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asbestos-cement manufacturing technology

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PLAINTIFF'S EXHIBIT

CT-1453

calculation of the output of the sieve cylinders

based on work by Dr. **I. I. Berney** — part VI

Before making use of the equation of filtration for the calculation of the output of the sieve cylinder, it was necessary to carry out a series of experiments under factory conditions, as the equation of filtration was derived at on the basis of data obtained from experimental work carried out on the special filter and there are substantial differences between filtration through this filter and through a sieve cylinder. The main differences are that the filtrating surface of the special filter is immobile while that of the sieve cylinder is rotating and hydrostatic pressure, with a sieve cylinder, is not constant.

These experiments, referred in AC/M No. 7-8 July/August 1968, were conducted on a sheet forming machine equipped with one sieve cylinder diameter 850 mm, with felt speeds of 37,8, 33, 28,9, 23,6 and 17,7 metres/minute and with suspensions of different concentration (0.03 to 0,12 gm/cm³). Concentration of each suspension was kept constant by preparing the suspension of a required concentration in a mixer and then feeding the vat of the machine without dilution.

In the course of the experiments, the thickness of the layer, its specific weight and the volume of filtrated material through the sieve cylinder were measured and the physical mechanical properties of the manufactured sheets were controlled.

A graph was plotted from the data obtained from these experiments and those carried out on the special filter (fig. 27). In table 8 are referred the thickness and weight of the elementary layer, the volume of filtrated material and the necessary calculations for the plotting of the graph.

The plotted data, graph (fig. 27), obtained from the experiments carried out under factory conditions, correlate to form a straight line (relation between t/V and V²), and consequently correspond to the equation of filtration (3-7).

The comparison of the graphs of filtration, obtained from the experiments carried out on the special filter and those carried out on the actual forming machine, leads to the conclusion that the value of the coefficient of resistance k_ϕ does not depend on the type of equipment used for the filtration. Suspensions of the same composition were also investigated on the special filter. It resulted that the value of B, when filtration took place on the sheet forming machine, was higher than the value of B when filtration took place on the special filter; in all cases the difference was of the order of approximately 2,4.

When calculating the output of the sieve cylinder of an asbestos-cement forming machine, B and V_0^2 will be symbolized as B_m and V_{om}^2 respectively and can be determined as follows:

$$B_m = B + 2{,}4 \qquad (3\text{-}19)$$

and

$$V_{om}^2 = \frac{B + 2{,}4}{A\phi} = V_0^2 + \frac{2{,}4}{A\phi} \qquad (3\text{-}20)$$

V_0^2 can be determined by equation (3-17).

The above indicated difference of the value of B under different filtration conditions, can be explained by the difference of pressure during the unstable period of the process (see AC/M No. 11-12, Nov.-Dec. 1968). The pressure on the sieve cylinder will be at a maximum when 1/3 of the wire will be in the suspension (1-3 fig. 1 see AC/M No. 5, May 1968) or in other words after 1-1,5 seconds from the beginning of the process of filtration.

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On the special filter, however, maximum pressure is observed after 0,2 seconds from the beginning of the process. Therefore, in the period of time (0.9 to 1,2 secs.) when on the filtrating wire a compact layer is not yet formed, filtration on the special filter takes place with a higher pressure than on the sieve cylinder; the volume of filtrated material (V_1) increases while B decreases (see equation 3-9).

Equipment for filtration with an agitator but without a vacuum pump, was constructed. It was observed that the filter sinks in the suspension at a much slower rate than in the equipment which has a vacuum pump; the slow rate of sinking of this filter increases the pressure of filtration. The values of B, registered during the filtration by this equipment differ considerably less from the corresponding values obtained during filtration on the sieve cylinder of the forming machine; this fact proves the correctness of the given explanation in connection to the causes which account for the differences in value of constant B.

Having thus proved the possibility of applying equation (3-18) also for the filtration through the sieve cylinder of the forming machine, the next step would be to determine V and to calculate the output of the forming machine.

In equation (3-18):

$$\frac{t}{V} = k_{\phi} \frac{\eta\, a^{1.5}}{P} (V^2 + V_0^2)$$

the values contained can be determined and how to determine these is explained in the following paragraphs.

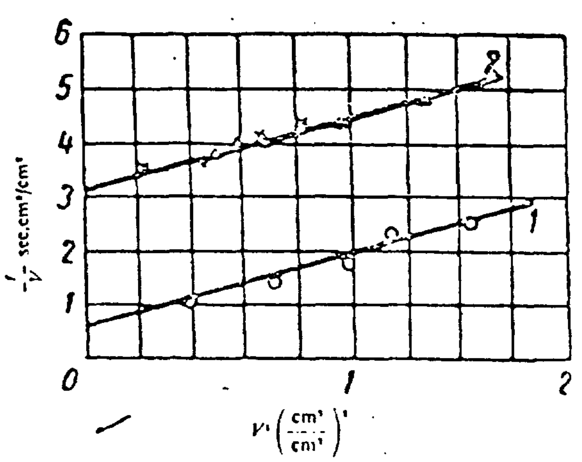

Fig. 27. - Graph of the filtration of suspension 1) On the special filter: $k\phi = 212$ (cm/gm)$^{1.5}$; B = 0.7 sec/cm. - 2. On the sieve cylinder of the forming machine: $k\phi = 218$ (cm/gm)$^{1.5}$; B - 3,1 sec/cm. For the composition of the suspension see table 8.

