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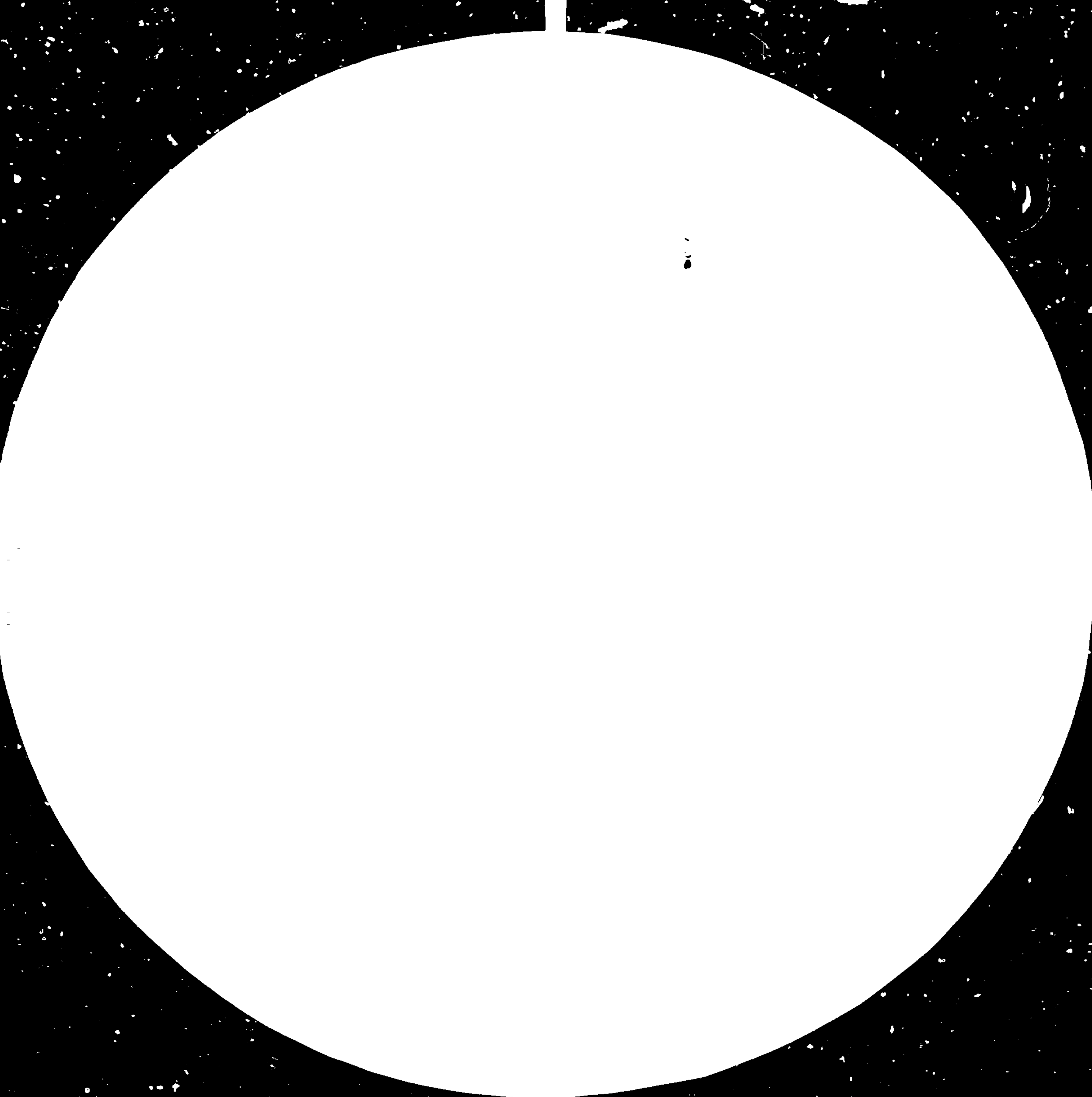

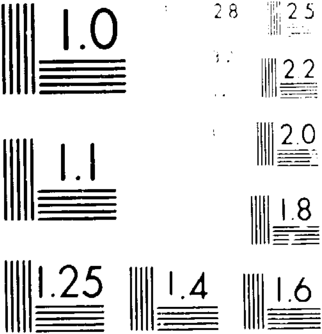
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Distr.
LIMITED

ID/WG.326/6
25 August 1980

ENGLISH
ORIGINAL: CHINESE

United Nations Industrial Development Organization

Interregional Seminar on Cement Technology

Beijing, China, 9 - 24 October 1980

DISCHARGE AND SEALING TECHNIQUE FOR CEMENT SHAFT KILNS *

by

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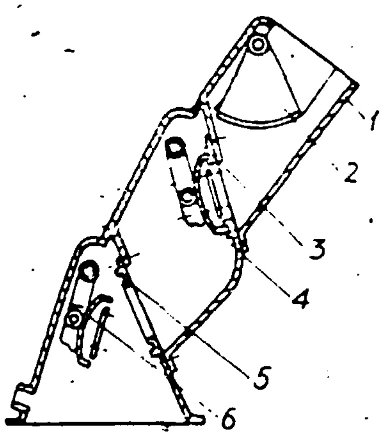
SUMMARY

Based upon the existence of drafting resistance formed by the material-clinker itself and the ratio of the amount of gas passing thru a shaft kiln to the amount of air leaking from the material blocked tube is equal to the square of the diameter ratio of the two, thru experimental research the author has designed a blocked discharger with a small tube as its main part. This sort of discharger as the discharging device of the cement mechanical shaft kiln is low in cost, easy to manufacture and operate, and it has been widely used in this country. In this paper, this discharger is presented in comparision with other types of dischargers, and its working principle and some testing data are given.

I. General Descriptions

The cement clinker discharger of the mechanical shaft kiln functions as both in air blocking and clinker discharging, which ensures that on the one hand, the high pressure air can be blown into the kiln in order to accomplish the burning process effectively and to have little or almost no air escaped from the kiln, and on the other hand, the clinker may be discharged smoothly and continously.

