ANNALS of the ORADEA UNIVERSITY.
Fascicle of Management and Technological Engineering, Volume VI (XVI), 2007

THE DYNAMIC STUDY OF VIBRATING TUBE MILLS. THE CALCULUS OF OPERATING RANGE WITH THE MODEL MECHANIC APPROACH OF"DIVIDING MASS IN TOW CYLINDER "

Assoc.prof.PhD.Eng **.Mariana Adriana Prichici,** Eng **Liliana Indrie,**
Assoc.prof.PhD.Eng.**Sabina Gherghel**
University of Oradea mprichici@uoradea.ro,

ABSTRACT

This paper wants to demonstrate how is possible, by simple model approach for the movement of grinding in vibrating ball mills to design of the vibrating ball mills . With the model mechanic approach of " dividing mass in tow cylinder "can bee determined the operating range, for different dimension of grinding chamber , and the filling ratio of grinding elements .

KEY WORDS: operating range, grinding elements, vibrating tube

1.INTRODUCTION

This paper attempt to show means and way to determine the operating range where the most effective grinding effects can be anticipated using simple teoretichal consideration of energy input for vibrating tube mills.

The mechanic model approach of" dividing mass in tow cylinder "the entire grinding elements bulk is divided in tow cylinder (fig.1) with a diameter d and length L, and density ρ_{mc} . The tow cylinder heave an up and down movement on Δ axes and a circular movement with frequency ω ($f=\frac{\omega}{2\pi} and \; period: T=\frac{2\pi}{\omega}$)(fig.2,3)

2.THE CALCULUS OF VIBRATION AMPLITUDE

The low of space in the up and down movement on Δ axes , for the first half of the period $T=\frac{2\pi}{\omega}$ and for the inferior cylinder is:

$$s=\omega At-\frac{g}{2}t^2 \qquad (1)$$

And for the superior cylinder is :

$$s=\omega At+\frac{g}{2}t^2 \qquad (2)$$

For the second part of period , the term: $\frac{g}{2}t^2$ change the sign .

The initial speed is:

$$v=\omega A \qquad (3)$$

$v=\omega A$ is changing with the change of vibration amplitude z , of harmonically up and down movement of grinding tube .