In equation (3-18):

a .- is the concentration of the suspension (gm/cm³), which is known;

η - is the viscosity of the liquid (gm · sec/cm²) at the same temperature of the suspension. Table 7 (AC/M No. 11-12, November December 1968) can be used for the determination of this value;

t - is the time of filtration, equal to $\frac{L}{u_c}$ (see fig. 1, AC/M No. 5, May 1968) where u_c represents the speed of the felt. L depends on how deeply the sieve cylinder is immersed in the suspension (see table 9). When the sieve cylinder is immersed for 0,6 of its diameter, L equals 0,565 · ΠD_c and when immersed for 0,7 of its diameter, L equals 0,633 × ΠD_c (ΠD_c represents the circumference of the sieve cylinder).

Constants $k\phi$ and V_0^2 can be determined from data obtained experimentally during the filtration on the special filter and using equations (3-14) and (3-17), substituting however, V_0^2, with

$$V_{om}^2 = V_0^2 + \frac{2,4}{A\phi}$$

P is the value of hydrostatic pressure (gm/cm²).

Maximum pressure P_n, during the work of the sieve cylinder (see fig. 1, AC/M No. 5, May 1968) is equal to the difference between the level of the suspension in the vat and the level of the liquid inside the sieve cylinder. However, P_n cannot be introduced in the equation of filtration; the equation is only valid for filtration at constant pressure (during the work of the sieve cylinder, pressure increases from 0 to P_n and again decreases from P_n to 0). It is therefore necessary to find the average value of hydrostatic pressure during the process of filtration and the average value will be symbolised by P_c. To obtain this, it is necessary to assume that pressure is a function of time and determine the average value of this function.

The method of calculation will not be given but the results are indicated in table 9.

From table 9 it can be seen that when the sieve cylinder is in the suspension for 0,6 of its diameter, P_c is equal to 0,33 D_c and for 0,7, P_c is equal to 0,40 D_c.

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TABLE 8

Data of the experiments performed on a sheet forming machine.

a) *Registered values.*

No of experiment	Felt speed metres/min.	Time of filtration - secs.	Concentration «α» - gm/cm³	V cm³/cm²	Thickness of layer δ_x (cm)	Specific weight of sheet $\gamma\alpha$ gm/cm³	$G = \gamma\alpha \cdot \delta\alpha\phi$ gm/cm²	αV gm/cm²	$K_y = \frac{G}{\alpha V}$	$\frac{V}{t}$	$\frac{t}{V}$	V^2	Removed from filtrated material gm/cm³
32	37,8	2,60	0,03	1,04	0,0143	1,70	0,0243	0,0312	0,73	—	—	—	0,0094
34	37,8	2,60	0,06	0,72	0,0187	1,73	0,0330	0,0432	0,75	—	3,60	0,520	0,0110
35	37,8	2,60	0,08	0,69	0,0265	1,74	0,0460	0,0552	0,83	0,265	3,77	0,476	0,0118
36	37,8	2,60	0,10	0,67	0,0289	1,76	0,0509	0,0670	0,76	—	—	—	0,0130
37	37,8	2,60	0,12	0,60	0,0350	1,69	0,0590	0,0720	0,82	—	—	—	0,0140
38	37,8	2,60	0,15	0,57	0,0340	1,72	0,0585	0,0855	0,68	—	—	—	—
39-B	33,0	2,95	0,08	0,75	0,0300	1,73	0,0520	0,0600	0,865	0,254	3,94	0,56	0,0110
22	28,9	3,40	0,08	0,83	0,0350	1,72	0,0602	0,0680	0,880	0,244	4,10	0,69	0,0106
18-B	23,6	4,20	0,08	0,975	0,0380	1,77	0,0672	0,0780	0,860	0,232	4,32	0,95	0,0105
4	17,7	5,50	0,08	1,12	0,0460	1,60	0,0736	0,0896	0,823	0,204	4,91	1,26	0,0082

b) *The comparison of the values of the volume of filtrated material and weight of the layer registered in the course of the factory experiments and calculated on the basis of the equations of filtration (see fig. 28).*