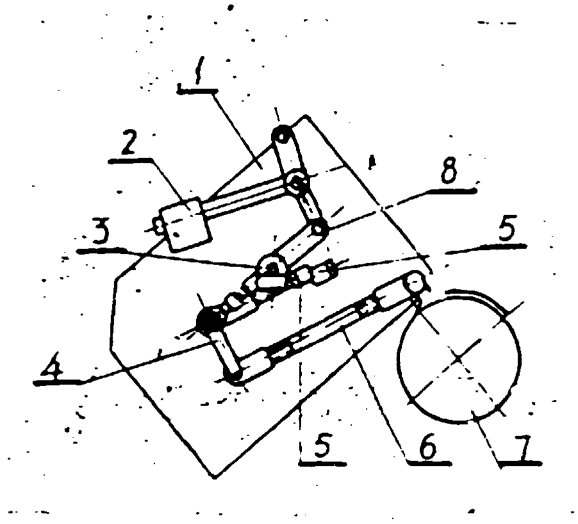
The developing process of the dischargers in China is one from simplicity to complication and then vice versa, while their level has been endlessly enhanced. In 1950's gate type dischargers (Fig. 1) were used in this country according to foreign experiences.



1. Shell
2. 1st stage cut-off orifice
3. Gate frame of 2nd stage
4. Sealing gate of 2nd stage
5. Gate frame of 3rd stage
6. Sealing gate of 3rd stage

Fig. 1 Three stage gate

Since then, many innovations and improvements have been carried out by us. For example, the number of gates has been increased from 3 to 4 or 5. As for the drive device it has been turned from the simple mechanical level type into double self-locking type (Fig. 2), and the hydraulic drive has been further employed (Fig. 3)



1. Shell
2. Weight A
3. Weight B
4. Crack
5. Two Tellied Press Blocks
6. Connecting Rod
7. Rotter Disk
8. Connecting Rod

Fig. 2 Self-locking device

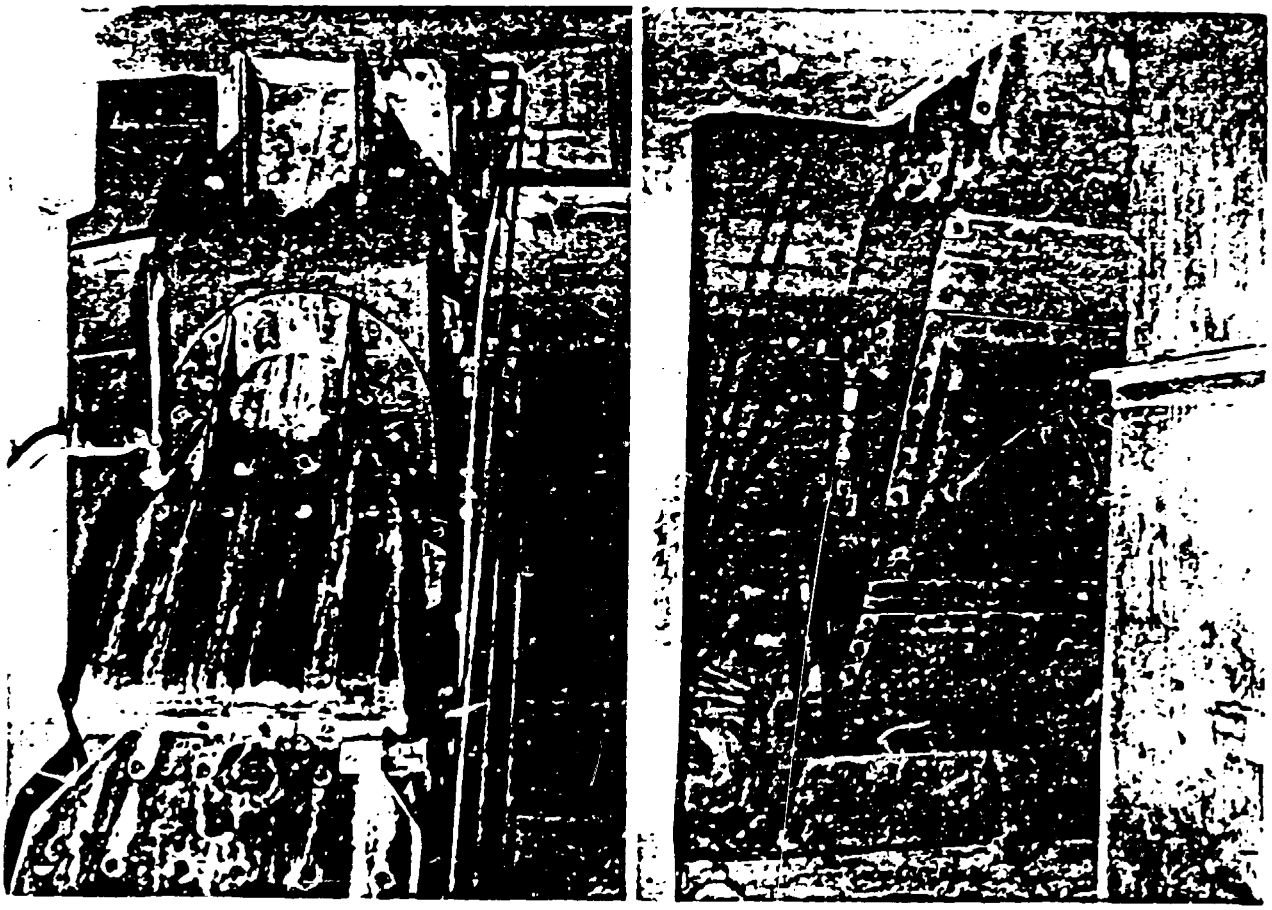


Fig. 3 A photo of three stage gate

Many types of structures for the gate and gate frame have been tried, and the sequence of operation is so designed that the gates are closed after the clinker flow has been intercepted (Fig. 1), with an aim to increasing the effectiveness of the discharger. Much progress has been made in this aspect. This type has been used to raise the suitability of the gate to increasingly highly presureized air into the kiln and to the rapid discharging of the clinker, thus promoting the development of the high production shaft kiln in this country.

For the discharger of gate type, sealing is achieved by means of the gate itself —— a multi-gate structure with intermittently reciprocating movement. As the gate must suit the handling of big lumps of clinker, this has accordingly resulted in big size, heavy weight, and high manufacture precision. The problems of air leaking and requiring frequent regular maintenance are caused by ceaseless abrasion due to the attack of dust carrying air under high pressure. The air leaking conditions are shown in Table 1.

