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PRODUCTION AND CHARACTERISTICS OF KOLA APATITE CONCENTRATE "SUPER"[1]

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1. Production of Kola apatite concentrate in JSC "Apatit"

The apatite concentrate in JSC "Apatit" is obtained from the apatite-nepheline ores by flotation method.

Before 1993 only "Standard" apatite concentrate was produced. It met the requirements of the specifications GOST - 22275-90, and will be referred to as "Standard".

The following are the requirements of concentrate "Standard":

- P_2O_5, % wt (dry basis) $\geq 39{,}0$
- H_2O, % wt $1.0 \pm 0{,}5$
- Residue on sieve No 0.16mm, % wt $\leq 13{,}5$

Sesquioxides (FeO, Fe_2O_3, Al_2O_3) by weight consist of not more than 3,0% guaranteed by the supplier.

The mineral chemical and granulation structures have wide range in composition, depending upon the processed ores and P_2O_5 content in the concentrate (39,0 - 39,4 %)

2. Origin and properties of Kola apatite concentrate "Super I"

The technology for the production of concentrate "Super" was first developed and tested in the plant ANOF-2 of JSC "Apatit" in 1993 from the usual flotated apatite concentrate. Hereinafter, it will be referred as Kola apatite concentrate "Super I".

As expected from the theoretical basis, when a disproportional distribution of apatite by particle size classes in flotated apatite concentrate was present, large particles were enriched, and the small particles, on the contrary, were impoverished of apatite (Table 2.1)

Table 2.1 - The distribution P_2O_5 on size classes of usual apatite concentrate

Size classes, mm	Mass, %	P_2O_5, %	Extraction P_2O_5, %
More than 0,200	4,2	39,37	4,3
0,200 - 0,160	8,4	40,12	8,7
0,160 - 0,100	19,1	40,29	19,8
0,100 - 0,071	14,2	40,39	14,7
0,071 - 0,040	12,9	40,45	13,4
0,040 - 0,020	17,9	39,20	18,0
0,020 - 0,010	8,6	37,56	8,3
0,010 - 0,005	6,6	36,47	6,2
Less than 0,005	8,1	31,82	6,6
	100,0	39,90	100,0

On this, existing technology and available equipment, the concentrate "Super" was obtained as a circulating fraction of concentrate's hydrocyclones, which were used in the circuit of flotated concentrate dehydration.

The generalized technological scheme to recover apatite concentrate "Super" is indicated on Figure 2.1.

The main feature of this technology are:

[1] *The report has been translated by N. Ryazantseva*

- To obtain a given quantity of a concentrate "Super", it is necessary to use about 65% of total usual flotated concentrate output. It means, that during the process time of a concentrate "Super" production, the reorganization of technological scheme almost of the whole factory is required;
- Output of the concentrate "Super" from the usual flotated concentrate is around 20-22%;
- With overflow liquids, there is plenty of lowered quality product from the concentrate's hydrocyclones coming into the production process of usual flotated concentrate. The lowered quality consists of particle size of about 6% more than 0,16 mm, and the P_2O_5 content of about 38,90%.

The results are as follows:

⇒ A specific load on thickening equipment grows to 25-40%, and increasing of operations thicking field for usual flotated concentrate is required for avoidance of that.

⇒ Kek humidity is increased by 0,3% on average during the filtration of usual flotated concentrate.

- Essential fluctuations of the output and the special features of grain consistence of the concentrate "Super" makes rather difficult the drying process of concentrate and maintenance of its needed humidity (0.8-1.0%) and as the result - the fluidity:
- Losses of apatite are increased during the production process of the concentrate "Super" with changes of technological regimes. The extraction of P_2O_5 in the final product comes down and the economic parameters of plant operation on the whole becomes worse.

The structure characteristics of the concentrate "Super I" are indicated on Tables 2.2-2.4. In comparison with the "Standard" concentrate the first one has more stable mineral, chemical and granulation structure, namely:

- The P_2O_5 of apatite in concentrate Super I increases up to 97-98% while the share of other minerals decrease to 2,0 - 2,7%
- The proportion of grains with sizes more than 0,16 mm increases from 11-13% up to 35% and the particles with size less than 0,071 decreases from 55-58% to 17-20%, including the most dusting class with particle size less than 0.02 mm, which reduce from 23.3% to 5,2%. This accounts for the difference in granulation characteristics
- The difference in the chemical composition consists in increasing of contents P_2O_5 up to 40.0-40.2% and a corresponding reduction the contents of titanium and aluminium oxides .