Felt speed metres/min.	Concentration α gm/cm³	Time of filtration t, secs.	Calculated values		Registered values		Difference between calculated and registered values in percent.	
			V, cm³/cm²	G, gm/cm²	V, cm³/cm²	G, gm/cm²	V	G
37,8	0,03	2,60	0,98	0,0248	1,04	0,0243	5,5	2,0
37,8	0,06	2,60	0,71	0,0352	0,72	0,0330	1,4	6,7
37,8	0,08	2,60	0,67	0,0445	0,69	0,0460	2,9	3,2
37,8	0,10	2,60	0,65	0,0538	0,67	0,0509	3,0	6,0
37,8	0,12	2,60	0,62	0,0618	0,60	0,0590	3,3	4,7
33,0	0,08	2,95	0,73	0,0485	0,75	0,0520	2,6	6,7
28,9	0,08	3,40	0,82	0,0550	0,83	0,0602	1,2	8,2
23,6	0,08	4,20	0,95	0,0630	0,975	0,0672	2,6	6,2
17,7	0,08	5,50	1,08	0,0716	1,120	0,0736	3,5	3,0

Diameter of sieve cylinder - 850 m/m. Hydrostatic Pressure: Maximum 48 cm; average 33 cm.

Temperature of suspension 23° C. Composition of asbestos-cement mass: Asbestos J-6-25 and P-5-65, 50 % of each type. Cement, type 40(
Fineness of grinding: residue on sieve 4900, 7,5 % wt/cm².

Ratio of components: Asbestos 13,5 % - Cement 86,5 %.

If these known values are substituted in equation (3-18), then an equation of the third degree is obtained with only one unknown.
To ease calculation by means of equation (3-18), an alignment chart was composed (see fig. 28).
Points $t/A\phi$ and V_{om}^2 are joined by a straight line; where the straight line meets curve V, we get the volume of filtrated material.
It would also be possible to obtain the solution of equation (3-18) by way of analysis.
If equation (3-18) is written in the following way:

$$y^3 + 3p_1 y + 2q_1 = 0$$

where y is the changing value, in this case the volume of filtrated material V:

$$V^3 + \frac{B}{A\phi} V - \frac{t}{A\phi} = 0; \qquad 3p_1 = \frac{B}{A\phi} = V_0^2;$$

$$2q = \frac{-t}{A\phi} = \frac{-tP}{\eta\, a^{1.5} k\phi}$$

then by application of the known formula:

$$V = \sqrt[3]{-q_1 + \sqrt{q_1^2 + p_1^3}} + \sqrt[3]{-q_1 - \sqrt{q_1^2 + p_1^3}}$$

The substitution of the value of p_1 and q_1 will give:

$$V = \sqrt[3]{\frac{tP}{2\eta a^{1.5} k\phi} + \sqrt{\left(\frac{tP}{2\eta a^{1.5} k\phi}\right)^2 + \left(\frac{V_0^2}{3}\right)^3}} + \sqrt[3]{\frac{tP}{2\eta\, a^{1.5} k\phi} - \sqrt{\left(\frac{tP}{2\eta\, a^{1.5} k\phi}\right)^2 + \left(\frac{V_0^2}{3}\right)^3}} \quad (3\text{-}21)$$

Although this will give the volume of the filtrated material V, its introduction in equation (2-2) will not make possible the determination of the output of the sieve cylinder because the coefficient of collection k_y is still unknown.
The coefficient of collection as established during the work done on the special filter, is not applicable where a sieve cylinder is involved because the value of k_y depends largely on angle ψ (see AC M No. 7-8, July-Aug. 1968) and this angle changes substantially during the rotation of the sieve cylinder. Consequently, the average value of k_y had to be determined directly on the factory machine.
Table 8 contains the registered values of the coefficient of collection obtained during this work. It results that with felt speeds ranging between 33 and 38 m/min and concentration between 0.06 and 0.14 %, i.e. conditions very near to actual manufacturing conditions, the coefficient of collection in average value, can be admitted to be equal to 0,83. For a sieve cylinder of diameter 500 mm, k_y is equal to 0,78.
If in equations (2-3 and 2-4), k_y is substituted by its average value ($k_y = 0{,}83$), then the following formulae will be obtained allowing to calculate the thickness of the asbestos-cement layer ($\delta\alpha\phi$) and the weight of asbestos-cement delivered by the sieve cylinder (G_c). $\delta\alpha\phi$ and $\gamma\alpha\phi$ will symbolize respectively the thickness and specific weight of the layer.

$$\delta\alpha\phi = \frac{0{,}83 aV}{\gamma\alpha\phi}\ \text{cm} \qquad (3\text{-}22)$$

$$G_c = 0{,}83 aV \cdot u_c \cdot B_c\ \text{gm/sec.}$$

In industry, the output of a sheet forming machine for example, is expressed by the number of sheets of any standard size produced per hour. In order to introduce this unit of measure into the last formula, it is necessary to establish the weight of asbestos-cement obtained during one hour of production and divide this by the weight of one standard sheet accounting for losses resulting from off-cuts which correspond in average to 10 %.
The useful production will therefore be:

$$G_c = 0{,}90 \times 3600 \times 0{,}83\, aV \cdot u_c \cdot B_c\ \text{gm/hr.}$$