Table 1. Air leakage measured for three stage gate discharger and rotary discharger

Designation of Plant	Discharger type	Measuring date	Air leakage NM^3/min.	Remarks
T	3-gate mechanical drive	1974	45-60	about one month after repair
X	3-gate mechanical drive	1974	30-36	10 days after repair
D	3-gate hydraulically driven	1980	1.8-2.6	two days after repair
R	rotary valve	1972	14	soon after repair

The so-called mini-cement industry in our country refers to a local industry set up by the local authorities' investment, the characteristics of which are its small scale, simple machinery and small amount of investment. As far as the equipment, management and operation are concerned, the conditions vary from plant to plant, but, on the whole, nearly all the plants develop along the same path of from-low-to high.

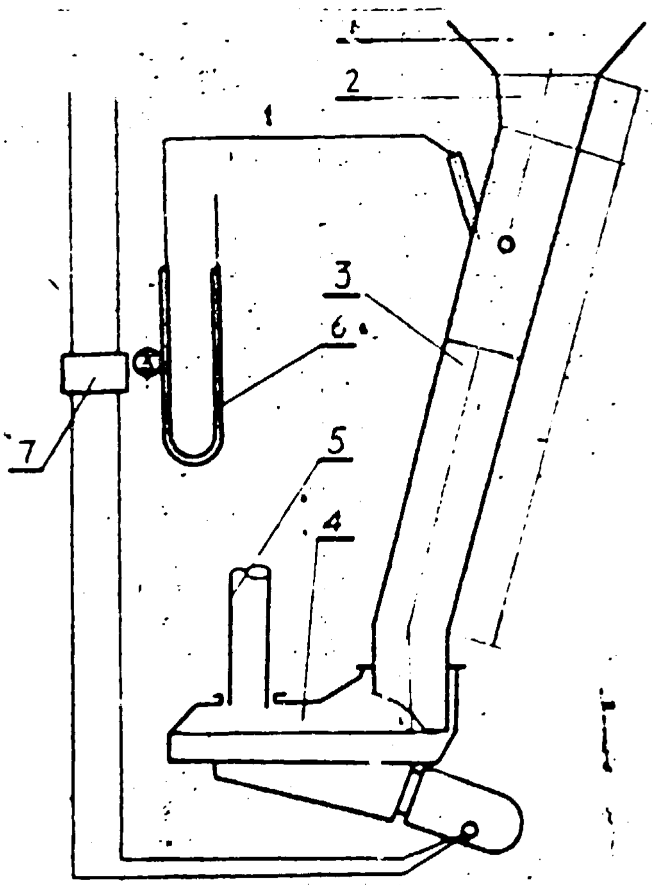
The over all dimensions of a 3-stage hydraulically drive gate are 3,300 x 2,800 x 1,400 mm and such a gate weighs 6,500 kg in total. The manufacture of such a equipment requires heavy duty machines. These of course cannot be widely used in our mini-cement industry.

Consequently, the personnel of our mini-cement industry have tried to seek better ways of discharging clinker from the kiln. The bell and counterweight type discharger and rotary type dischager have thus been developed accordingly. However, neither of them has received further development, as the air-locking effect is not satisfactory with the former and with the later big lumps of clinker cannot be discharged effectively, meanwhile its abrasion is rather severe.

From 1965-67, according to the theoretical analysis and inference based on our production experiences and also with reference to the information from abroad, we have adapted a tube filled fully with clinker (known as material blocking tube) and the tube can play the role of a discharger both in blocking and discharging clinker from the kiln. If the draught resistance per unit area of a small diameter material blocking tube is equal to that inside the kiln, the ratio of its air leakage to the amount of air passing thru the kiln must be equal to the second power of the ratio of their diameter, i.e. $Q_b:Q_k = D_b^2:D_k^2$. When $D_k:D_b = 1:1/10$, $Q_k:Q_b = 1:1/100$. Hence, it may be seen, the air blocking efficiency of the M.B.T is quite appreciable. For a shaft kiln 2.5 m in diameter a Ø250 mm M.B.T. is quite enough for its discharging capacity. If the tube is installed vertically, the control over discharge may be realized by a vibrating chute. And when the tube is installed horizontally, it may be realized by a vibrating M.B.T.. They are known as vertical discharger and horizontal M.B. discharger, respectively as shown in Fig. 4 and Fig. 5. Through the experimental investigations and the production practice in a number of plants carried out over the past ten years or so, great achievement has been made. Table 2 gives the air leaking conditions for M.B.T., and the pros and cons as compared with other dischargers are listed in Table 3.

Table 2 Air-leakage measured for material blocking discharger

Designation of plant	Material blocking tube type	Height of material column m	Air leaking pressure mm H_2O	Air leakage Nm^3/min	Remarks
Q	vertical	2-3	1500	5-16	
X	vertical	2-3	2000-3000	4-8	
T	vertical	2-3	1500-2000	10-20	
H	vertical	1.8-2.2	450-520	1.[illegible]3-1.76	
Ta 1st.	/	5	-1100	12.6-13.75	model test
Ta 2nd.	/	5	1350	5.76	model test



1. Discharge hopper
2. T. Reducer
3. M.B.T.
4. Vibrating throttle
5. Dusting pipe
6. U-pressure differential indicator
7. Auto-control switch

Fig. 4 Vertical M.B. Discharger

Table 3 Comparison of three dischargers

Description	Three-stage gate	Rotary valve	M.B.D.	
			vertical	horizontal
Weight, kg	6500	2500	800-1200	1850-2000
Price, 10,000 Yuan	5-8	1-2	0.2-0.5	0.3-0.8
Manufacture	complicated	comparatively difficult	Easy	not difficult
wear	Severe	Fast	Light	not severe
Maintenance	3-6 months	20-30 days	2 years	½ year
Motor k.w.	2.8	4.5-7.0	0.35-0.5	5.5
Air leakage* Nm^3/min	plant T 45-60 in 1974 Plant X 30-36 in 1974 Plant D 1.8-2.6 in 1980	Plant R 14	1.2-20	-3

* See also Tables 1 and 2.

