72

asbestos-cement manufacturing technology

72

PLAINTIFF'S EXHIBIT

CT-1456

the conditions of operation of the sieve cylinders

based on work by Dr. I. I. Berney — part IX

The conditions of operation of the sieves.

The conditions of operation of asbestos-cement manufacturing machines are far from being standardised. The concentration of the suspension in the vats remains the responsibility of the technicians of the plant and much depends on the human factor and skills. As a result of this situation, even if the raw materials are kept standard, the production of the machines and the quality of the manufactured product vary considerably from case to case. Such a situation can be explained by two reasons:

1. the absence of a technological control of the properties of the raw materials currently supplied to the various factories and this is due in many cases to the ignorance of both the seller and the buyer.
2. the lack of knowledge of the existing relation between the conditions of operation of the sieve cylinders and the quality of the manufactured product.

On the basis of the investigations already carried out, the following recommendations can be made:

1. *Determination of the technological properties of asbestos and of cement.* In view of the fact that the properties of asbestos and the properties of cement, when considered separately, cannot fully characterise the quality of asbestos-cement, it becomes necessary when determining the properties of asbestos-cement to investigate asbestos-cement samples; these samples may be prepared in the laboratory and a useful piece of equipment for the preparation of such samples can be the Special Filter described in AC/M No. 7/8 - 1968. Preparation of samples must simulate as nearly as possible, actual manufacturing conditions. The Special Filter may also be used for determing the filtration characteristics (k_o and V_0^2) of the suspension.
2. On the basis of the previously established fact that the rate of filtration is the main factor in regard to conditions of operation of the sieve cylinders, influencing the quality of the manufactured product, it became necessary to clearly specify this factor. On the strength of the conducted investigations, a specific rate of filtration of approximately 0.240 cm/sec, could be recommended.
   The establishment of a specific rate of filtration, will secure the most advantageous conditions of operation of the machines as for instance with the improvement of the filtration properties of the raw materials, the concentration of the suspension can be considerably increased in the vats; in doing this, it has already been demonstrated that the rate of filtration will not change and the physical mechanical properties of the manufactured product will not change either. On the other hand, the output of the machine will be increased in relation to the increase of the concentration. When the rate of filtration is established, it becomes possible to calculate basically the conditions of operation of the machine which depend on concentration and thickness of the elementary layer and subsequently make specific recommendations; *such recommendations cannot however be standardised and will differ in each case depending on the results of the investigation of the raw materials, in the laboratory.*

The method of calculation is given hereafter, illustrated with examples:

Example No. 1.

Calculate the conditions of operation of an asbestos-cement sheet forming machine which has 3 sieve cylinders of 1000 mm. diameter each, and a felt speed of 32 metres/minute.

73 73

Investigation of raw materials in the laboratory has given the following data: $k\phi = 300\ (cm/gm)^{1.5}$; $V_0^2 = 0.4\ cm^2$; temperature of suspension 30° C; calculated rate of filtration 0.240 cm/sec.

By means of graph in fig. 37, the concentration of the suspension in the center cylinder can be determined to correspond to a rate of filtration of 0.240 cm/sec. With $k\phi$ equal to 300, the concentration of the suspension in the center cylinder will be 0.086 gm/cm³ or 8.6%. With the felt speed being 32 metres/minute, the concentration in the last vat can be 0.07 gm/cm³ or 7%.

As the concentration in the last vat is lower than that of the center vat, then in the first vat it must be increased to approximately such an extent that the average of the three is approximately 8.6%. On this assumption, the concentration in the first vat should be brought to 9.6%.

The thickness of the layer delivered by each of the three cylinders can be calculated by using equation (3-22) and substituting V for $U\phi t$ (average rate of filtration), which has an equivalent value.

$$\delta a\phi = \frac{0.83a}{\gamma a\phi} U\phi t$$

Substituting t for 3.34 secs and $\gamma a\phi$ for 1.5, $U\phi$ can be found from graph fig. 37 in accordance with the established concentration of the suspension and $k\phi = 300$. The calculation will give:

For the first cylinder:
a=0.096 gm/cm³; $U\phi$=0.228 cm/sec; $\delta a\phi$=0.040 cm.

For the second cylinder:
a=0.086 gm/cm³; $U\phi$=0.240 cm/sec; $\delta a\phi$=0.038 cm.

For the third cylinder:
a=0.070 gm/cm³; $U\phi$=0.261 cm/sec; $\delta a\phi$=0.034 cm.

The total thickness of the yielded layer from the three sieve cylinders will therefore be 0.112 cm.

