1931

Size and shape of clay grains as affected by various methods of grinding

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SIZE AND SHAPE OF CLAY GRAINS AS AFFECTED BY VARIOUS METHODS OF GRINDING

by

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A

THESIS

Submitted to the faculty of the

SCHOOL OF MINES AND METALLURGY OF THE UNIVERSITY OF MISSOURI

in partial fulfillment of the work required for the

DEGREE OF

BACHELOR OF SCIENCE IN CERAMIC ENGINEERING

Rolla, Missouri.

1931.

Approved by ________________________________

Professor of Ceramic Engineering

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INTRODUCTION

It is a common belief among those persons manufacturing dry pressed brick that the shape of grain of the clay used for this purpose would materially affect the physical properties of the resultant product. Some believe that clays, dry pan-ground, give a better product than clays disintegrated mechanically or passed through rolls. In some recent dry press investigations[1] it was found that some milling methods gave an advantage over other methods, in the matter of pressure transmission. Due to this, a possible cause for the advantage was attributed to the shape of the grains resulting from the various methods of grinding.

Note.
1. Investigations of the Dry Press Process. E.T. Harvey Report to the Memphis meeting of National Brick Manufacturers Association. February, 1930.

OBJECT

It is our purpose therefore, to ascertain, if possible, just how large a variation in shape of grain is produced by the commonly used methods of milling and in this way see if there is sufficient variation in the shape of these grains to cause the variation in the resultant dry press product.

METHOD OF INVESTIGATION

To determine the variation in shape of grain some basis of comparison has to be established. It is therefore proposed to divide or classify the various shapes of grains as chunky, flaky, and elongated.

Chunky grains are those having all axial dimensions approximately the same value, such as a cube or sphere.

Flaky grains have the dimensions in one plane about the same value but the third dimension is only a small fractional part of the other two dimensions.

Elongated grains have two dimensions approximately the same but the third dimension is greater than that of the other two.

MATERIALS USED

The materials selected for this investigation are the same as those used in other dry press operations. They vary greatly in their physical properties, and cover practically the entire plasticity range used in the dry press process of brick making.

The materials and mixes follow:

1. Semi Flint Clay (b)
2. Missouri No. 1 Flint Clay
3. Grog (a)
4. Cheltenham Clay (b)
5. Semi Flint Clay (b) 92%--Grog (b) 8%
6. Grog (b)
7. North Missouri Semi Flint Clay 92%
   Grog (a) 8%
8. Cheltenham Clay (b) 25%--Missouri No. 1
   Flint Clay 75%

9. St. Louis Surface Clay (red burning loess)

10. Cheltenham Clay (c)

11. North Missouri Semi Flint Clay

12. St. Louis Surface Clay 14.3%--
    Cheltenham Clay (c) 85.7%

13. St. Louis Surface Clay (a)

PRINCIPLES OF GRINDING

There are six principles of grinding, which can be employed in grinding, they are as follows:

1. Compression
2. Rollaction
3. Beam action
4. Impact
5. Attrition or abrasion
6. Slaking action

No method of grinding employs all of the grinding principles. Each method has one or two of the principles as an important factor and may have several minor influencing factors.

The dry pan method of grinding has compression and rollaction as the important grinding factors. Wet pan grinding employs the same principles as does the dry pan. The difference of operation being, the wet pan has no screen plates for the clay to drop through upon reaching a certain size. Water is also added in the wet pan method of grinding and if the cla y is ground too long the clay may begin to slake if the moisture content is great enough. This introduces the principle of slaking action. The principles of grinding in the ball mill method of reducing clay to sufficient size is attrition or abrasion. The rolls have as a primary grinding principle rollaction, there is also compression and some beam action. Impact is the grinding principle in the disintegrator grinding.

METHODS OF MILLING AND SCREENING

Each of the mixes and the single clays were subjected to the different methods of grinding which are as follows: Dry pan, rolls, ball mill wet pan, and disintegrator.

The grinding being continued until the entire sample had passed through 8 mesh. The Cheltenham clay (c) and the St. Louis surface clays were ground until the entire sample had passed through 10 mesh.