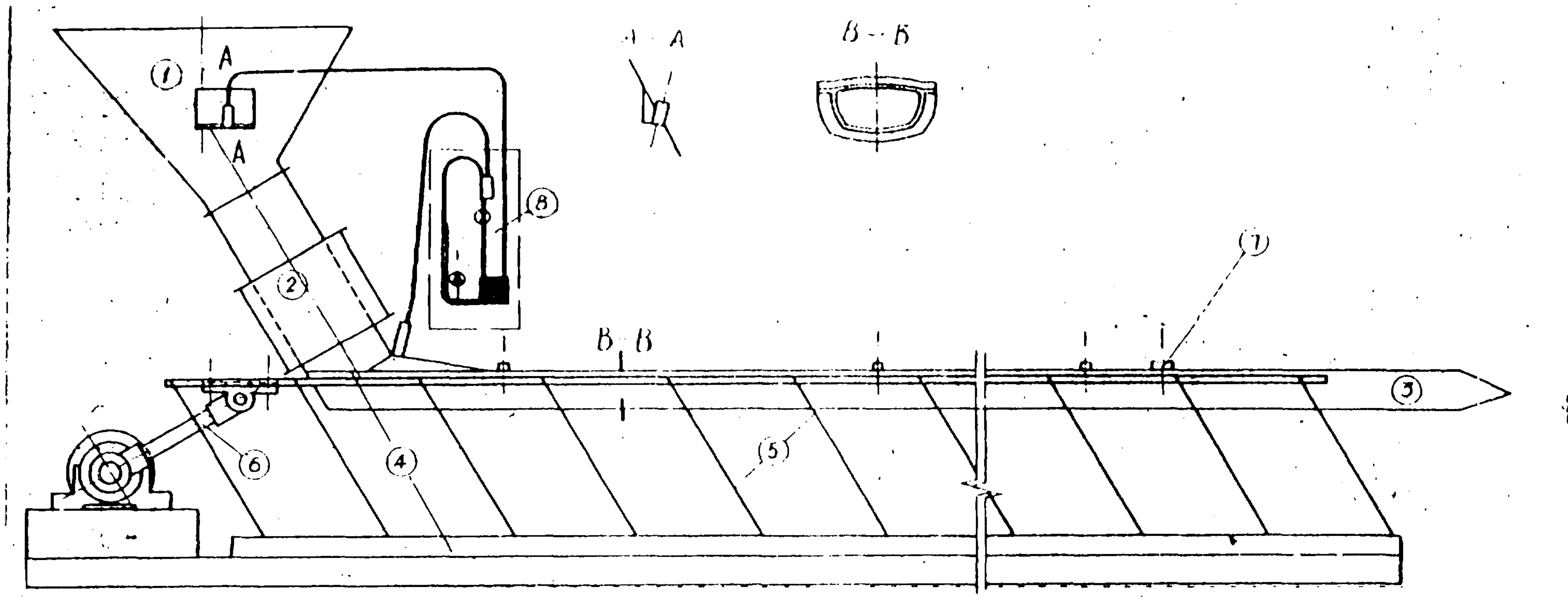
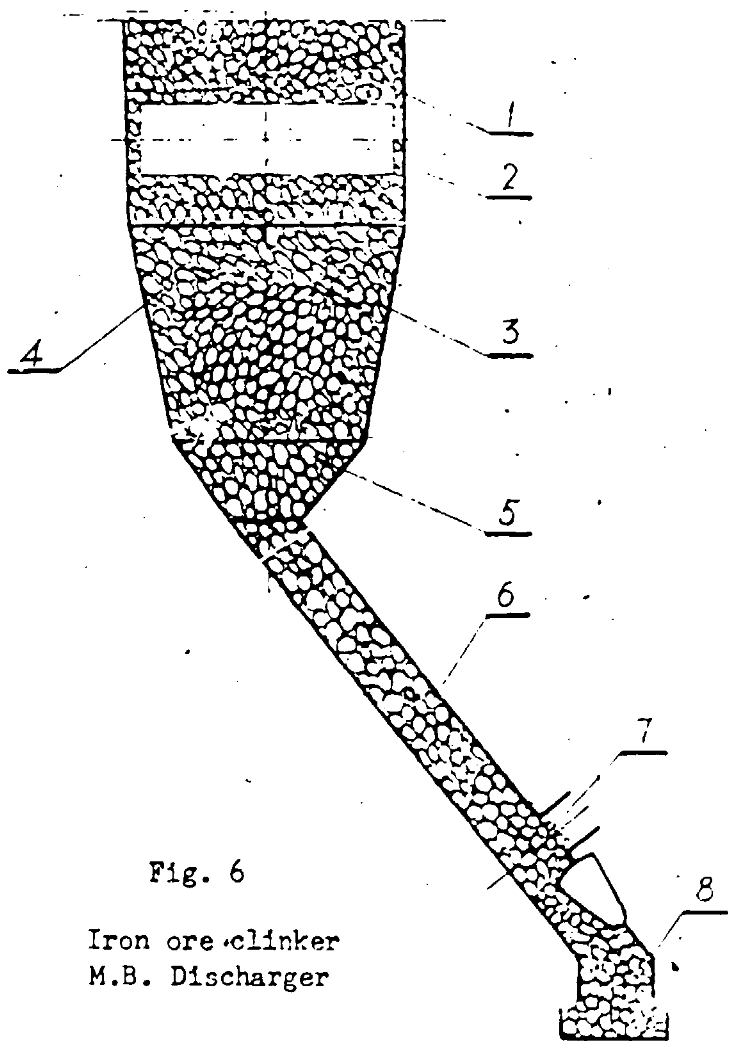


Fig. 5 H Horizontal M.B. Discharger

1. T. Reducer
2. Flexible connection
3. Vibrating M.B.T.
4. Frame
5. Spring system
6. Driving system
7. Dusting system
8. Auto-control system

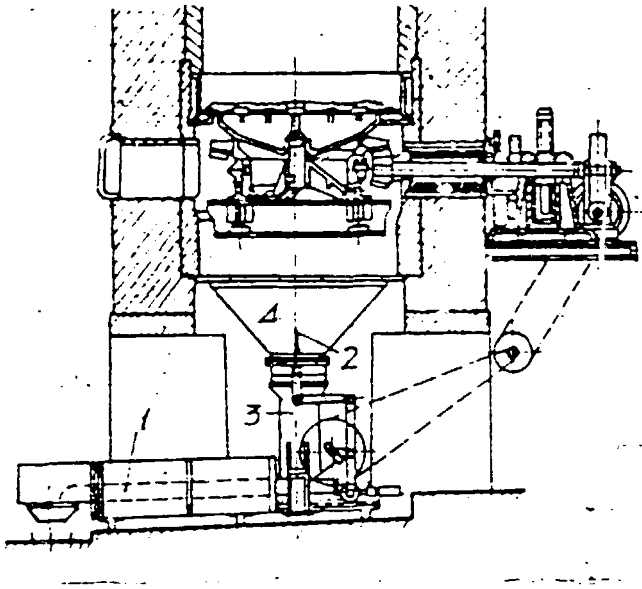
The concept of making use of the air resistance capacity from the bulk material (i.e. broke up and dispersed materials) itself, i.e. "air locking-material blocking", has long been applied in industries, but mostly applied to powder materials. In the later half of 1960's, it was also used for granular materials in China's metallurgical industry (Fig. 6). The diameter of such M.B.T. is rather big, the ratio of tube diameter to the grain size of material is $D_b : d = 12 \circ 14$. In the middle of 1970' it was also reported in foreign literature that the clinker cooler from the rotary kiln was material-blocked which belongs to the granular materials blocking technique. A material blocking discharger which was used in the early stage for cement mechanical shaft kilns is described in a book from USSR (KILNS IN CEMENT INDUSTRY, BOOK I)(Fig. 6).