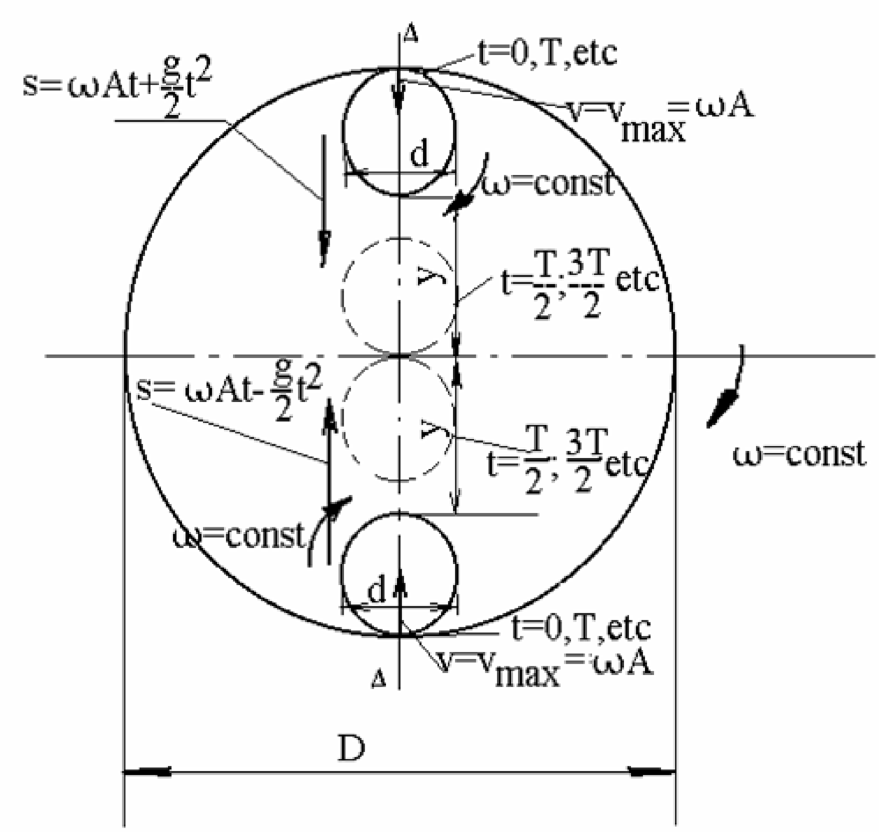

Fig. 1*Geometrical condition for the mechanic model*

The vibration amplitude z is given by:

$$z = A \sin \omega t \qquad (4)$$

The instantaneity speed v is:

$$v = \dot{z} = \omega A \cos \omega t \qquad (5)$$

The maximum speed of the inferior cylinder have been at the moment: : t=0,t=T;t=2T,etc, when the grinding tube is perfect cylinder(fig.2)

$$v_{\max} = \omega \cdot A \qquad (6)$$

The low of space in the up and down movement is given by:

$$s = \omega \cdot A \cdot t \mp \frac{g}{2} t^2 \qquad (7)$$

In figure 1, at the moment $t = \frac{T}{2}; s = y = \frac{D}{2} - d$,we consider the space of tow cylinders in the time interval $\frac{T}{2}$ as approximate equal between them, and equal with y , so we can write: $y = \frac{D}{2} - d = \omega \cdot A \cdot \frac{T}{2} \pm \frac{g}{2}\frac{T^2}{4} = \pi \cdot A \pm \frac{g}{2}\frac{\pi^2}{\omega^2}$

and : $$y = \frac{D}{2} - d = \pi \cdot A \pm \frac{g}{2}\frac{\pi^2}{\omega^2} \qquad (8)$$

