective grinding effected can be anticipated using simple theoretical consideration of the energy input for vibrating tube mills.

2. REQUIREMENT AND OBJECTIVE

A prerequisite for the following model observation is the assumption that the attainable grinding results are in direct relationship to the energy input .Thus those parameters that have considerable influence on the input energy should be investigated. The parameters that primarily influence the vibration state and thus the input energy , are :

- the vibration amplitude of grinding tube ;
- the size of the grinding chamber ;
- the filling ratio of grinding elements ;

The objective of these observations in the configure the above –mentioned parameters so that a maximum energy can be transferred to the grinding bulk .The investigation of the se problems will be based on the model of “ divided mass in n bar“

The model of " divided mass in n bar" will be used to describe the movement behavior of different , extreme cases .

3.THE MECHANIC MODEL APPROACH OF " DIVIDED MASS IN n BAR". GEOMETRICAL CONDITION FOR IT .

The mechanic model approach of " divided mass in n bar" (fig.1) the entire grinding element bulk is united to n bar with a diameter d , length L and density ρ_{mc} .

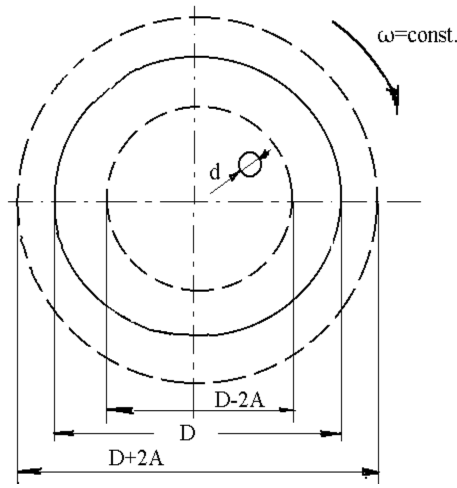


Fig 1 Geometric condition for the "divided massin n bar" mechanic model

1 THE CALCULUS OF VIBRATING AMPLITUDE

The vibration amplitude of tube mills is given by an armonical low :

$$s = A \sin \omega t \qquad (1)$$

The instantanee speed :

$$v = \dot{s} = \omega \cdot A \cos \omega t \qquad (2)$$

and it has a maximum value :

$$v_{\max} = \omega \cdot A \qquad (3)$$

The mass of one bar is :

$$m_b = (k_1\rho_1 + k_2\rho_2)\frac{\pi \cdot d^2}{4} L \qquad (4)$$

The *energy* of the group of " n " bar , given by translating movement of them , with the speed given by (3) , is :

$$E_{trans,bare} = \frac{1}{2} n \cdot m_b \cdot \omega^2 A^2 \qquad (5)$$

With the definition of the ***filling ratio*** :

$$\eta = \frac{n\frac{\pi \cdot d^2}{4} L}{\frac{\pi \cdot D^2}{4} L} = n\frac{d^2}{D^2} \qquad (6)$$

so the number of bar is given by the expression :

$$n = \eta \frac{D^2}{d^2} \qquad (7)$$

It must be noted the rapport between the diameter of n bar and the diameter of the tub mill:

$$\delta = \frac{d}{D} \qquad (8)$$

results :

$$d = \delta \cdot D$$

substituting in (7) results :

$$n = \frac{\eta}{\delta^2} \qquad (9)$$

Substituting (4) , (8) , (9) in (5) results :

$$E_{trans,bare} = \frac{\pi}{8}\left(k_1\rho_1 + k_2\rho_2\right)\eta \cdot D^2 L\omega^2 \cdot A^2 \qquad (10)$$

The *Energies* of the group of " n " bare from the rotating movement *of each* bar with constant frequency ω is :

$$E_{rot,bare} = n\frac{1}{2} J_b \cdot \omega^2 \qquad (11)$$

în wich J_b is :

$$J_b = m_b \frac{d^2}{8} = \frac{\pi}{32}\left(k_1\rho_1 + k_2\rho_2\right) D^4 \delta^4 L \qquad (12)$$

Substituting (9) and (12) in (11) , results :

$$E_{rot,bare} = \frac{\pi}{64}\left(k_1\rho_1 + k_2\rho_2\right)\eta \cdot D^4 \cdot \delta^2 L\omega^2 \qquad (13)$$

The *energy* of the group of " n " bar , given by translating movement of them and from the rotating movement *of each* bar with constant frequency ω, from the relation (10) and (13):

$$E_{tot,bare} = \frac{\pi}{8}\left(k_1\rho_1 + k_2\rho_2\right)\eta \cdot D^2 L\omega^2\left(A^2 + \frac{1}{8}D^2\delta^2\right) \qquad (14)$$