1. Shaft kiln
2. 8 roller discharge grate
3. Discharging hopper
4. Conc. iron ore clinker
5. T. Reducer
6. M.B.T.
7. Dusting tube
8. Apran conv. throttle

Fig. 6

Iron ore clinker M.B. Discharger



1. Vibrating conv. throttle
2. Material control plate
3. M.B.T.
4. Hopper

Fig. 7 M.B.T. in the early stage

This discharger was merely applied to suit the technical conditions at that time. In order to reduce the problem of material bridging and lodging, M.B.T.'s with big diameter and big cross section were used, resulting in large amount of air leakage (25% estimated). Such a M.B.T. could only be used for the shaft kiln with air pressure up to 300-400 mmH_2O, and would not suit the modern shaft kilns with high air pressure. On the basis of experimental investigations and practical experiences we have summarised the air blocking principle of M.B.T. and the reasons for the bulk materials passing thru M.B.T. with small diameter, thus realizing the "Blocking Technique of Small Diameter Tube with Material Blocks".

II. Working Principle

The description is to be divided into four parts: air blocking principle, discharging principle, movement of the material within the M.B.T. and movement of the material in the vibrating throttle.

2.1 Air blocking principle

The air blocking function of M.B.T can be expressed in terms of air leakage. The flow of air travelling thru M.B.T. and leaking pressure are represented by the following equations:

$$Q_b = A_b \cdot V_b = 0.785\, D_b^2\, V_b \quad \ldots\ldots (1)$$

$$P_b = \mu \frac{V_b^2}{2\,g} \cdot \frac{h_b}{d} \cdot \frac{\gamma_b}{\rho^2} \quad \ldots\ldots (2)$$

$$V_b = \sqrt{\frac{2gd\rho^2 P_b}{\mu\, h_b \gamma_b}} \quad \ldots\ldots (3)$$

where: Q_b = air flow escaped from M.B.T., i.e. air leakage;

P_b = pressure of air leakage;

V_b = virtual air velocity in M.B.T. (empty tube);

D_b = inside diameter of M.B.T.;

μ = resistance coefficient of material column;

g = acceleration of gravity;

h_b = height of material column;

d = mean grain size of clinker;

γ_b = volumetric weight of the leaking air from M.B.T.

ρ = porosity of the material column.

2.1.1 Relationship between air leakage and the diameter and height of the material blocking column.

It can be seen from the above equations that resistance coefficient μ remains constant if the clinker size d and porosity ρ keep unchanged. Under such conditions if P_b, h_b, γ_b remain unchanged, V_b will also do so. $Q_b \propto D_b^2$, as shown in Fig. 8 .

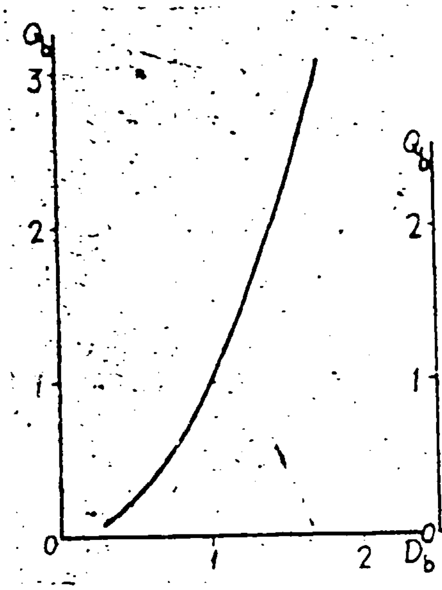


Fig. 8

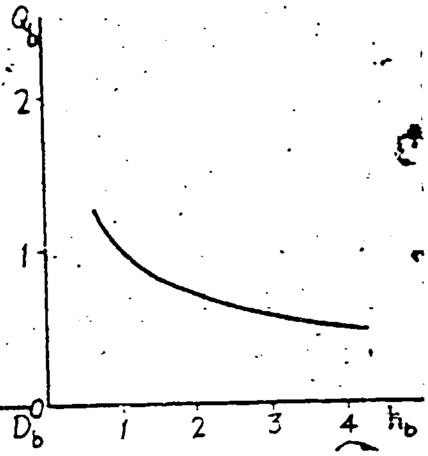


Fig. 9

That is to say, the air leakage will increase by 125% if the diameter increases by 50%. And the leaking will reduce by 75% if the diameter decreases by 50%. Then if $P_b . D_b . \gamma_b$ remain unchange, V_b varies inversely with $\sqrt{h_b}$, and $Q_b \propto 1/\sqrt{h_b}$, as shown in Fig. 9. This means when the material blocking column prolongs its height by 50%, the air leakage will be reduced by 19%. And if the column height is cut down by 50%, leaking is increased by 14%. Hence, we know the effect on air leaking of the variation in the diameter of M.B.T. is much greater than the variation in column height, and this is why much better results in air blocking are obtained with small tubes.

2.1.2 Resistance function of the material blocking column

From equation (2) we have:

$$\frac{\mu}{d\rho^2} = \frac{2\,g\,P_b}{V_b^2 h h_b \gamma_b} \quad \ldots\ldots (4)$$

According to the production records and the experiment measurements the air leaking pressure for the vertical material blocking discharger is normally between 1000–3000 mm H_2O, γ_b = 1.0–1.2. The value of V_b and h_b is comparatively small. Therefore, on the right hand side of the equation the numberator is rather big and denominator is rather small, consequently $\frac{\mu}{d\rho^2}$ must be relatively big. This is due to the resistance of irregular pores naturally formed among the clinker particles in the blocking column. And we call it the Labyrinthic (or winding) resistance function of the material blocking column.