The clay and mixes 1, 2, 3, 4, 6, and 11 were ground through 8 mesh by the dry pan, rolls and ball mill methods of grinding. Samples 9 and 10 were ground through 10 mesh by these respective methods. Clays and mixes 5, 7, and 8 were ground through 8 mesh using the dry pan, wet pan, and disintegrator methods of grinding. One sample of number 5 was also dry pan ground through 10 mesh. Materials 9, 10, and 12 were ground through 10 mesh by the dry pan, wet pan and disintegrator methods respectively. Material number 13, St. Louis Surface Clay (a) was ground through 10 mesh by all five of the methods of grinding.

Each batch was quartered to secure a representative sample for screen analysis. The sample was placed in a Tyler Rotap machine for twenty minutes.

The contents of each screen on 10, 14, and 20 were weighed to the nearest one-hundredth of a gram and the percentage retained calculated. The portion through 20 mesh was not studied for it would have required the use of a microscope to differentiate the shape of grains.

The samples taken from the screen analysis were then quartered to secure a representative sample. The sample of each screen analysis was weighed and then separated into flaky, elongated, and chunky grains, these were weighed and the percentage of each calculated on a basis of the whole sample. The representative sample from which the grains were studied contained about 200 to 250 grains.

PRESENTATION OF DATA

The data collected is presented in the tables but it was impracticable to present plots of each individual screen analysis. Average percentage of grain shapes of the three grain sizes for each material were plotted.

Table No. 1 Semi Flint Clay (b) Through 8 Mesh

Mesh	Dry Pan			Rolls			Ball Mill		
	Flaky	Elongated	Chunky	Flaky	Elongated	Chunky	Flaky	Elongated	Chunky
on 10	4.67	15.89	79.44	7.74	25.81	66.45	2.27	30.30	67.43
10-14	6.12	16.3	77.55	14.3	25.00	60.71	9.33	18.66	72.01
14-20	6.42	7.34	86.25	10.7	13.74	75.57	4.00	9.00	87.00
Average	5.74	13.19	81.08	10.91	21.52	67.58	5.20	19.32	75.48

Table No. 2 Missouri No. 1 Flint Clay Through 8 Mesh

	Dry Pan			Rolls			Ball Mill		
Mesh	Flaky	Elongated	Chunky	Flaky	Elongated	Chunky	Flaky	Elongated	Chunky
on 10	7.11	13.39	79.50	8.18	22.73	69.09	4.91	20.86	74.23
10-14	11.93	5.50	82.57	10.59	15.29	74.12	6.59	18.68	74.73
14-20	14.46	6.02	79.52	18.84	8.69	72.47	7.32	7.32	85.36
Average	11.16	8.30	80.53	12.54	15.57	71.89	6.27	15.62	78.10

Table No. 3 Grog (a) Through 8 Mesh

	Dry Pan			Rolls			Ball Mill		
Mesh	Flaky	Elongated	Chunky	Flaky	Elongated	Chunky	Flaky	Elongated	Chunky
on 10	1.67	25.00	73.33	6.99	13.77	79.24	0	25.61	74.39
10-14	1.61	12.90	85.49	5.71	8.58	85.71	0	5.00	95.00
14-20	1.89	7.55	90.56	2.90	5.90	91.20	3.26	6.56	90.18
Average	1.72	15.15	83.13	5.20	9.42	85.38	1.09	12.39	86.52

Table No. 4 Cheltenham Clay (b) Through 8 Mesh

	Dry Pan			Rolls			Ball Mill		
Mesh	Flaky	Elong'ted	Chunky	Flaky	Elongated	Chunky	Flaky	Elongated	Chunky
on 10	2.94	21.57	75.49	4.71	19.80	75.49	4.98	16.74	78.38
10-14	6.25	18.75	75.00	11.43	17.14	71.43	7.50	9.50	83.00
14-20	5.00	10.62	84.38	13.04	11.95	75.01	3.08	4.62	92.30
Average	4.73	16.98	78.29	9.73	16.29	73.98	5.19	10.29	84.52

