NEW FURNACE PROCESS WITH VERTICAL CIRCLE TURNING OVER

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1. Introduce

At first, this process was discovered experimentally by checking of mental reasonings. It was necessary to find such furnace that allow to burn any bad fuel. This fuel is understood following: hard combustible wastes from population and industry, wood junk (sawdust, bark, leaf, twings), oiled sand and road metal, special prompt growing plant after little drying, etc.

The problem is sharp for our country, because any transported fuel is too expensive for us, and known furnace equipment for cheap fuel (it is mean bad fuel) is expensive too Hence, good high price fuel permits to cheapen the furnace, but bad low price fuel demands the complicated furnaces. The research aim consists in disclosing of furnace process which can connect cheap furnace with high power and efficacy. This aim is attained by increasing of react surface of burning fuel. It is used simple movement and construction, combination of functions of different devices.

The first task is to see principal main correlations with certain admissions. Further object of this research will be new type of furnace equipment for wide using.

2. Rotor furnace processes.

Generally, the furnace is installation for burning of definite fuel to transmit products combustion heat on any objects. Furnace process efficiency is relation of produced by furnace beat energy to while potential energy of fuel. Furnace efficiency causes chemical and mechanical unburning down and nonutilized heat flows (radiation and convective cooling, slag wastes, etc.) Heat power of furnace volume is important parameter, it is heating out from volume furnace unit with maximum efficiency. Air plenty coefficient characterises perfectly ratio of furnace, because if is relation of served in furnace air quantity to theoretical necessary quantity.

It is necessary for attainment of high efficiency furnace process followings:

·to decrease heat losses (to increase efficiency);
·to increase heat power (to decrease furnace dimensions);
·to approach (be air plenty coefficient to 1 (no dilute hot burning by cold air).

Rotor furnace process is turning over of fuel bulk which consists from polyfractial pieces, moving is realised by special air cooled blades in vertical plane The aim of this turning over is to decrease surface of air/buming fuel reaction This physical aimis added by series of technical tasks (fuel replace, slag and ash removal) and by regime demands (increasing of concentration and temperature uniform, upholding of assigned consumption, etc). Vertical turning over allows to satisfy mention above demands because furnace process must be intensified by decreasing of oxygen diffusion owing discover new reaction surface Oxygen diffusion in fixed fuel layer is very difficult, fuel is burning ruly on surface of layer, and vertical circle move may improve thermo and mass diffuse processes.

Fuel burning rate being a basis of furnace installation calculation is noted by differential from such:

$$\frac{d\delta}{d\tau} = \frac{c}{M\frac{\rho_1}{\rho_2}\left(\frac{\delta}{Nu_D D}+\frac{1}{k}\right)}$$

where σ - dimension of fuel particle, c - oxygen concentration in space about fuel, M - stechiometric relation, ρ_1, ρ_2 - density of fuel and gas; D - diffusion coefficient, Nu_D - Nusselt diffusion criterion, k - burning rate constant.

We can see that at first it is necessary for growing of burning rate to increase ”c" (and it may be possible by vertical turning over), to increase Nu by growing Reynolds criterion, i.e. by increasing of particle blowing (in the fuel particle will be separate from bulk by blades) to increase particle temperature in order to increase "k" (radiation heating will improve by vertical turning over), in decrease dimension of fuel particles turning over must destroy mechanically each particle).

Hence, rotor furnace process represents intensified burning of fuel particles bulk replaced by special blades in vertical plane. New surfaces of air/fuel contact are forming owing to falling layer, to changing form of layer, to increasing of new gas volumes around each fuel particle.

3. Consideration scheme.

Rotor furnaces without specifying of constructive peculiarities) in horizontal cylinder 1(see figure 1) with rotaring blades 2. Fuel is going to furnace by feeder 3 Gas product combustion are removed by gasflow 4 or 5. Air is served by airflow 6 through wall of cylinder I with feeder 3. Slag is removed through tube 7. Blades 3 have unshown of picture engine and rotate round cylinder 1 axis. Blades 2 may have various form, profile, flexibility and etc, but we shall not take into account its in futher calculation, because it is topic of technical improvement of furnace.

Let us take transverse section of furnace on half length it and shall reckon it as middle for whole furnace. Hence, let us reckon our task as two measure. Than we have consideration scheme shown in figure 2.