The air blocking resistance function of M.B. column increases with the decrease of clinker size and porosity. It has been found in production practice that a mechanical shaft kiln with a new discharging grate produces smaller particles of clinker, which gives better effect of air blocking resistance, and the particle becomes bigger giving a rather poor effect as the discharging grate is worn out. For instance, the air leaking for new kiln #3 (producing small particles of clinker) equipped with a big diameter of M.B.T. in a certain cement plant was less than that for old kiln #2 (producing big particles of clinker) with small diameter of M.B.T.

The conditions of the clinker falling into the M.B.T. vary with the inclinations of the M.B.T. and affect the porosity of the material column appreciably, making the Labyrinthic resistance vary prominently. The same model with the same column height was used in two different experiments, but the tube was installed in two different inclinations, giving different results as shown in Fig. 10.

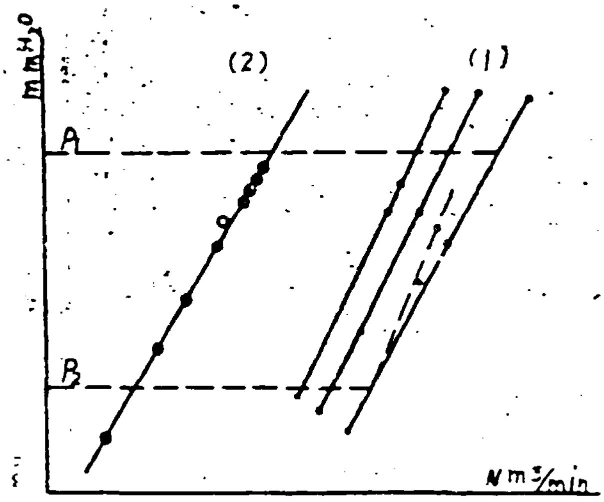


Fig. 10

In the first experiment the model M.B.T. was inclined at 45°, clinker filling rate being 62.4%. In the second one the tube was inclined at 65°, the rate being 37.8%. The two experiments can be summarized with equations (5) and (6):

$$P_b = 8\ V_b^{2} \qquad .....(5)$$

$$P_b = 80\ V_b^{1.62} \qquad .....(6)$$

It is seen from Fig. 10 or equations (5) and (6) that under the same air leaking pressure P_{b1} or P_{b2} the following relationship exists:

$$Q_{b1} : Q_{b2} \doteq 2.1 - 3.1 \text{ or } 2.2 - 3.2$$

This shows that the size of clinker particles and tube inclination have a great infleunce on the average porosity, making the effecive-ness of the material column height vary by as much as $\sqrt{5}$ - $\sqrt{10}$ times.

Besides there are other factors affecting its velocity and amount, such as the temperature of the leaking air etc., which would not be discussed here in detail.

Among these factors, the composition of size and the clinker temperature, etc., depend mainly on the production operation, and may not be readily changed at will. However, the length, diameter and inclination of the M.B.T. are determined in design, manufacture and erection and they must be guaranteed by management and maintenance.

Therefore, the air blocking ability of M.B.T. is mainly determined by the diameter and inclination of M.B.T. as well as the cross section and density of the material column.

2.2 Principle of discharging

As described above the material blocking discharger of a modern shaft kiln is characterized by the samll diameter of M.B.T. and its ability allowing the lumpy material to be discharged. The discharging grate area of a mechanical shaft kiln is rather big as compared with the cross sectional area of the M.B.T. (which is small). There is bound to be a question of transition from the big grate area to the small tube area. How can the clinker with a certain particle size pass thru the transitional reducer and flow into the M.B.T. uniterruptedly with a small diameter? This is something worthy exploring.

2.2.1 Falling dispersedly, clinker does not store in the transitional reducer

The necessary and sufficient conditions for the clinker to pass thru the transitional reducer freely and to get into the M.B.T. are that the size of clinker lumps must be smaller than the tube diameter (or approach the diameter as a limit) and the lumps of clinker remain in a dispersedly falling state.

The maximum average output for a Ø2.5 m modern cement shaft kiln is 11 t/hr. If the unsteadiness of the discharging rate from the kiln is considered and the unsteadiness factor is taken 3, the maximum discharging rate will be 33 t/hr. or 9.2 kg/s. The throttle of the material blocking discharger turns out 50 t/hr, which is much more than the discharging capacity of the kiln. This shows it is certainly possible for the falling clinker to keep dispersed in the transitional reducer. As for the balance between the actual discharge from the kiln and the discharging capacity of the throttle it may automatically be controlled, in order to guarantee the material column in the M.B.T. to have the required level.

If the largest lump size of the clinker discharged from the kiln is 130x110x60 mm, its weight will be about 1.5 kg. A discharging rate of 9.2 kg/s comprises roughly 6 pieces of clinker, and averagely one falling lump in every 1/6 second. The falling clinker acts, as a free falling body shortly after leaving the kiln grate. The falling height is given by the equation $S = 1/2\ gt^2$, where t= time taken by the falling body in seconds. Therefore, as long as there is time difference among the falling clinker lumps, there must be a corresponding height difference. And the height difference will increase as the time prolongs. If two pieces of clinker fall down one after another and their lengths of falling time are t_1 and t_2 respectively, the distance between them must be $S_1 - S_2 = 1/2\ g\ (t_1^2 - t_2^2) = 1/2\ g\ (t_1+t_2) \times (t_1-t_2)$ ..... (7) $t_1 > t_2$, $S_1 - S_2 > 0$. After t seconds, the distance will become

$$S_1' - S_2' = 1/2\ g\ (t_1 + t_2 + 2t)\ (t_1 - t_2) \quad ..... (8)$$

$$\because t_1 + t_2 + 2t > t_1 + t_2, \quad \therefore S_1' - S_2' > S_1 - S_2 \text{ Q.E.D.}$$

After falling down for a certain duration of time, the clinker particles will touch the bottom plate of the transitional reducer and then bounce or slide. As the inclination angle of the bottom plate is usually much greater than the internal friction angle between clinker and plate and also greater than 45°, the bouncing or sliding is an accelerated motion (Fig. 11). When several pieces of clinker particle take part in such a motion the same rule — as long as there are time differences when clinker particles fall, there must be corresponding height differences — will hold.