Table No. 5 Semi Flint Clay (b) 92%-Grog (b) 8%

	Through 6 Mesh									Through 10 Mesh		
	Dry Pan			Wet Pan			Disintegrator			Dry Pan		
Mesh	Flaky	Elongated	Chunky	Flaky	Elongated	Chunky	Flaky	Elongated	Chunky	Flaky	Elongated	Chunky
on 10	9.86	[illegible]	[illegible]	0	10.89	89.11	10.00	32.00	58.00	----	-----	----
10-14	[illegible]	8.20	87.50	0	5.75	94.25	7.41	22.22	70.37	8.55	15.38	76.07
14-20	5.86	[illegible]	89.36	1.89	5.66	92.45	19.61	7.84	72.55	9.00	11.00	80.00
Average	6.67	7.61	[illegible]	.63	7.43	91.94	12.34	20.67	[illegible]	8.77	13.19	78.03

Table No. 6 Grog (b) Through 8 Mesh

	Dry Pan			Rolls			Ball Mill		
Mesh	Flaky	Elongated	Chunky	Flaky	Elongated	Chunky	Flaky	Elongated	Chunky
on 10	0	12.24	87.76	0	18.03	81.97	0	6.90	93.10
10-14	0	[illegible]	[illegible]	0	8.51	91.49	1.08	[illegible]	[illegible]
14-20	1.10	4.60	94.30	1.82	[illegible]	96.36	2.34	2.34	95.32
Average	.36	[illegible]	[illegible]	.61	9.45	89.94	1.54	4.76	93.90

Table No. 7 North Missouri Semi Flint Clay 92%-- Through 8 Mesh
Grog (a) 8%

	Dry Pan			Wet Pan			Disintegrator		
Mesh	Flaky	Elongated	Chunky	Flaky	Elongated	Chunky	Flaky	Elongated	Chunky
on 10	5.42	9.63	84.95	0	11.82	88.18	0	40.96	59.04
10-14	5.72	14.29	79.99	0	10.45	89.55	13.64	27.27	59.09
14-20	5.45	5.45	89.10	0	3.51	96.49	11.11	5.56	83.33
Average	5.53	9.79	84.68	0	8.59	91.41	8.25	24.59	67.15

Table No. 8 Cheltenham Clay (b) 25%-- Missouri No. 1
Flint Clay 75% Through 8 Mesh

	Dry Pan			Wet Pan			Disintegrator		
Mesh	Flaky	Elongated	Chunky	Flaky	Elongated	Chunky	Flaky	Elongated	Chunky
on 10	7.41	17.1	75.54	0	12.36	87.64	8.57	27.14	64.29
10-14	7.22	8.33	84.45	0	1.67	98.33	16.22	29.73	54.05
14-20	6.58	3.95	89.47	0	2.23	97.77	15.39	12.82	71.79
Average	7.07	9.78	83.15	0	5.42	94.58	13.39	23.23	63.38

Table No. 9 St. Louis Surface Clay Through 10 Mesh

	Dry Pan			Rolls			Ball Mill		
Mesh	Flaky	Elongated	Chunky	Flaky	Elongated	Chunky	Flaky	Elongated	Chunky
---	--	--	--	--	--	--	--	--	--
on 14	6.98	13.96	79.06	1.30	12.98	85.82	3.70	9.26	87.04
14-20	1.82	9.09	89.09	2.30	3.45	94.25	4.55	[illegible].82	88.63
Average	4.40	11.52	84.07	1.80	8.22	90.03	4.12	8.04	87.83

Table No. 10 Cheltenham Clay (c) Through 10 Mesh

	Dry Pan			Rolls			Ball Mill		
Mesh	Flaky	Elongated	Chunky	Flaky	Elongated	Chunky	Flaky	Elongated	Chunky
--	--	--	--	--	--	--	--	--	--
on 14	8.33	25.00	66.67	9.80	21.57	68.63	2.33	25.58	72.09
14-20	5.71	11.43	82.86	7.35	13.24	79.41	3.17	9.52	87.31
Average	7.02	18.21	74.76	8.57	17.41	74.02	2.75	17.55	79.70