The energy of the tub mill from translation movement is:

$$E_{vibr,moara} = \frac{1}{2}M_{moara}\omega^2 A^2 \qquad (15)$$

and from :

$$E_{rot,moara} = \frac{1}{2}J_{moara}\omega^2 \qquad (16)$$

in wich:

$$J_{moara} = \frac{1}{4}M_{moara}D^2 \qquad (17)$$

From (16) , (17) results :

$$E_{rot,moara} = \frac{1}{8}M_{moara}D^2\omega^2 \qquad (18)$$

From (15) and (18) results the total energy of tube mill :

$$E_{tot,moara} = \frac{1}{2}M_{moara}\omega^2\left(A^2 + \frac{1}{4}D^2\right) \qquad (19)$$

4.DETERMINATION OF VIBRATION AMPLITUDE

Because only a part of energy of tube mill is transmitting on the n bar , it must be noted with z<<1 ***this part of energy of tube mill*** , so :

$$z \cdot E_{tot,moara} = E_{tot,bare} \qquad (19)$$

$$zM_{moara}\left(A^2 + \frac{1}{4}D^2\right) = \frac{\pi}{4}\left(k_1\rho_1 + k_2\rho_1\right)\eta \cdot D^2 L \cdot \left(A^2 + \frac{1}{8}D^2\delta^2\right) \qquad (20)$$

From (20) the vibration amplitude A can be calculated :

$$A=\frac{D}{2}\sqrt{\frac{z\cdot M_{moara}-\frac{\pi}{8}\left(k_1\rho_1+k_2\rho_2\right)\eta\cdot D^2L\delta^2}{\frac{\pi}{4}\left(k_1\rho_1+k_2\rho_2\right)\eta\cdot D^2L-z\cdot M_{moara}}} \qquad (21)$$

The vibration amplitude A can exists only with the condition:

$$\frac{\pi}{8z}\left(k_1\rho_1+k_2\rho_2\right)\eta\cdot D^2L\delta^2 < M_{moara} < \frac{\pi}{4z}\left(k_1\rho_1+k_2\rho_2\right)\eta\cdot D^2L \qquad (22)$$

The graphical evaluation of ecuation (21) in shown in fig.2 , for M200x1,5 m , with D=0,2 m ,L=1,5 m , the condition (22) is :