Table 2.2 - The distribution P_2O_5 by size classes in the concentrate "Super I"

Class size, mm	Mass, %	P_2O_5, %	Extraction P_2O_5, %
More than 0,200	14,3	40,05	14,2
0,200 - 0,160	22,4	40,45	22,5
0,160 - 0,100	34,8	40,72	35,3
0,100 - 0,071	11,6	40,61	11,7
0,071 - 0,040	6,6	40,51	6,6
0,040 - 0,020	5,1	39,67	5,0
0,020 - 0,010	2,0	38,59	1,9
0,010 - 0,005	1,3	36,78	1,2
Less than 0,005	1,9	32,93	1,6
	100,0	40,25	100,0

Table 2.3 - Mineral structure of the concentrate "Super I", obtained in plant ANOF-2 conditions

Name of minerals	Mass share of mineral, %
Apatite	97,2 - 98,0
Nepheline	0,8 - 1,4
Aegirine	0,8 - 1,2
Sphene	0,1 - 0,2
Lamprophyllite	0,1 - 0,2
Feldspar and Hydromica	0,1 - 0,2
Titanomagnetite and Ilmenite	Traces

Table 2.4 - Chemical structure of the concentrate "Super I", obtained in plant ANOF-2 conditions

Elements	Mass share, %	Elements	Mass share, %
SiO_2	1,60 - 2,10	MnO	0,02 - 0,05
TiO_2	0,15 - 0,25	CaO	50,80 - 51,50
Al_2O_3	0,35 - 0,60	SrO	2,70 - 2,90
Fe_2O_3	0,30 - 0,50	Na_2O	0,30 - 0,50
FeO	0,01 - 0,03	K_2O	0,10 - 0,20
P_2O_5	40,00 - 40,30	F2	3,10 - 3,40
Sum TR2 O3	0,85 - 0,95	H_2O	0,10 - 0,20
MgO	0,05 - 0,10		

3. Production of Kola apatite concentrate "Super" using two stage flotation concentration

3.1 Short description of concentrate "Super II" production technology

The defects of concentrate "Super I" production technology, described in section 2.1. necessitated the research to preserve the positive features obtained in concentrate "Super I".

A two-stage cycle of flotated concentrate technology was developed, including a hydrocyclone overflow recleaning after the first step in hydrocyclone of the second stage. Thus, the hydrocyclones of both stages are united and form a final product concentrate "Super II".

Such technology permits increases in output of concentrate "Super" from the concentrate tanks of extraction not only largest, but also intermediate size classes within the specified contents P_2O_5 (see Table 2. 1). This technology was tested in the plant ANOF-2 conditions.

The flow chart for the production of concentrate "Super II" is shown in Figure 3. 1.

Distinctive features of the technology are as follows:

- Initial quantity of flotated concentrate required for the production of concentrate "Super II", was less compared with concentrate "Super I" by 2.6 times;
- The output of the concentrate "Super II" from usual flotated concentrate in comparison with concentrate "Super I" is increased by 22 to 42%;
- The recycled product returned to the production process of normal apatite concentrate indicated in Figure 2.1 is reduced from 418 to 136 t/hour, approximately three times less. In this case, recycled product has lower contents P_2O_5 (38.20%) and class of particles with size more than 0,16-2.0% only.