The weight of a standard sheet with a volume of say 680 cm³ will be equal to $\gamma\alpha\phi \times 680$ gms.
The weight of asbestos-cement obtained during one hour of work divided by the weight of a standard sheet, will give the output of the sieve cylinder:

$$\Pi_c = \frac{0{,}90 \times 3600 \times 0{,}83\, aV \cdot u_c \cdot B_c}{\gamma\alpha\phi \times 680} = \frac{3{,}95\, aV}{\gamma\alpha\phi} u_c \cdot B_c\ \text{number sheet/hr.} \qquad (3\text{-}23)$$

TABLE 9

Average hydrostatic pressure and length of the wet part of the perimeter of the sieve cylinder in relation to the diameter of the cylinder mould.

Diameter of sieve cylinder D_c, mm.	Average hydrostatic pressure P_c cms.			Wet part of perimeter, L cms.		
	coefficient of immersion			coefficient of immersion		
	0,6	0,7	0,75	0,6	0,7	0,75
720	23,7	28,8	30,20	128	143	151
850	20,0	34,0	35,70	151	169	178
1000	33,0	40,0	42,00	178	198	210
1200	36,0	48,0	50,30	214	238	252

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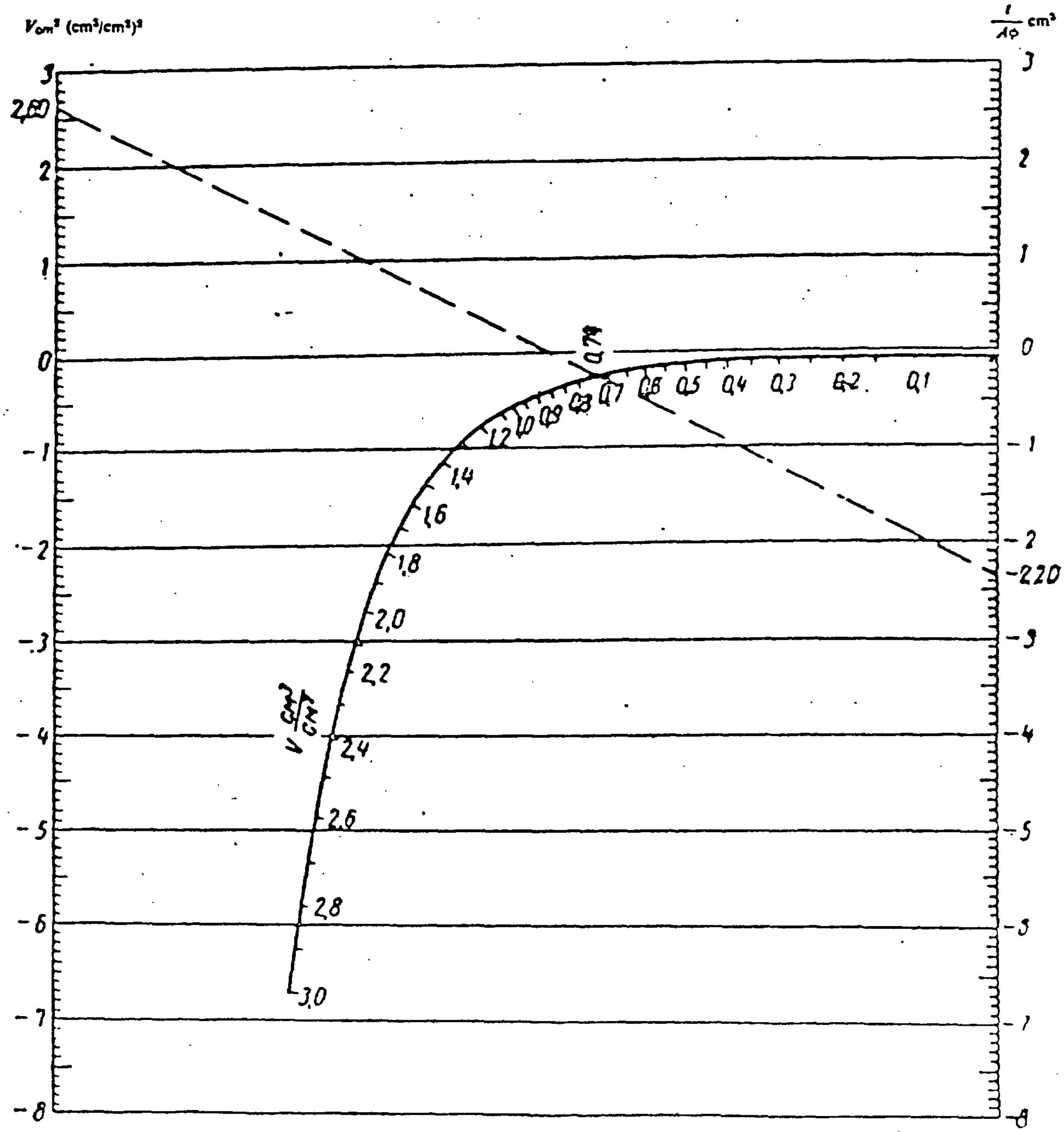