The average rate of filtration is the rate of filtration corresponding to each cylinder times the thickness of the layer delivered by the corresponding cylinder. divided by the total thickness of the layer; in our case;

$$\frac{(0.228 \times 0.040) + (0.240 \times 0.038) + (0.261 \times 0.034)}{0.112} =$$
$$= 0.242 \text{ cm/sec.}$$

Under the above conditions the output of the machine would be:

$P = 4.76\ \delta a\phi u_c B_c = 4.76 \times 0.112 \times 53.4 \times 170 = 4840.$

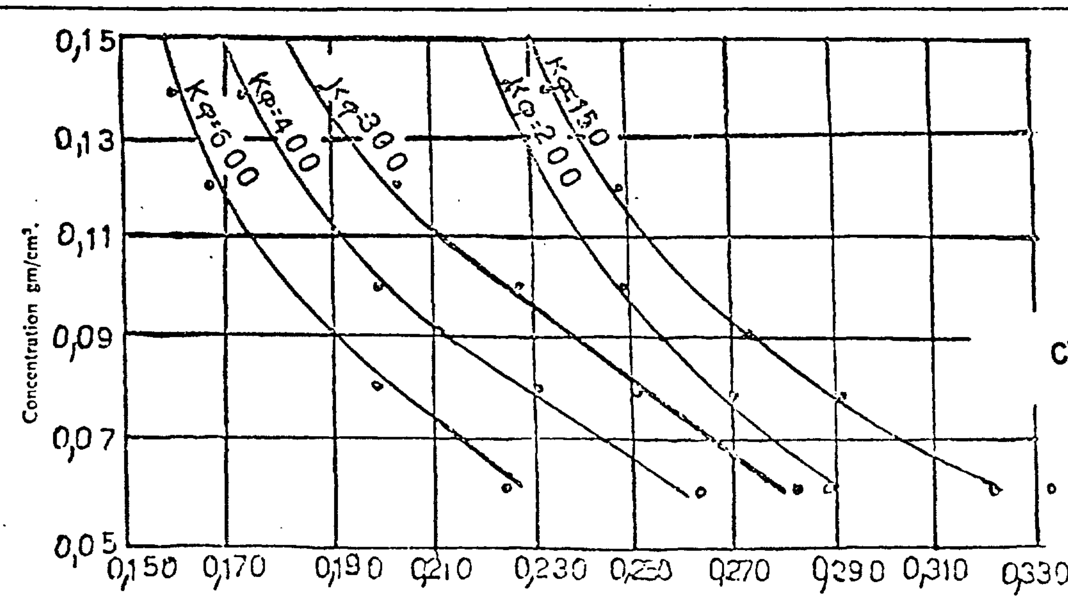

Fig. 37. - The dependence of the rate of filtration on $K\phi$ and on the concentration of the suspension. V_0^2 = 0.4 cm²; D_c = 1000 mm.; u_c = 32 metres/min.; t = 30° C.

74

The calculations have indicated that the concentration of the suspension in the first vat (as established using graph fig. 37) and the concentrations of the other 2 vats permitted to obtain an average rate of filtration not less than 0.240 cm/sec. This rate guarantees the manufacture of a sheet of satisfactory structure and strength.
The above calculations are of course theoretical; effective output is in practice, lower by 10-12% and this is usually due to the fact that the concentration cannot, in an absolute sense, be kept constant. The effective output therefore, during an 8 hour shift, should be:

$$\frac{8 \times 4840 \ (100 - 10)}{100} = 3485.$$

Example No 2.

To what extent will conditions change when the temperature of the suspension is lowered from 30° C to 20° C, while all the other technological parameters remain unchanged as in example No 1?
In order to avoid the deterioration of the quality of the end product, the concentration in the vats must be lowered to such extent that the rate of filtration is maintained constant and equal approximately to 240 cm/sec.
When the volume of the filtrated material was calculated by means of the equation of filtration (see AC/M No 11/12 - 1968), it was found that temperature exerts an influence on the viscosity of the material and that viscosity enters in the formula for the determination of $A\phi$.
Concentration « a » also enters in the same formula. In order therefore to maintain constant the volume of filtrated material and rate of filtration, it is necessary to reduce « a » to such limits that the increase of viscosity η will not affect the value of $A\phi$.
By equating the expressions for $A\phi$, with different values for « a » and η we shall obtain:

$$\frac{k\phi \cdot \eta_1 \cdot a_1^{1.5}}{P} = \frac{k\phi \cdot \eta_2 \cdot a_2^{1.5}}{P}$$

and following: $\eta_1 \cdot a_1^{1.5} = \eta_2 \cdot a_2^{1.5}$; $a_2^{1.5} = \frac{\eta_1 \cdot a_1^{1.5}}{\eta_2}$