3.2 Granulation structure of the concentrate "Super II"

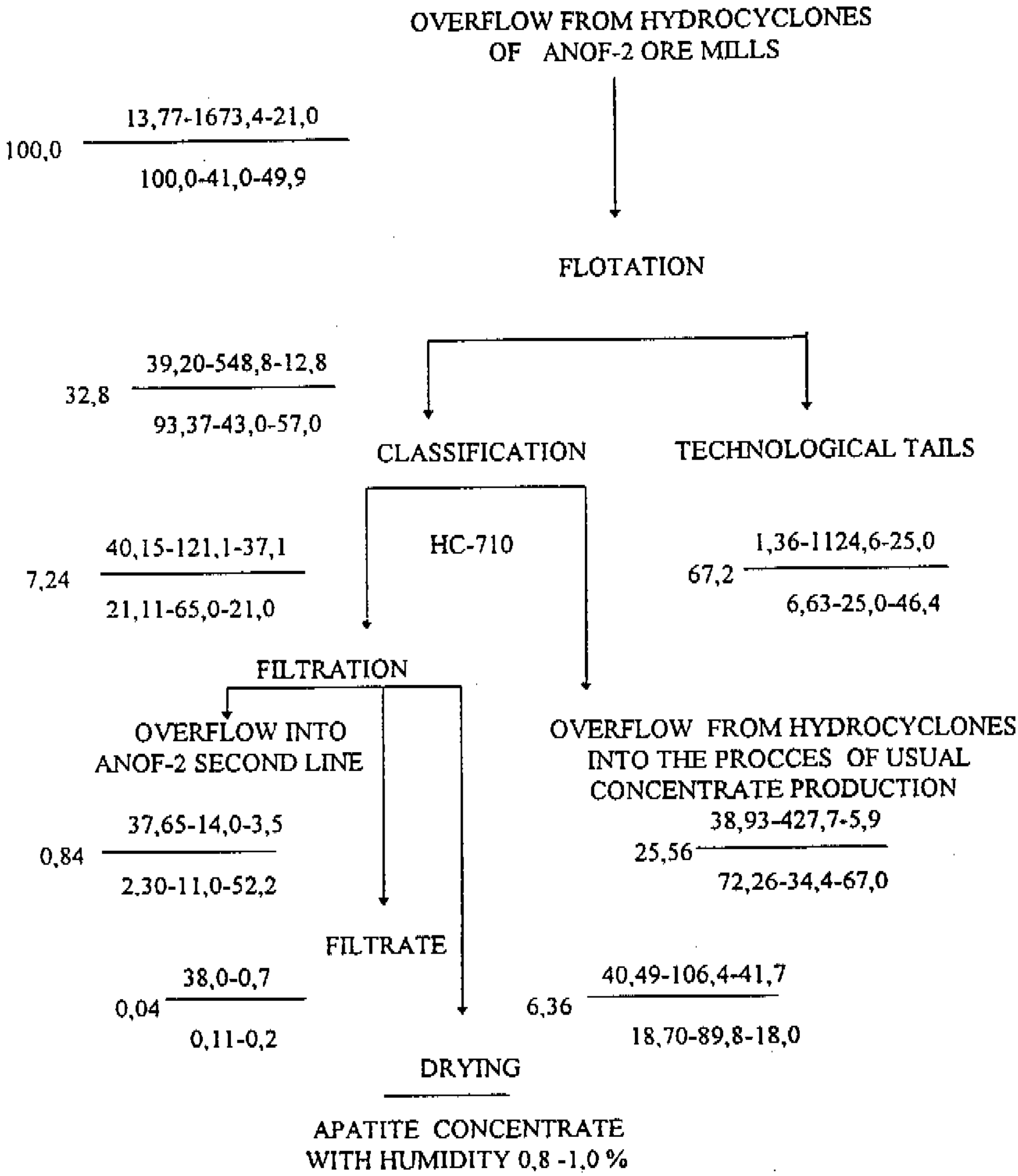
In Table 3.1, we can see the granulation characteristics of all products, obtained from usual flotated concentrate during two stage cycle in the hydrocyclones. The graphs on Figures 3.2 and 3.3 are constructed on the basis of the Table 3.1. It should note, that the particles of the first stage of classification is a concentrate "Super I".

From the indicated data (Figure 3.2), it is clear concentrate "Super II" differs from a concentrate "Super I" mainly by the higher contents of size classes 0.02-0.15 mm and lower contents of classes larger than 0.15 mm. The contents of size classes less than 0.020 mm in both products are approximately the same.

The drawing of size classes extraction from usual flotated concentrate into concentrates "Super I" and "Super II" are indicated on the Figure 3.3.

It is clear from the drawing, that the addition of a second stage of cycle helps to increase the output of the final product by raising all size classes extraction. Thus the largest increase comes with intermediate size classes. It should note also, that the limit size of the median (D50) when changing from one stage into two stage cycle is reduced from 0.11 mm to 0.08 mm.