Fig. 28. - Alignment chart for the solution of the equation of filtration of asbestos-cement suspensions by means of formula:

$$\frac{t}{V} = k\phi \frac{\tau_o^{1.5}}{P} (B^2 + V_o^2).$$

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TABLE 10

Calculation of the productivity of sieve cylinders under different technological conditions ($\gamma x\phi = 1{,}5$ gm/cm³; $K_n = 0{,}6$; $B_e = 170$ cm).

No. of example	No. of cylinder	Data of suspension: $K\phi$ (cm/gm)$^{1.5}$	V_o^* (cm³/cm³)	Temperature °C	η, gm·sec/cm²	a, gm/cm²	Data on sieve cylinder and machine: D_e, cm	L, cm	u_e, cm/sec	Calculation of productivity: P_e, cm	$t = \frac{L}{u_e}$, secs.	$A\phi = K\phi \frac{\eta x^{1.5}}{P_{e3}}$ sec/cm²	$\frac{t}{A\phi}$, cm²	$V_{um}' = V_o^* + \frac{2,4}{A\phi}$ cm²	V per alignment chart cm³/cm²	$\delta_{x\phi} = \frac{0,83\,aV}{\gamma x\phi}$ cm	$\Pi c = \frac{3,95\,aVu_eB_e}{\gamma x\phi}$ sh/h	$u\phi = \frac{V}{t}$ cm/sec
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	1	268	0,4	30	7,95	0,10	100	178	53,4	33	3,34	2,04	1,64	1,58	0,78	0,043	1870	—
	2	268	0,4	30	7,95	0,08	100	178	53,4	33	3,34	1,46	2,29	2,04	0,84	0,037	1610	—
	3	268	0,4	30	7,95	0,06	100	178	53,4	33	3,34	0,95	3,52	2,93	0,92	0,030	1300	—
										Total of 3 sieve cylinders				—	—	0,110	4780	0,254
2	1	268	0,4	30	7,95	0,12	100	178	53,4	33	3,34	2,68	1,25	1,30	0,72	0,048	2050	—
	2	268	0,4	30	7,95	0,10	100	178	53,4	33	3,34	2,04	1,64	1,58	0,78	0,043	1870	—
	3	268	0,4	30	7,95	0,08	100	178	53,4	33	3,34	1,46	2,29	2,04	0,84	0,037	1600	—
										Total of 3 sieve cylinders				—	—	0,128	5520	0,234
3	1	268	0,4	30	7,95	0,10	100	178	60	33	2,96	2,04	1,45	1,58	0,72	0,040	1930	—
	2	268	0,4	30	7,95	0,08	100	178	60	33	2,96	1,46	2,03	2,04	0,78	0,035	1690	—
	3	268	0,4	30	7,95	0,06	100	178	60	33	2,96	0,95	3,12	2,93	0,86	0,028	1360	—
										Total of 3 sieve cylinders				—	—	0,103	4980	0,264
4	1	268	0,4	15	11,20	0,10	100	178	53,4	33	3,34	2,91	1,15	1,25	0,67	0,037	1600	—
	2	268	0,4	15	11,20	0,08	100	178	53,4	33	3,34	2,08	1,61	1,55	0,76	0,033	1430	—
	3	268	0,4	15	11,20	0,06	100	178	53,4	33	3,34	1,68	1,99	1,33	0,89	0,026	1090	—
										Total of 3 sieve cylinders				—	—	0,096	4120	0,224
5	1-2	226	0,20	30	7,95	0,10	50	89	53,4	17	1,67	3,34	0,5	0,92	0,48	0,025 × 2	1075 × 2	—
	3-4	226	0,20	30	7,95	0,08	50	89	53,4	17	1,67	2,38	0,7	1,20	0,52	0,022 × 2	934 × 2	—
	5-6	226	0,20	30	7,95	0,06	50	89	53,4	17	1,67	1,55	1,08	1,75	0,54	0,017 × 2	726 × 2	—
										Total of 6 sieve cylinders of ø 50 cms			—	—	—	0,128	5470	0,280
6	1	170	0,5	30	7,95	0,10	100	178	53,4	33	3,34	1,29	2,60	2,36	0,87	0,048	2100	—
	2	170	0,5	30	7,95	0,08	100	178	53,4	33	3,34	0,93	3,60	2,98	0,94	0,042	1820	—
	3	170	0,5	30	7,95	0,06	100	178	53,4	33	3,34	0,60	5,57	4,40	1,05	0,034	1480	—
										Total of 3 sieve cylinders				—	—	0,124	5400	0,286
7	1	300	0,4	15	11,20	0,09	100	178	41,7	33	4,27	2,74	1,56	1,28	0,82	0,041	—	—
	2	300	0,4	15	11,20	0,07	100	178	41,7	33	4,27	1,87	2,28	1,68	0,92	0,036	—	—
										Total of 2 sieve cylinders				—	—	0,077	2590	[illegible]04