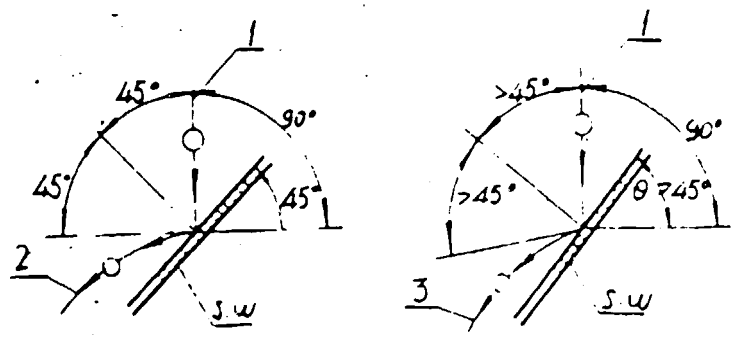


Fig. 11

This shows that as long as no clinker is stored in the transitional reducer, there is a theoretical basis for the dispersed falling of the clinker off the discharging grate of shaft kiln to take place.

Under the action of the discharging grate, normally the clinker falls one piece after another and it rarely happens that two pieces of clinker fall simultaneously. Thru constant observations in the actual production, even including the case when the M.B.T. has been intentionally removed (leaving only a stump on the top for a better observation), no such phenomena have been observed. This indicates that there is also a practical back-ground for the dispersed falling of the clinker off the discharging grate of the shaft kiln to take place.

The probability that several lumps of clinker fall to the top of M.B.T. simultaneously is very rare.

In most cases the clinker lumps do not leave the grate at the same instant. Starting from this factual condition, we present the theory of "dispersed falling of clinker," which requires that no clinker are stored in the transitional reducer and the clinker lumps pass dispersedly thru the reducer. There are the necessary and sufficient conditions for the clinker not to be bridged in the reducer.

We have also analysed the imaginary case of two big lumps of clinker falling exactly at the same instant. If two big lumps fall together they might be in a various arrangements. Imagine that the two lumps fall in parallel in the form of a horizantal strip. They will have a maximum area of projection on a horizontal plane (Fig. 12). But if one of the two lumps is hindered (irrespective of whichever

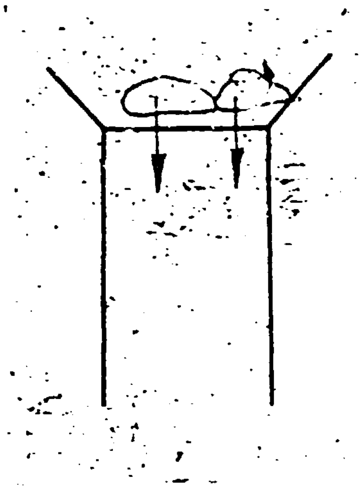


Fig. 12

point on the clinker lump) they will becomes one in veritcal position and the other in horizontal position, or one after the other. Therefore, in order to solve this specail case of two lumps falling together, the M.B.T. may be designed according to the following expression:

$$Db = k\bar{d} \quad ..... \quad (9)$$

where: $\bar{d}$ = size of the special big lump of clinker i.e. arithmetical mean of its three dimensions: length, width and height;

k = coefficient depending on the frequency of occurence of big lumps.

It is extremely rare for three or four lumps of clinker to fall together. It is also scarcely possible for several falling lumps to lodge in the reducer without a specail arrangement. No consideration is thus needed here.

2.2.2 Conditions for the clinker to densely pass thru transitional reducer

If a shaft kiln discharger at an extremely high rate in a short period with an unsteadiness factor much greater than 3, the mean particle size of the clinker discharged from the kiln must be rather small, and under such conditions the clinker may build up in the reducer, and pass in a dense state. We have observed over many years in practice that the clinker will freely pass through the reducer as long as the percentage of exceptionally large lumps does not exceed 5% and that of ordinary big pieces does not exceed 40%. The big lumps, as their proportion is small, are separated by small particles. Therefore, they still pass thru individually.

If the discharging rate from the kiln in a short period is not extremely high, yet with an unsteadiness factor still somewhat exceeding 3, say 5 or 6 and the lump size of the clinker discharged from the kiln is not too small, then it is possible for the clinker to build up in the reducer, and the clinker will lower down in a dense state. Now so long as the above mentioned percentages for the big lumps of clinker are still maintained at 5% and 40%, clinker bridging may still not occur. And of course if the said percentages are exceeded bridging may then take place. However, we have found in production practice over a long period that the transitional reducer (Fig. 13) with three ablique surfaces (a) and the small tapering reducer (b) may assist the clinker to flow in a dense state and reduce the possibility of bridging. This is because these types of reducers have a comparatively small resistance, and the unsteadiness factor is not considerably exceeded and not so much clinker is maintained in the reducer under a small pressure. This problem can also be solved by increasing the capacity of the throttle, but other unfavourable factors will be brought about.

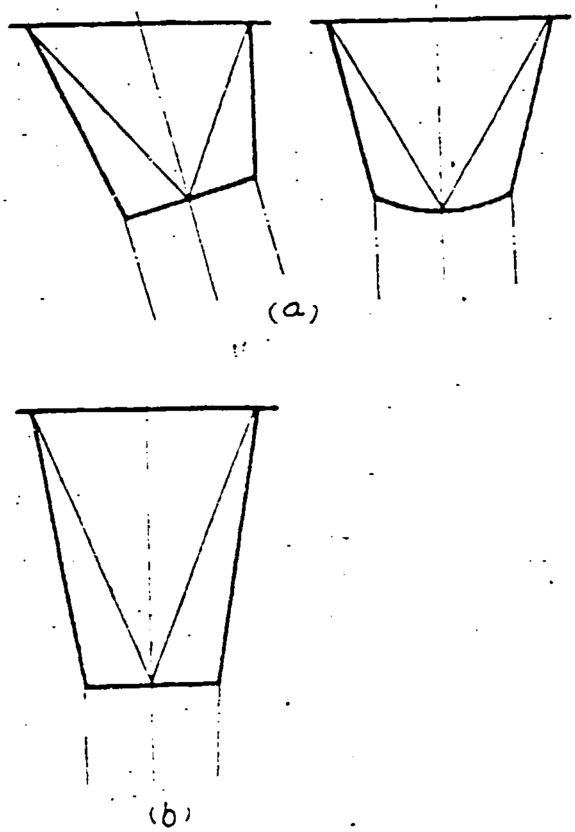


Fig. 13 The construction of two kinds of reducer

2.2.3 Conditions for the clinker column to pass thru the M.B.T. with small diameter

The conditions for the dense clinker column to pass thru a small diameter of M.B.T. normally are that the diameter of the tube remains constant without variation, and the tube is straight without bends, and absence of such hindrances as spots, pits and projections on the inner wall of the tube. The column may also pass thru an enlarged tube and a downward bend. It is not necessary to provide an enlarged tube as it is unfavourable to air blocking; the downward bend is not recommended unless really needed as it would add to the frictional force of the inside of the tube.