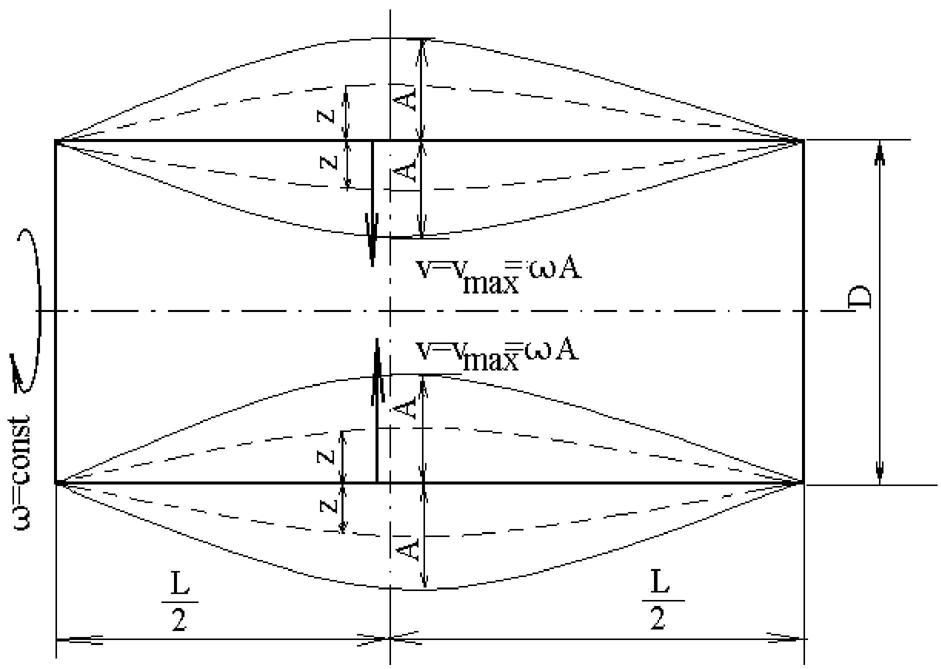

Fig.2 *Calculus scheme of mechanic model*

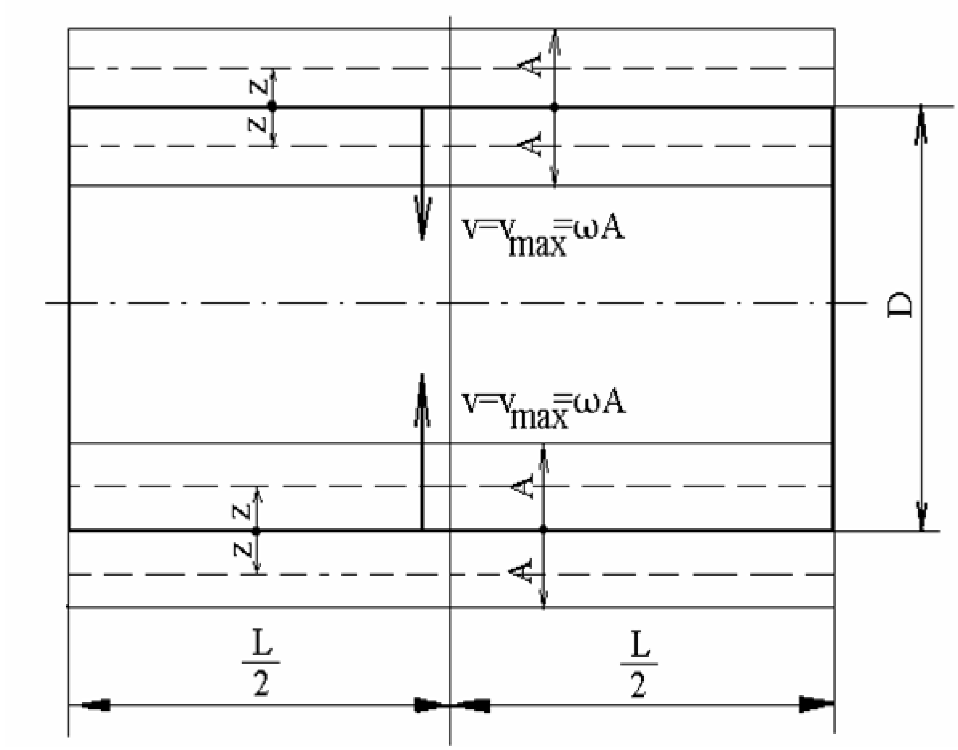

Fig . 3 *Scheme for determination of vibration amplitude*

The" minus " sign is for the ascendant movement of the inferior cylinder in his movement ,wich for the same time , is smaller than the movement of superior cylinder in his ascendant mouvement . To complete his space : $y = \frac{D}{2} - d$ the inferior cylinder,we adopt , sign “plus” în relation (8) and results a biggest o value for the a amplitude A . So, we obtain :

$$A = \frac{y}{\pi} + \frac{g\pi}{2}\frac{}{\omega^2} \qquad (9)$$

The tow cylinders will run in the time T/2 , distance $y = \frac{D}{2} - d$,the term : $\frac{g}{2}\left(\frac{T}{2}\right)^2$ should have a valour smaller than the valour $\omega \cdot A\frac{T}{2}$ to y .So , for D=0,6 m , η=0,4 and ω=20π rad/sec , we obtain : $y \cong 0{,}0316m, \frac{g}{2}\left(\frac{T}{2}\right)^2 \cong 0{,}0122m$ and valour fori $\frac{g}{2}\left(\frac{T}{2}\right)^2$ does not be negligee in front of the valour of y . With a decreased of frequency and the diameter of the vibrating tube, , term : $\frac{g}{2}\left(\frac{T}{2}\right)^2$ has smaller valour in rapport with y . So , for the diameter D=1m , η=0,4 , ω=40π rad/sec , we obtain the following value :

$$y \cong 0{,}057m; \frac{g}{2}\left(\frac{T}{2}\right)^2 \cong 0{,}00306m.$$

In figure 3 is present the variation of amplitude of vibrating tube mills .We adopt a simplifications:we consider that the harmonically vibration amplitude of grinding tube is constant on the long tub ax.