TECHNOLOGICAL CIRCUIT OF APATITE CONCENTRATE "SUPER I", OBTAINING IN ANOF-2 CONDITIONS



Designations:

	Mass share P_2O_5, %	Productivity t / Hour	Mass share of class > of 0,16 mm, %
Output of concentrate	Extraction P_2O_5	Mass share of solid %	Mass share of class <0,071 mm %

Fig. 2.1

Joint Stock Company «APATIT» **JKSIMMET** 11:00 am Mon Jul 15 1996
User: B A S F Test: concentrate «Super» Layout: layout2

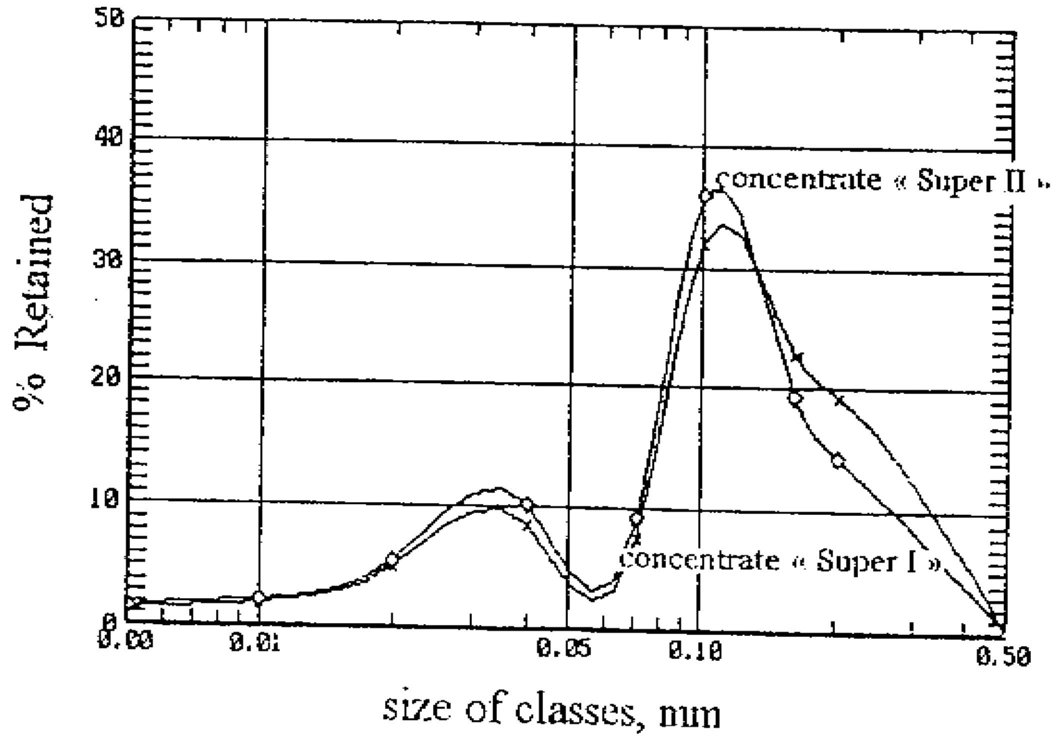


Fig 3.2

Joint Stock Company «APATIT» **JKSIMMET** 11:03 am Mon Jul 15 1996
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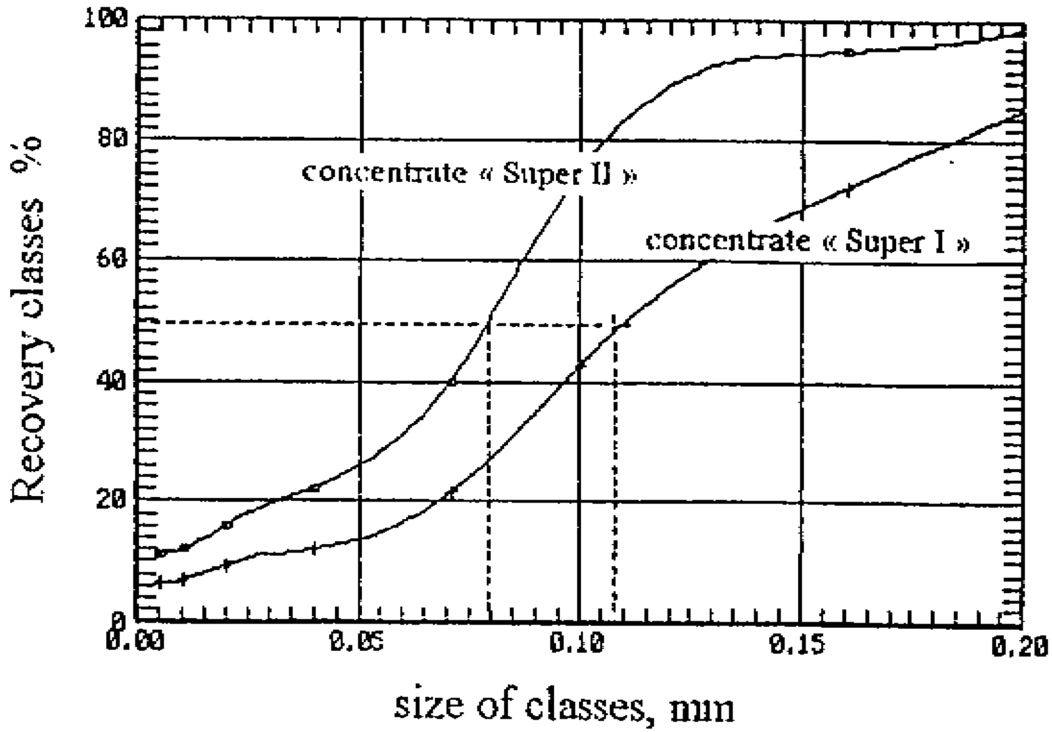


Fig 3.3

Table 3.1. Granulation characteristic of products from two stage usual flotated concentrate classification

Size classes, mm	Mass share of the class, %					
	Flotated concentrate	Overflow of HC one stage	Sands of HC one stage	Overflow of HC two stages	Sands of HC two stages	Apatite concentrate "Super II"
More than 0,200	6,2	1,3	19,2	0,1	5,5	14,2
0,200 - 0,160	8,7	3,3	22,7	0,7	13,0	19,2
0,160 - 0,100	20,6	16,3	31,9	8,9	43,1	36,0
0,100 - 0,071	9,8	10,7	7,5	10,3	12,0	9,1
0,071 - 0,040	19,6	23,8	8,4	26,8	13,0	10,0
0,040 - 0,020	14,7	18,5	4,9	21,9	6,2	5,4
0,020 - 0,010	8,1	10,5	1,9	12,7	2,6	2,2