It can be seen in table 17 (AC/M No 5/6 - 1969) that viscosity η at 30° C equals 7.95 and at 20° C equals 9.91.
Introducing in the equation the value of the concentration in the first vat per example 1 (a_1), the value of the concentration in the same vat at 20° C can now be obtained:

$$a_2^{1.5} = \frac{7.95 \times 0.096^{1.5}}{9.91} = 0.0238$$

$a_2 = (\sqrt[3]{0.0238})^2 = 0.083$ gm/cm³.
In the same way, the concentration in the second and third vats can be calculated and are respectively 0.074 and 0.061 gm/cm³.
On the basis of the data contained in table 19, concentration should be 0.068 gm/cm³.
The calculation indicates that a change in temperature from 30° to 20° C, requires a reduction of the concentration by approximately 1/7. The rate of filtration in the above examples can be worked by means of graph fig. 37.
It is in the same way that calculations can be made when the felt speed exceeds the admitted speed of 32 metres/minute. The results will in any case be satisfactory for practical purposes. If however, a more exact calculation of the rate of filtration is required this can be obtained by means of the equation of filtration.
Typical cases met in practice of operating conditions of machines (taking into account also the filtrating properties of the raw materials and temperature of the suspensions) have thus been considered.
In many plants, this kind of calculation, is not even known; the best values for the concentration are usually obtained as a result of the skill of specialised technicians with a long experience; however, even such skilled technicians cannot always secure optimum conditions and this often leads to reduction of the output and deterioration of quality to which no explanation can be given. It is therefore imperative that the principle of calculations, be introduced in plant running. To obtain this, every factory must organize a proper laboratory equipped to investigate regularly the technological properties of the raw materials and other factors.
The principle of calculation of the operating conditions of a machine, becomes even more important where automatic feed regulators are used.

Example No 3.

A 2 sieve cylinder sheet forming machine with cylinders diameter 1000 mm. is operating with a felt speed of 25 metres/minute. Properties of the suspen-

75

TABLE 19

Maximum tolerable felt speeds, in relation to the concentration of the suspension.

Concentration of suspension in vat in % at point « O »	Average concentration in the vat %	kg/cm²		Maximum tolerable felt speed	
		Ultimate displacement strain T_0	Plastic viscosity η_{pl}	cm/sec	metres/minute.
6	4.8	20.5	0.370	47.4	28.4
8	6.4	23.0	0.407	48.2	28.9
10	8.0	33.0	0.425	66.0	39.5
12	9.6	43.0	0.460	80.0	48.0
15	12.0	57.0	0.550	88.0	52.7

sion are per example 1. Temperature of the suspension is 15° C. Concentration in the first vat is 9% and in the second 7%. It is required to determine the extent to which the thickness of the elementary layer can be increased if the felt speed is increased to 34 metres/minute and the temperature of the suspension to 30° C, on condition of course that the strength characteristics of the end product, remain unchanged.

Determination of the thickness of the layer and rate of filtration, prior to any change in the conditions of operation is required. These can be determined from table 10 (see AC/M No 1/2 - 1969). Under the above conditions, the thickness of the layer would be equal to 0.077 cm. and the average rate of filtration equal to 0.234 cm/sec. The output would consequently be equal to $4.76 \times \delta a\phi \cdot u_c \cdot B_c$ equal to $4.76 \times 0.077 \times 41.7 \times 170 = 2600$.

The thickness of the layer and the rate of filtration after the change of the conditions, can be established using graph fig. 37. In order to maintain unchanged the strength properties of the product, despite the increase of the thickness of the layer, an arbitrary rate of filtration of 210 cm/sec is taken. Using graph in fig. 37, the average concentration with $u\phi = 0.210$ and $k\phi = 300$ should be 11%. If it is admitted that the concentration in the first vat is 12% and in the second 10%, the thickness of the layer can be worked out by using equation (3-22)

$$\delta a\phi = \frac{0.83\,a}{\gamma a} \cdot u\phi t$$

By substitution when the felt speed is 34 metres minute (see table 10 AC/M No 1/2 - 1969):

$$t = \frac{L}{u_c} = \frac{178}{56.6} = 3.14 \text{ secs.}$$

The calculation will give the following:

For the first cylinder:
a=0.12 gm/cm³; $u\phi$=200 cm/sec; $\delta a\phi$=0.042 cm.

For the second cylinder:
a=0.10 gm/cm³; $u\phi$=0.225 cm/sec; $\delta a\phi$ = 0.039 cm.

Thus the total thickness of the layer delivered by the 2 cylinders will be 0.081 cms. and the output equal to $4.76 \times 0.081 \times 56.6 \times 170 = 3700$.

As it results from the above calculations, the changes in the conditions of operation will only cause an increase of 5% in the thickness of the layer and 3% in the rate of filtration. Such insignificant variations will not affect the strength characteristics of the end product and yet the output will be increased by 42% (from 2600 to 3700).

Attention is drawn to the fact that when designing the increase of the thickness of the layer, care must be taken that the rate of filtration is not decreased; if this happens, it is necessary to find the way to increase the rate of filtration and it is only after securing a satisfactory rate of filtration that productivity can be increased; otherwise, with a low rate of filtration, the strength characteristics of the end product will deteriorate and consequently deviations from this principle shoud not be permiteed.