3.DETERMINATION OF THE VIBRATION AMPLITUDE

Starting with the definition of the filling ratio of mills:

$$\eta = \frac{2\frac{\pi \cdot d^2}{4}L}{\frac{\pi \cdot D^2}{4}L} = \frac{2d^2}{D^2} = 2\left(\frac{\frac{D}{2} - y}{D}\right)^2 \qquad (10)$$

By transpose we obtaine the following expression for the distance y:

$$y^2 - Dy + D^2\left(\frac{1}{4} - \frac{\eta}{2}\right) = 0 \qquad (11)$$

with: $$y_{1,2} = \frac{D}{2}\left(1 \pm \sqrt{2 \cdot \eta}\right) \qquad (12)$$

Because we can see in figure 1 ,that $y < \frac{D}{2}$, so we adopt for the distance y only the expression : $$y = \frac{D}{2}\left(1 - \sqrt{2 \cdot \eta}\right) \qquad (13)$$

Substituting (13) in (9) we obtain vibration amplitude :

$$A = \frac{D}{2\pi}\left(1 - \sqrt{2\eta}\right) + \frac{\pi \cdot g}{2\omega^2} \qquad (14)$$

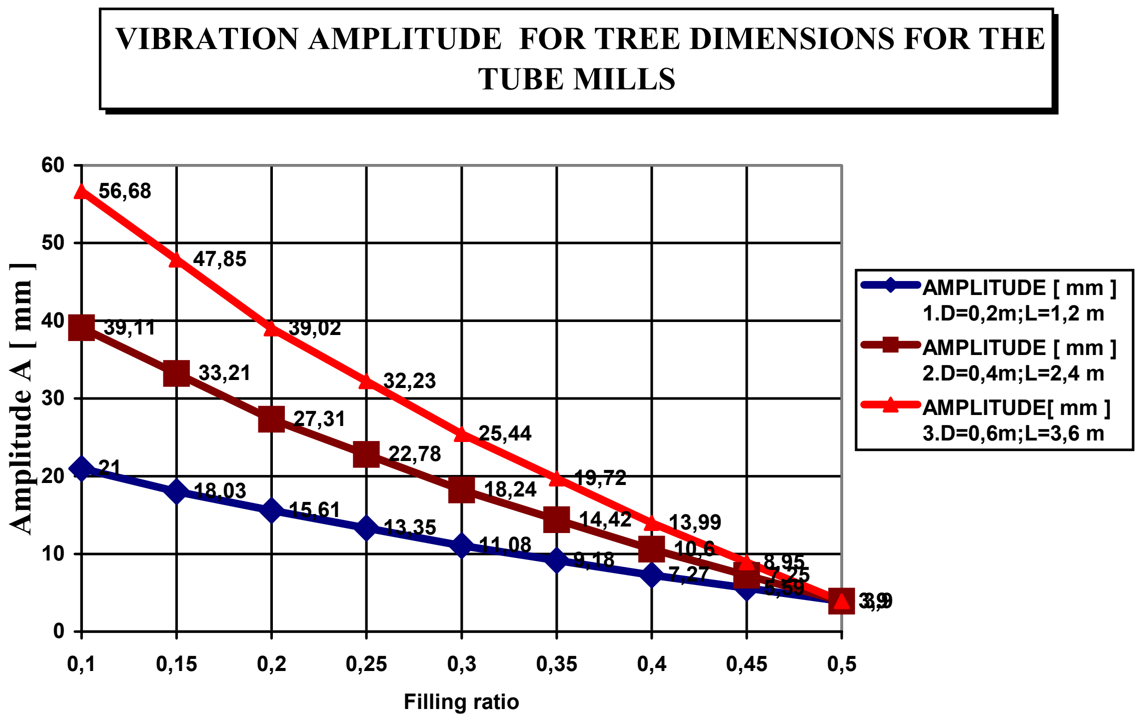

Fig. 4 Vibration amplitude as a function of filling ratio