2.3 Movement of the clinker in the M.B.T.

The clinker discharged from the kiln is bulk material has both fluidity and internal frictional force.

Thru abserving a transparent model of the vertical M.B.T. and carefully listening to the noise inside the tube we have found that the movement of the clinker column in the tube is of a pulsatory character and not like a plug falling uniformly. As shown in Fig. 14, the material in the lower portion of the column is activated by the vibration of the arrow head. Where as the material in the top or middle portion may instantaneously be suspended and cavities A could be formed.

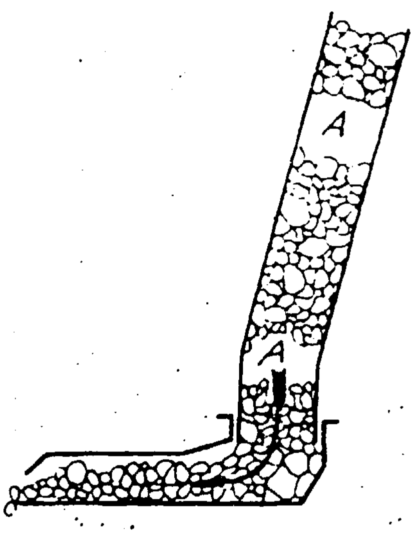


Fig. 14

The movement of the materials in the vertical M.B.T.

The suspended material may fall down little by little or cave in, making the cavities enlarged, displaced or disappear. Such phenomena appear alternately and the cavities may be big or small, and numerous or few. The process of the cavities forming, increasing, displacing and disappearing and their ceaseless alternation is the law of material column movement in the M.B.T., and this is also the process for the clinker in the column to be bridged and collapsed alternatively.

The motive of pulsation is the sliding force downward and the frictional resistance on the tube wall and between the clinker grains. The material column will not move if it has no sliding force. If there is no or little friction on the tube wall, the column will fall down as a whole and no pulsation will arise. The internal friction within the column varies considerably with the density and arrangement of the bulk clinker. This is why the clinker above the cavity is instantaneously suspended, forming a pulse.

The sliding force increases as the inclination of the M.B.T. increases and the friction of the tube wall decreases. Therefore, in order to increase the sliding force, reduce the frictional resistance of the tube wall, accelerate the pulse, and diminish the cavity and raise the air blocking ability, the inclination of the M.B.T., should be set at 90 or near to 90.

Clinker segregation may arise in the M.B.T. and it is particularly evident when the tube stops discharging. This is caused by gravity and the blowing force. And the small particles, granulars and powdered clinker will move downward passing thru the pores between the big lumps of clinker, resulting in the variation of the physical properties (i.e. porosity, volumetric weight, ray-absorbing ability, dielectric constant, etc.) in various parts of the column. Such variation depends on the height of the column and its pulse. The variation is more marked when the discharge is restarted from a halt. Frequent sudden changes will be observed if an automatic differential pressure indicator is employed. Attention should be paid when an automatic control is to be designed for material blocking.

Such phenomena of segregation will bring about even more unfavourable results when big lumps are hindered. That is to say, small lumps will go forward while big lumps are jammed and the big lumps behind tend to push forward and accumulate, causing the big lumps to build up. The percentage of big lumps in the column is thereby increase, and there is a possibility for the clinker to bridge at the place where hindrance occurs. Consequently, it should be assured that any spots with notable frictional resistance likely to hinder the big lump to flow freely or other hindrances should be avoided in the design, manufacture and maintenance of the M.B.T.

2.4 The pushing force of the moving material in the vibrating throttle

In this country a vibrating trough is used in most cases as the throttle (known as the vibrating throttle) for the vertical M.B. discharger. In the vibrating throttle there are two pushing forces on the moving materials: (1) pushing force from vibration and (2) natural (gravitational) sliding force of the clinker. The magnitude of the vibrating force varies with the amplitude. The magnitude of the sliding force of the clinker depends upon the surface slope of the clinker. When the slope is greater than the internal friction angle, the clinker will slide down by gravity even without the pushing force from vibration. As the internal friction angle varies with the grain compostion of clinker, in order to increase the function of the throttle, efforts should be made to reduce the sliding angle of the clinker in the throttle as much as possible, so as to increase throttling performance of the pushing force from the vibration.

III. Conclusion

The air blocking effect of the M.B.T. discharger is noticeable, and its air leakage has been practically reduced to 2-3% of the air blown into the kiln. This is mainly due to the Labyrinthic effect of the clinker column and the small cross section of the M.B.T..

Conditions for the clinker particles to freely pass thru the M.B.T. with small diameter are as follows:

When they pass thru the transitional reducer the maximum size of clinker lump must be less than the diameter of the tube and the falling clinker must be in a dispersed state. When there are not many big pieces of clinker (which are smaller than the tube diameter) and they are in a state of being separated by small pieces of clinker the clinker may still densely pass thru the transitional reducer.

The major advantages of the M.B. discharger are the structural simplicity, requring less steel, light weight, low cost, easy maintenance, slight air leakage (rather concentrated, if any) and ease in dusting. The M.B. discharger may save 95-97% of cost as compared with three stage gate dischargers. In the case of a Ø2.5 m mechanical shaft kiln with a spohn grate, origninally equipped with a three stage gate discharger, one third of the initial cost may be saved if the discharger is converted into M.B. discharger.

As the installation of the M.B. discharger is extremely simple, has prominent advantages as listed above and is easy to popularize, it has promoted the development of the mini-cement industry in this country, helped to mechanize the common shaft kiln and to simplify the conventional mechanical shaft kiln. No doubt, its applications will be further developed and enlarged.

For further development of the vertical M.B. discharging technique, the following points are suggested:

The M.B.T. to be used should be as small as possible in diameter to reduce the air leakage;

Big inclination i.e. nearly perpendicular to the ground level, is to be applied in order to put the clinker column into effective play;

To assure the stability of the material level in the M.B.T. and the free flowing of the clinker, a sensible and reliable automatic control system should be introduced.

Further more, as the M.B. discharger is indeed very simple, it might be overlooked and misunderstood and not regarded as a key part of the mechanical shaft kiln. If it is not properly dealt with in design, manufacture, erection, operation and maintenance and repair, its performance will be certainly affected. Thus advantages may become disadvantages, and this of course must be avoided.