According to fig.2: R - cylinder radius, L - blade width, α - blade turn angle(from vertical below), γ - angle between blades (between radiuses of adjoining blades); h - height of fuel layer falling. This height is limitated by angle β of natural slope, when whole fuel is failed.

The task is to determine the surface of falling from blade flow, it equals twice height "h" of flow, and new surface "m", when fuel bulk is turning in cell between blades:

$$S=2hn_1k' + mn_2k$$

where n_1 - quantity of cells (blades), from its fuel is falling; n_2 - quantity of cells (blades), where fuel bulk is rotaring; let us accept:

$$n_1 = n_2 = n360°(90°+ \beta),$$

n - whole quantity od blades; β-angle of natural slope of fuel bulk:

$$90° + \beta = \alpha$$

According to trigonometrically relations: $h= 2\cdot(R-1)(1-\sin\alpha)$

k' - coefficient of regard of various "h" for different blades with various "α”; "k" - item for different cells.

Let us see transverse section of cell between two blades (fig.3) for defining add surface "m":

$a < m < [(H^2 + (a + (b - a) / 2)^2)]^{0.5}$, when $0<\xi<\arcsin(H/(a+b)/2))$

and $[(H^2 + (a + (b - a) / 2)^2)]^{0.5} > m > 1$, when $\arcsin(H/(a+b)/2)) <\xi<0$ for middle meaning: $m = a/\cos\xi$

We have following relations according to geometrical construction on fig.3:
$a = 2\pi(R-l)/n$; $\gamma = 360°/n$; $\alpha'=90°-\alpha$; $\xi = \varepsilon - \alpha + \beta$; $H = l\cos(\gamma/2)$; $b = 2\pi R/n$; $\xi = (90 + \gamma/2)°$

4. Specific surface of reacting.

It is important to know not absolute measure of reacting surface, i.e. surface of contact air/fuel, but the surface suited on unit of quantity of burning fuel bulk:

$$s= S/G \ m^2/kg$$

where G - quantity of fuel in furnace, for two dimension task:

$$G=\rho_1 V n_3 360° k'''(90 + \beta)$$

$$n_3 \approx n_1 \approx n_2, \ V=0.5H(a+b)$$

k''' - discount of cell filling, for down cells is maximum, for α=β equals 0.

Then specific surface of reacting:

$$S=\frac{S}{G}=\frac{2hn_1k'+mn_2k''}{\rho_1 V n_3 360^0 k'''/(90+\beta)}=\frac{8(R-l)(1-\sin\alpha)+2\pi(r-l)k''/(n\cos\varsigma)}{\rho l\cos(\gamma/2)(2\pi(R-l)/n+2\pi R/n)360/(90+\beta)k'''}=\frac{R-l}{\rho l(2R-l)}\frac{n(4(1-\sin\alpha)k'+\pi k''/(n\cos\varsigma)}{\pi\cos(\gamma/2)360^0 k'''/(90+\beta)}$$

If we denote blade relative width as r = 1/R and take finish of strewing of fuel when
$90° + \beta = \alpha$, i.e. $\sin\alpha = \cos\beta$,
$\xi = (90 + \gamma/2)°$, and approximatly
$k' \approx k'' \approx k''' \approx 0.5$ we have for analysis:

$$s=\frac{1-r}{\rho r R(2-r)}\frac{n94(1-\cos\beta)+\pi/(n|\cos\varsigma|)}{\pi\cos(\gamma/2)360^0/(90+\beta)}$$

5. Numerical analysis.

Postulating fact of specific surface of reacting being main characteristic of rotor fuel, we can follow up the influence of various parameters of dimension "s". We shall give real dimensions of some parameters and to calculate function "s".

Table of research parameter dimension

Parameter	Dimension of parameter with constant of other
R,m	0.1; 0,2; 0,3 ,0;5
r	0.1; 0.3; 0.5; 0.7; 0,9
n	2 , 4 ; 6 ; 8 ; 16
β	30 ; 45 ; 60 , 80

It is taken for calculation: $\rho_1 = 1000$ kg/m^3 (for wet wood substance).

Calculation show that "s" decrease with increasing “R" and "r". Strong influence "β” on "s" exists for very little angle natural slope.

Hence, concrete construction of rotor,furnace depend from heat power mainly, i.e. wide sorts of fuel may be burned init.