0,010 - 0,005	5,9	7,6	1,3	9,2	1,9	1,5
Less than 0,005	6,4	8,0	2,2	9,4	2,7	2,4
Output, %	100,0	72,4	27,6	56,9	15,5	43,1

3.3. Mineral structure of concentrate "Super II"

The mineral structure of concentrate "Super II" produced in the ANOF-2 conditions, is indicated in Table 3.2

Table 3.2 - Mineral structure of concentrate "Super II", after two stage cycle on the plant ANOF-2 (26.06.96)

Mineral name	Mineral mass share, %
Apatite	98,3
Nepheline	0,9
Aegirine	0,5
Sphene and Lamprophyllite	0,15
Lepidomelane	traces
Titanomagnetite and Ilmenite	0,1
Feldspar and Hydromica	0,05

It is clear from the comparison of concentrate "Super I" and "Super II", that the mineral structure of both products is practically identical. That is to say, the technology changes in concentrate "Super" production process were not reflected in mineral structure of final product practically.

3.4. Chemical structure of concentrate "Super II"

The complete chemical analysis of concentrate "Super II" structure, as in case with concentrate "Super I" (Table 2.4) was not carried out. However, it practically corresponds with structure of concentrate "Super I" under the contents of such components, as P_2O_5 - 40.45%. Al_2O_3-0,35% and TiO_2-0.13%.