Note. When calculating the productivity of the sieve cylinder with ø 500 m/m (example No. 5) the value K_s equals 0,78 and therefore instead of the values 3,95 in column 18 and 0,83 in column 17, are applied correspondingly the values 3,70 and 0,78.

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Production of standard sheets per hour in relation to 1 m^2 of useful surface of the sieve cylinder (immersed in the suspension), is the specific productivity, symbolized as Π_y.
Referring to fig. 1 (see AC/M No. 5, May 1968), the useful surface of the sieve cylinder is:

$$F_c = \frac{LB_c}{10^4}\ m^2 \qquad (3\text{-}24)$$

where: L is the section of the sieve cylinder immersed in the suspension in cms.

B_c is the length of the filtrating surface of the sieve cylinder in cms.

If felt speed is expressed in accordance with equation (2-5) and dividing the value obtained from equation (3-23) by the value F_c, the following expression can be written:

$$\Pi_y = \frac{\Pi_c}{F_c} = \frac{3{,}95\, aV \cdot u_c \cdot B_c \times 10^4}{\gamma\alpha\phi L B_c} =$$

$$= \frac{3{,}95\, aVLB_c \times 10^4}{\gamma\alpha\phi\, L t B_c} = \frac{3{,}95 \times 10^4 a}{\gamma\alpha\phi}\left(\frac{V}{t}\right)$$

number sheet/hour/m^2 (3-25)

It results that the specific productivity of the sieve cylinder is proportional to the concentration of the suspension a and to the average rate of filtration V/t. The thickness of the layer $\delta\alpha\phi$ can be introduced in equation (3-23), using equation (3-22) and this will give:

$$\Pi_c = 4{,}76\, \delta\alpha\phi \cdot u_c B_c/\text{number sheet/hour} \qquad (3\text{-}26)$$

The results of the experiments carried out under factory conditions are referred in table 8. The weight of the asbestos-cement layer, obtained per unit of filtrating surface of the sieve cylinder was calculated using the equation of filtration and was compared to the values obtained experimentally (see also table 8). Such comparison indicated (see table) that the technological calculation of the sieving part of the forming machine, based on the equation of filtration with different concentrations and felt speeds, corresponds to the experimental data obtained.
Details of the calculations of the output of the sieve cylinder, will be fully explained in the following chapter, with practical examples. In a subsequent chapter, the dependence of the physical mechanical properties of asbestos-cement, on the working conditions of the machine, will be examined.

Details of the calculation of the output of the siev. cylinder using the equation of filtration and example:

The thickness of the asbestos-cement layer and th output of the sieve cylinder — under different tech nological conditions — can be calculated by mean of the equation of filtration. The influence of th dimensions of the sieve cylinder on its output ca also be determined as well as a number of othe calculations:

Example No. 1: An asbestos-cement sheet formin machine operates with 3 sieve cylinders of 1000 mr diameter, immersed in the suspension, during work for 0,6 D_c; and felt speed 32 m/min corresponding t 53,4 cm—sec.
It would be required to determine the thickness c the layer and the output of the sieve cylinder unde the following technological conditions: specific weigh of sheet 1,5 gm/cm³ — temperature of suspensio 30° C — concentration of suspension in the fir vat 0,10 gm/cm³, in the second vat 0,08 gm cm and 0,06 gm/cm³ in the third. The characteristic of filtration are the following: $k\phi = 268$ (cm gm) and $V_0^2 = 0{,}4$ cm³/cm² with $P\phi = 40$ gm cm².
For the determination of V according to the align ment chart, it is necessary to calculate the values c $t/A\phi$ and V_{om}^2; the calcultation is the following:
The time of filtration is: $t = \frac{L}{u_c}$ where L is th length of the part of the perimeter of the sieve cylind immersed in the suspension and u_c-the speed of th felt. If the sieve cylinder is immersed for 0.6 of i diameter, then the coefficient of immersion k_n (s table 9) is also equal to 0,6 and L equal to 178 cm

$$t = \frac{L}{u_c} = \frac{178}{53{,}4} = 3{,}34 \text{ secs.}$$

Constant $A\phi$ is determined using equation (3-1

$$A\phi = k\phi \frac{\gamma_t \cdot a^{1,5}}{P_c}$$

Pressure P_c will be the same for all 3 sieve cylinde and as the coefficient of immersion k_n is equal 0,6 then pressure P_c will be equal to 33 cms (s table 9).
As the average hydrostatic pressure results to be cms. in the course of this work, and that of the wo carried out in the laboratory was 40 cms. the resul ing difference is less than 1.5 times and hence the would be no need for the recalculation of $k\phi$ and V_0

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the values found during the laboratory work can therefore be used.