6. Rotor rotation rate.

If "τ" is time of rotor rotation, when angle "α" changes from 0 to β and ω - angle rotation rate ($\omega=2\pi/T$, T - period of turning), so:
$\omega\tau = 90 + \beta$, or $\omega = (90 + \beta)/\tau$, 1/sec

Mass burning rate is; $k_g = \Delta G/G_0\tau$, where: ΔG - burnt fuel for time "τ"; G_0 - initial fuel mass.

If we have part of burnt fuel for time, when $90° + \beta = \alpha$:

$\lambda = \Delta G/G_0$, then $k_g = \lambda/\tau$, or $\tau = \lambda/k_g$, hence: $\omega = k_g(\beta + 90)/\lambda$

We see that rotation rate increase when burning rate is high, but great rotation rate brings to big part unburnt fuel for one rotation cycle.

7. Conclusion.

This new furnace process allow to create new furnace installations for any bad fuel, for wide using. Now, we prepare project of this furnace. We wait some problems in construction of blades because it is very hot and chinical activity environment But we have aircooled blades and it will help solve the task.

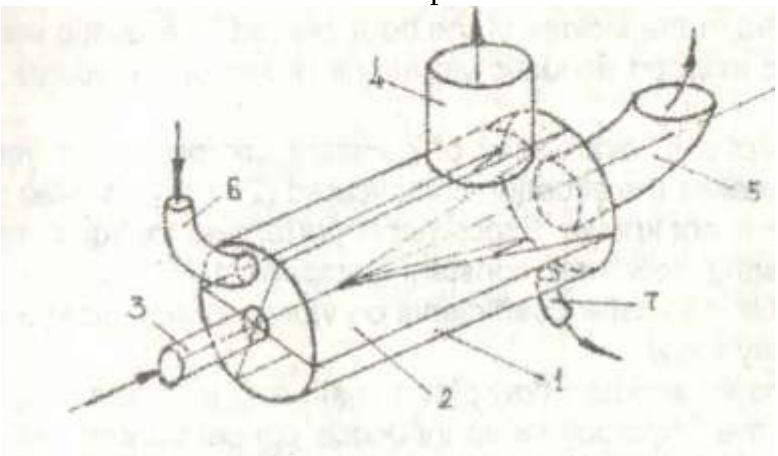

Fig. 1. Constructive scheme of rotor furnace

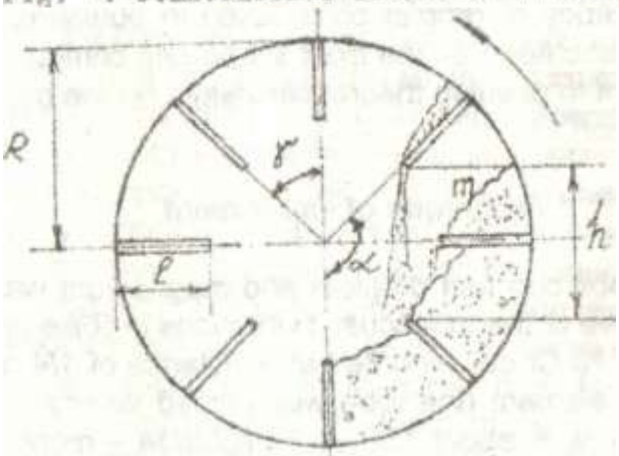

Fig. 2. Calculation scheme

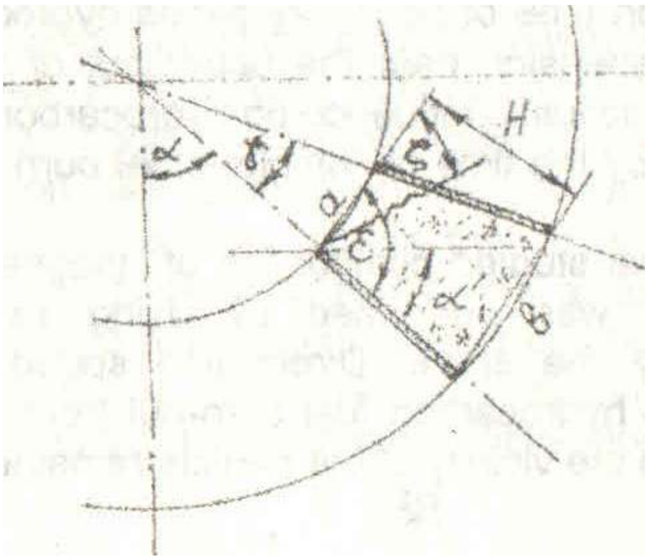

Fig. 3. Parameters of cell