$$413{,}51\cdot\eta \le M_{moara} \le 827{,}02\cdot\eta \qquad (23)$$

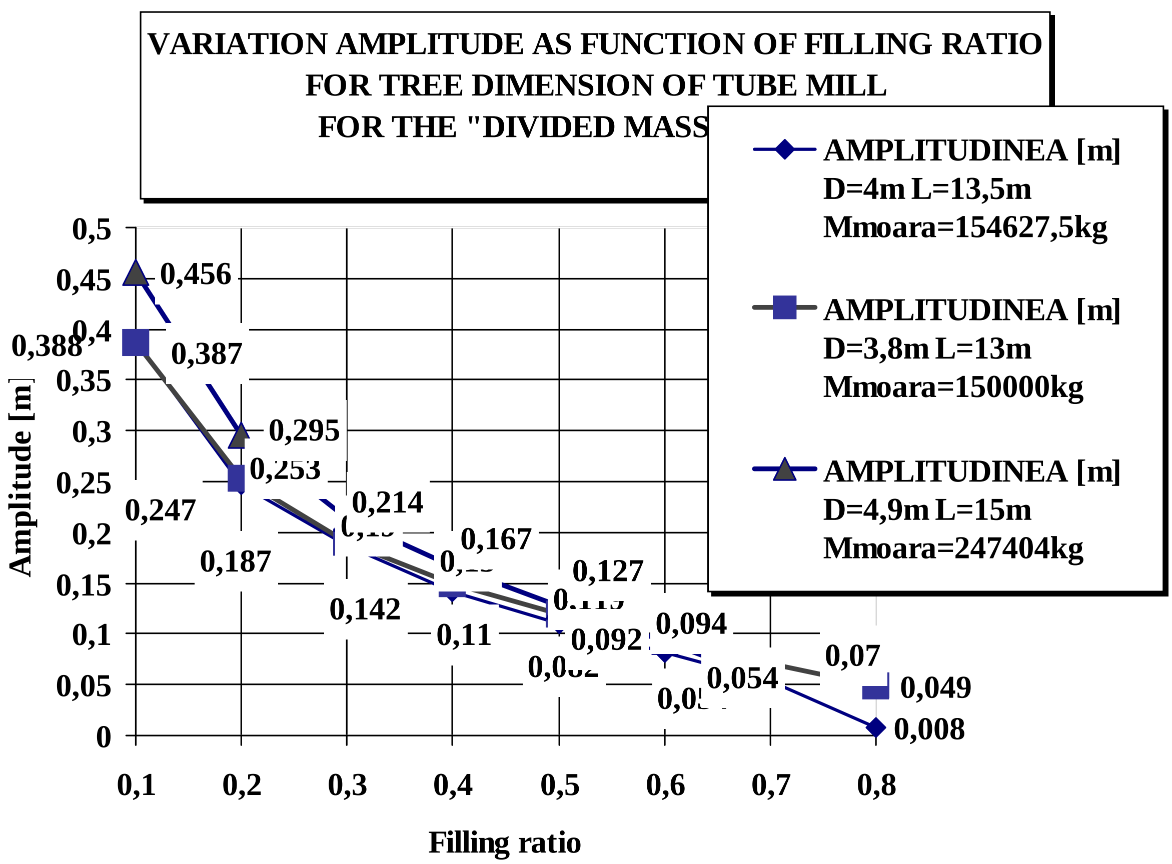
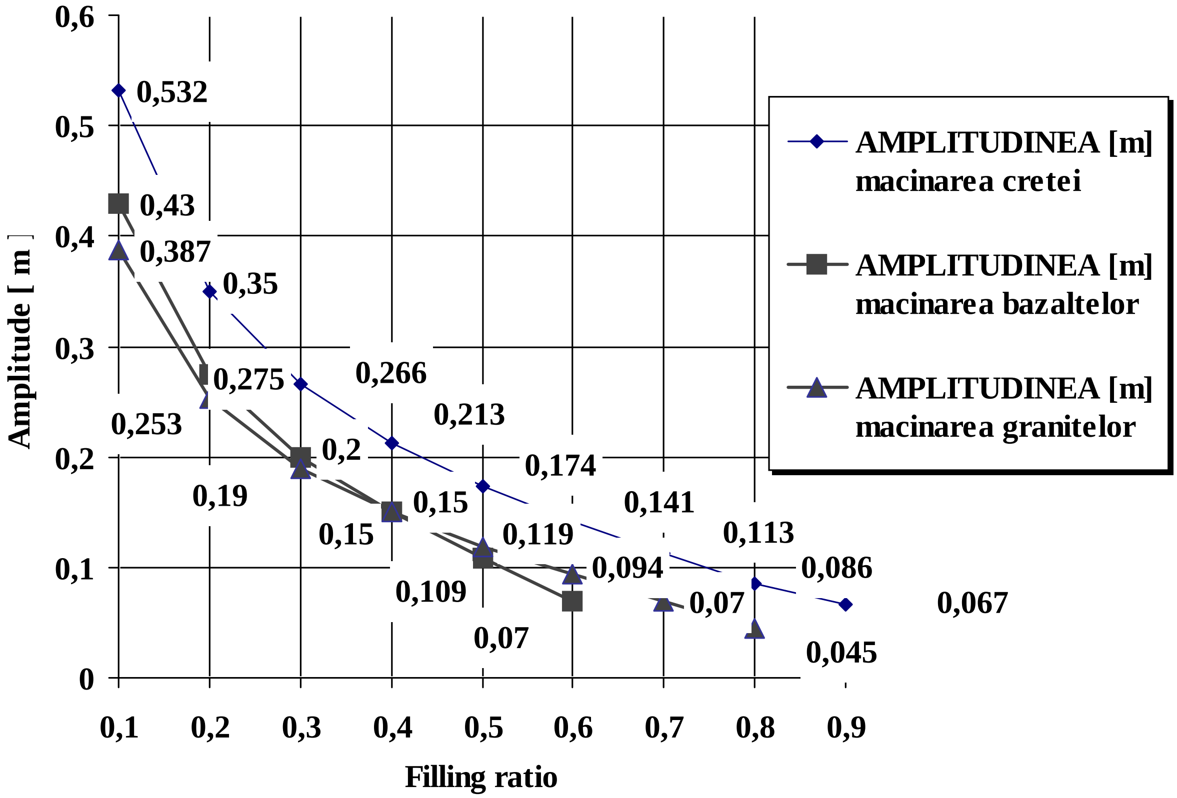


Fig.2 Vibration amplitude as a function of filling ratio for the “ divided mass in n bar”

VIBRATION AMPLITUDE AS FUNCTION OF FILLING RATIO FOR THE TUN MILL WITH DIMENSION: D=4,9m,L=15m, FOR DIFFERENT MATERIALS FOR THE "DIVIDED MASS IN N BAR "



From the graphical evaluation of equation (21) , it can be recognized that :

- With an ***increased of filling ratio*** , only ***low amplitudes*** are required for obtaining the described sequence of movement ;
- an ***increase in diameter*** of the grinding tube requires a ***proportional increase*** in the oscillation ***amplitude*** ;

However , in order to make statements of the filling ratios which should be selected for a specified grinding tube diameter , the energy input must be examined as a function of filling ratio .

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