For the viscosity of the suspension at 30° C, see table 7 (AC/M No. 11-12, Nov./Dec. 1968): η at 30° C = 7,95 g · sec/cm².

Therefore the following can be written:

For the first sieve cylinder:

$$A\phi = k\phi \frac{\eta \cdot a^{1.5}}{p_c} = 268 \frac{7{,}95 \times 0{,}10^{1.5}}{33} =$$

$$= 268 \frac{7{,}95 \times 0{,}0316}{33} = 2{,}04 \text{ sec/cm}^3$$

and

$$\frac{t}{A\phi} = \frac{3{,}34}{2{,}04} = 1{,}64 \text{ cm}^3$$

For the second sieve cylinder:

$$A\phi = 268 \frac{7{,}95 \times 0{,}08^{1.5}}{33} = 268 \frac{7{,}95 \times 0{,}0226}{33} =$$

$$= 1{,}46 \text{ sec/cm}^3$$

and

$$\frac{t}{A\phi} = \frac{3{,}34}{1{,}46} = 2{,}29 \text{ cm}^3.$$

For the third cylinder:

$$A\phi = 268 \frac{7{,}95 \times 0{,}06^{1.5}}{33} = 268 \frac{7{,}95 \times 0{,}0147}{33} =$$

$$= 0{,}95 \text{ sec/cm}^3$$

and

$$\frac{t}{A\phi} = \frac{3{,}34}{0{,}95} = 3{,}52 \text{ cm}^3.$$

The *initial volume* of the filtrated material will be determined using equation (3-20):

$$V_{om}^2 = V_0^2 + \frac{2{,}4}{A\phi}$$

and therefore:

For the first cylinder:

$$V_{om}^2 = V_0^2 + \frac{2{,}4}{A\phi} = 0{,}4 + \frac{2{,}4}{2{,}04} = 0{,}4 + 1{,}18 = 1{,}58.$$

For the second sieve cylinder:

$$V_{om}^2 = 0{,}4 + \frac{2{,}4}{1{,}46} = 0{,}4 + 1{,}64 = 2{,}04$$

For the third cylinder:

$$V_{om}^2 = 0{,}4 + \frac{2{,}4}{0{,}95} = 0{,}4 + 2{,}53 = 2{,}93$$

The volume of filtrated material for the first, second and third sieve cylinders can be established using the alignment chart fig. 28. These values are th following:

First: 0,78 cm³/cm²; second 0,84 cm³/cm²; thi 0,92 cm³/cm².

The introduction of the values of filtrated materi and concentration, in equation (3-22) will give t thickness of the layer delivered by the first, secon and third sieve cylinders:

For the first:

$$\delta\alpha\phi = \frac{0{,}83 \times 0{,}10 \times 0{,}78}{1{,}5} = 0{,}043 \text{ cms}$$

For the second:

$$\delta\alpha\phi = \frac{0{,}83 \times 0{,}08 \times 0{,}84}{1{,}5} = 0{,}037 \text{ cms.}$$

For the third:

$$\delta\alpha\phi = \frac{0{,}83 \times 0{,}06 \times 0{,}92}{1{,}5} = 0{,}030 \text{ cms.}$$

and consequently the thickness of the layer deliver by the three sieve cylinders will be:

$$0{,}043 + 0{,}037 + 0{,}030 = 0{,}110 \text{ cms}$$

Equation (3-23) will consequently yield the outp of each sieve cylinder in sheet/hour and for 3 si cylinders the summed up output will be:

$$\Pi = \frac{3{,}95}{\gamma\alpha\phi}(a_1V_1 + a_2V_2 + a_3V_3)u_cB_c =$$

$$\frac{3{,}95}{1{,}5}(0{,}10 \times 0{,}78 + 0{,}08 \times 0{,}84 + 0{,}06 \times 0{,}92)$$

$$53{,}4 \times 170 = 4780 \text{ sheets/hour.}$$

It is to be remembered however, that actual produ tion of the machine will be equal to the calculat output only in the absence of fault and if conce tration, temperature and filtration properties of t suspension will not be changing. As the variati of concentration is almost inevitable, it is con quently necessary to base all calculations on t average value of the concentration.