4. Dusting of concentrates "Super I" and "Super II"

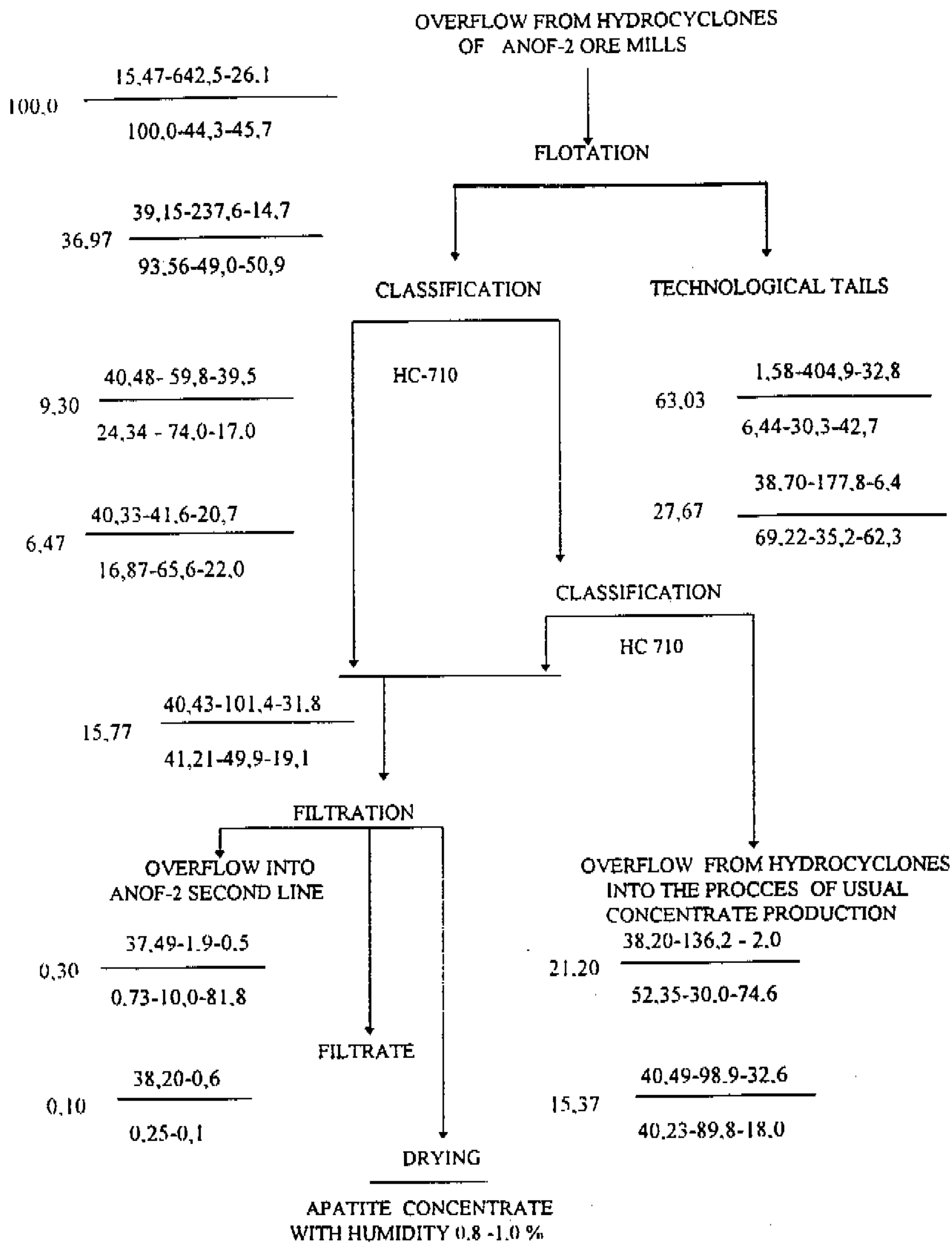
The special tests concerning the dusting of concentrate "Super II" was not conducted. However, the concentrate "Super II" dusting parameters is acceptable our consumers using "Super I".

As described in item 2.2, concentrates "Super I" and "Super II" practically not differ in the contents of fine-dispersion fractions with size less than 0,02 mm which cause large dusting. Therefore, under real conditions concentrate "Super II" in dusting characteristics.