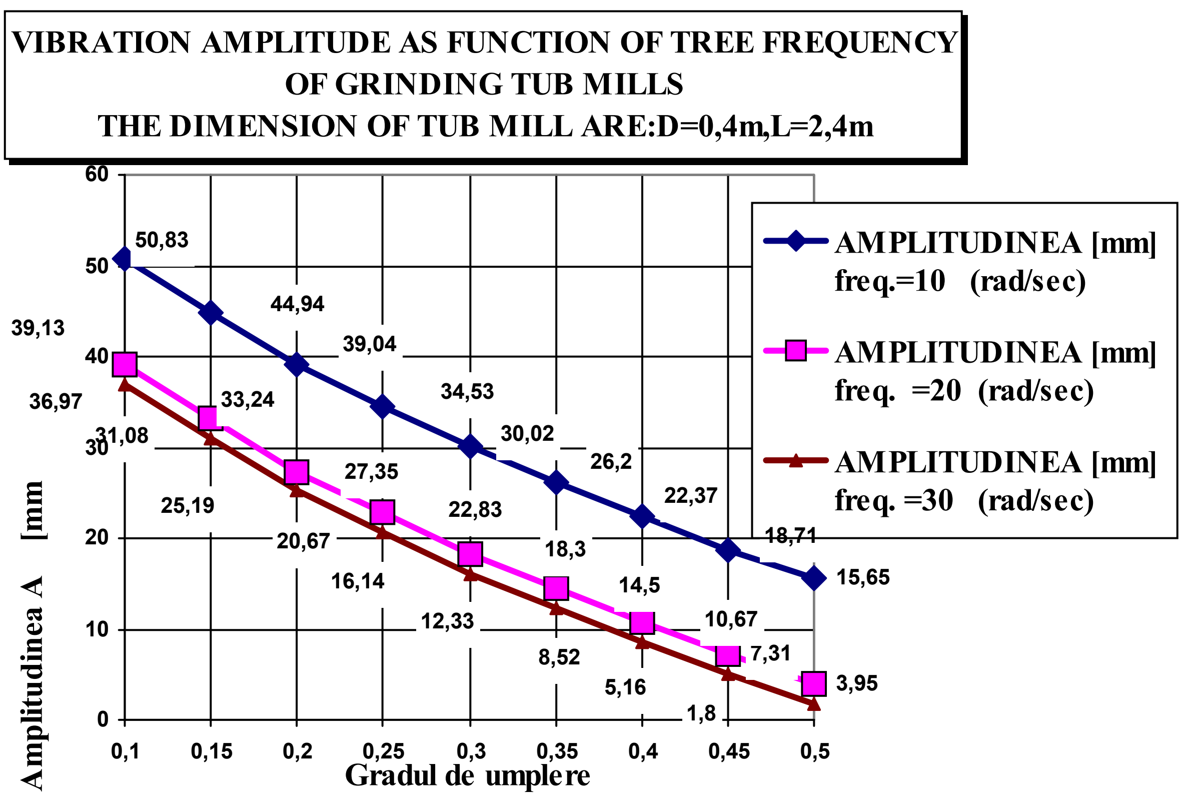

Fig .5_ Vibration amplitude as a function of frequency of grinding tub mull

The grafical evolution of equation (14) $A=f(\eta)$is shown in fig.4 and fig.5

4.CONCLUSIONS

From the graphical evaluation of equation (14), it can be recognized that:

- -Low amplitudes A are required with the increased of filling ratio η ;
- -An increase in diameter D of a grinding tube requires a proportional increaser in the oscillation amplitude ;
- -Mills with large grinding tube diameter should be operated with a high filling ratio , since oscillation amplitude greater than 10 mm can only be achieved at great technical effort ;
- -The configured of graph of variation of amplitude A in function of filling ratio η is the same when is changing the value of frequency ω of the tub mills.

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