Table 10 was prepared and can be used for su sequent examples in order to abbreviate calculatio

Example 2. By how much will output be increas when all conditions remain unchanged and only t concentration of the suspension is increased as fo lows:

in the first vat: from 0,10 to 0,12 gm/c

in the second vat: from 0,08 to 0,10 gm/cm³

in the third vat: from 0,06 to 0,08 gm/cm³

In this case, $k\phi$, η and P_c are the same as in example

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The calculated values of $A\phi$, $t/A\phi$ and V_{om}^2 are given in table 10 ind. 13, 14, 15.
The values of V — determined according to the alignment chart fig. 28 — are given in table 10 index 16 and the thickness of the layer in the same table, index 17.
The calculation shows that the above increases in concentration will give a layer of 0,128 cms and consequently the output will be increased from 4780 to 5520 sheets/hour corresponding to an increase of 15,2 %.

Example 3. By how much will the output of the machine be increased when felt speed is increased from 32 to 36 m/min. while all other operating conditions are as in example 1.
When felt speed changes, only 2 values change: t and $t/A\phi$; these values are contained in table 10. The calculation indicates that the felt speed increase will result in a decrease of the thickness of the layer from 0,110 cms to 0,103 cms but the total productivity will increase from 4780 sheets/hour to 4980, corresponding to 4 %.

Example 4. By how much will productivity increase if the temperature of the suspension is increased from 15° to 30° C. All other conditions per example 1. The calculations referred in table 10 show that the increase in temperature from 15° to 30° C leads to an increase of the output by 16 % i.e. from 4120 sheets/hour at 15° to 4780 at 30° C.

Example 5. If in each of the 3 vats of the machine, instead of one sieve with a diam. of 1000 mm, two sieves of diam.. 500 mm each are installed in total 6—500 mm. Ø sieve cylinders instead of 3—1000 mm. What would the results of this change be when all other conditions of operation of the machine remain unchanged?
Evidently, the reduction in diameter of the sieve cylinders will cause the change of L - P_c - t - $A\phi$ - V_{om}^2. The calculation of L - P_c and t does not present any difficulty as these values decrease proportionally to the reduction in diameter of the sieve cylinders. The pressure however with a sieve cylinder of 500 mm. Ø — equal to 17 cms — differs by more than 1,5 times from the pressure when the data was established in the laboratory (40 cms) and consequently the values of $k\phi = 268$ and $V_0^2 = 0,4$ which were obtained in the laboratory using the special filter, have to be recalculated using equations (3-14) and (3-17):

$$k\phi = \frac{268}{P^s} \cdot P^s = \frac{268}{40^{0,2}} \cdot 17^{0,2} = \frac{268}{2,09} \cdot 1,76 =$$

$$226\ (\text{cm/gm})^{1,5}$$

$$V_0^2 = 0,4 \times \frac{P}{P\phi}\left(\frac{P\phi}{P}\right)^s = 0,4 \times \frac{17}{40}\left(\frac{40}{17}\right)^{0,2} =$$

$$0,4 \times 0,42 \times 1,18 = 0,20\ (\text{cm}^3/\text{cm}^2)^2.$$

Under typical conditions of manufacture, index s is equal to 0,20. The results of the corresponding calculations indicate that the change of the 3 — 1000 mm Ø sieve cylinders with 6 — 500 mm Ø, results in an increase of the output from 4780 to 5470 sheets/hour, equivalent to 14 % and this in spite of the fact that the working surface of the filtrating wire is not increased as a result of the change. Two otherwise identical sheet forming machines, but one equipped with 2 vats and 4-500 mm. Ø sieve cylinders and the other with 2 vats and 2-1000 mm. Ø sieve cylinders, regularly show differences of 12-15 % in output, always in favour of the 4 cylinder machine. This confirms the correctness of the calculations by means of the equation of filtration.

Example 6. Conducted investigation has proved that the filtration properties of an A/C suspension depend to a great extent on the composition of the cement used (this will be treated in a subsequent chapter). The filtration properties of the suspension containing a given type of cement was characterised by the following values, in the course of the conducted investigation:

$$k\phi = 170\ \Sigma\ (\text{cm/gm})^{1,5};\ V_0^2 = 0,5\ (\text{cm}^3/\text{cm}^2)^2.$$

Using cement of this type which would give to the suspension filtrating properties with values as above, instead of the cement which was used in the previously described series of experiments ($k\phi = 268$ and $V_0^2 = 0,4$), by how much would the output be increased when all other conditions are per example 1?
According to the data in table 10, the productivity with the introduction of this new variable will increase from 4780 to 5400 sheets/hour corresponding to an increase of 13 %.
In practice, conditions can be met under which, the asbestos-cement suspension, due to the properties of the cement used, has $k\phi = 700$ and at times even $k\phi = 1000$ (cm/gm)^{1,5}. In such cases, productivity will drop by 30-40 % compared to the output per example 1.

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