5. Fluidity of concentrates "Super I" and "Super II"

The fluidity of concentrates "Super I" and "Super II" depends of humidity. It was determined under laboratory conditions with a special method, which shows different properties of some loose powdered materials on the basis of the several characteristics. This theory was developed by Karra. Fluidity of a powder estimates on four parameters according with such theory:

TECHNOLOGICAL CIRCUIT OF APATITE CONCENTRATE "SUPER II", OBTAINING IN ANOF-2 CONDITIONS



Designations:

Output of concentrate	Mass share P_2O_5, %	Productivity t / Hour	Mass share of class > of 0,16 mm, %
	Extraction P_2O_5	Mass share of solid %	Mass share of class <0,071 mm %

- corner of natural slope
- compactness
- spatula corner
- agglutination

Each of this parameters consists of a 25-mark system. The sum of marks is the common characteristic of loose powder fluidity. Under the Karra table according the marks sum the working characteristics for different stages of fluidity are determined.

On base of above described method the characteristics of apatite concentrates "Super I" and "Super II" fluidity were determined. The results of these tests are in Table 5.1.

From this data it is clear that apatite concentrates "Super I" and "Super II" have the same fluidity with identical humidity of products. The changes of concentrate "Super" obtaining technology does not practically influence to the fluidity of the final product.

In the Table 5.2, the working characteristics of loose products are listed in depending on the fluidity.

Table 5.2 - Mineral structure of concentrate "Super II", after two stage cycle on the plant ANOF-2 (26.06.96)

Characteristic of fluidity	Working characteristic
Excellent	The material does not hang. Auxiliary equipment is not required
Good	The material does not hang. Auxiliary equipment is not required
Satisfied	The material sags at special conditions. Auxiliary equipment is not required usually
Allowable	The material hangs sometime. Auxiliary equipment may be required
Unsatisfied	Auxiliary equipment, vibration is necessary

6. The conclusion

In this report we try to show briefly some special features of apatite concentrate "Super I" and "Super II" production technology on the basis of classification of the flotated concentrate by size classes.

The main properties of these concentrates are described.

It is visible from the indicated data that the concentrate "Super II", which was obtained by two stage method of classification the normal flotated concentrate in hydrocyclones differs in granulation structure with size classes. larger than 0.02 mm from a concentrate "Super I", which was delivered earlier.

The concentrate "Super II" does not practically differ from the concentrate "Super I" on mineral and chemical structures or dusting and fluidity characteristics.

But the industrial tests confirms that the concentrate "Super II" production technology improves essentially the drying process with stabilization of humidity contents in limits of 0.6 - 1.0 %.

Table 5.1 - Research results of Kola apatite concentrate "Super I" and "Super II" fluidity characteristics

Product	H_2O %	Corner of natural slope		Compactness (C) %				Spatula corner		Agglutination		Homogeneity coefficient		Marks sums	Fluidity characteristics
		degree	mark	loose weight g/sm^3 loose cond.	Compact cond.	C	mark	degree	mark	%	mark	%	mark		
Apatite concentrate "Super I"	1,7	-	0	1,03	1,43	28,0	12	82,5	7	-	-	3,6	23	42	not satisfied
	1,1	-	0	1,17	1,54	24,0	16	72,7	12	-	-	3,6	23	51	not satisfied
	0,6	39,7	18	1,49	1,76	15,3	20	49,0	16	-	-	3,6	23	77	satisfied
	0,0	32,6	21	1,76	1,96	10,2	22	38,2	20	-	-	3,6	23	86	good
Apatite concentrate "Super II"	1,7	-	0	1,04	1,44	27,8	12	80,0	7	-	-	3,8	23	42	not satisfied
	1,5	-	0	1,08	1,50	28,0	12	78,0	7	-	-	3,8	23	42	not satisfied
	1,1	-	0	1,17	1,54	24	16	73,0	12	-	-	3,8	23	51	not satisfied
	1,0	39,5	18	1,41	1,63	13,5	21	55,0	16	-	-	3,8	23	78	satisfied
	0,6	37,8	18	1,64	1,87	12,3	21	46,8	16	-	-	3,8	23	78	satisfied
	0,0	33,0	21	1,73	1,93	10,4	22	38,6	20	-	-	3,8	23	86	good