Table No. 11 North Missouri Semi Flint Clay Through 8 Mesh

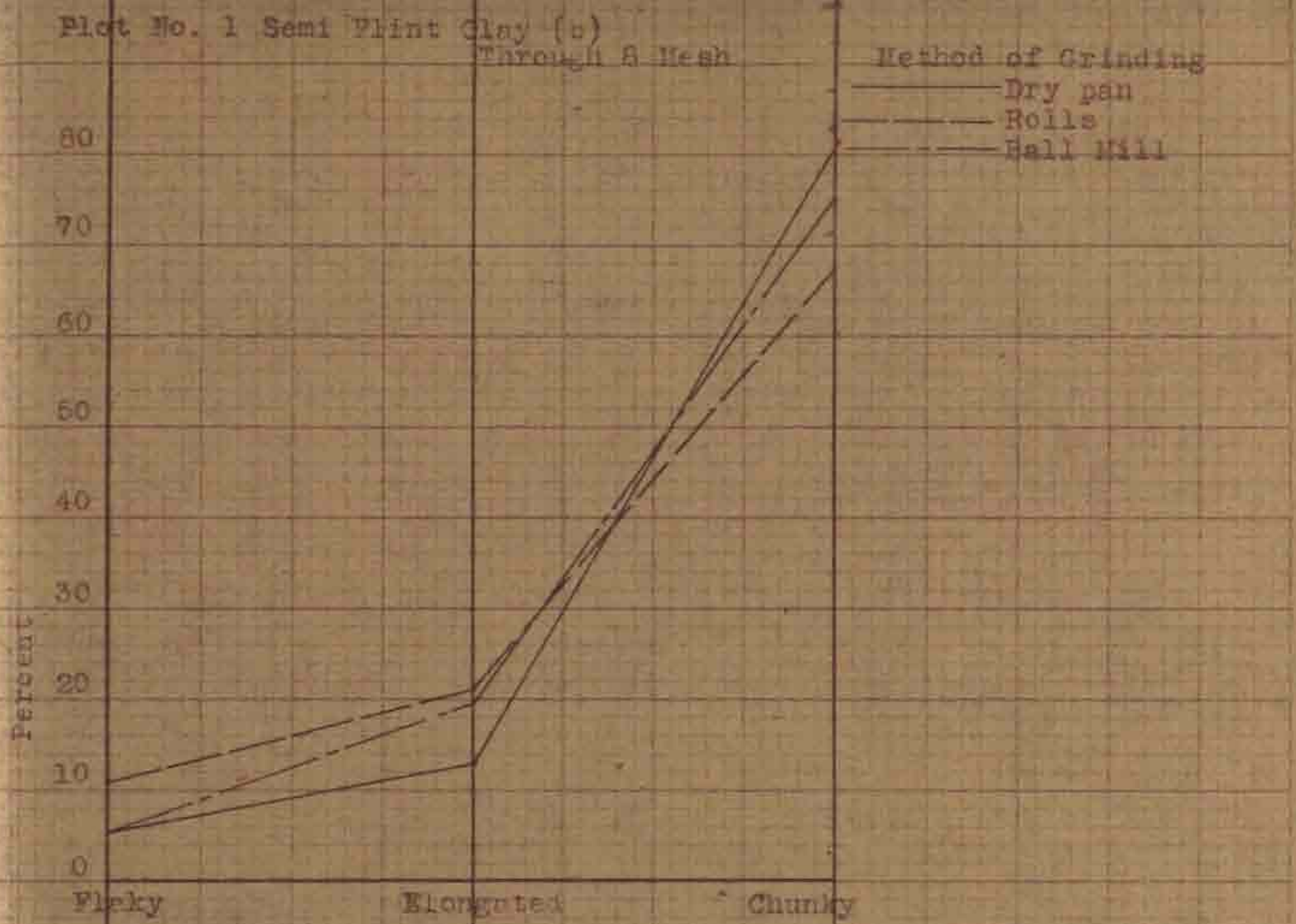
	Dry Pan			Rolls			Ball Mill		
Mesh	Flaky	Elongated	Chunky	Flaky	Elongated	Chunky	Flaky	Elongated	Chunky
on 10	0	36.04	63.96	1.2[illegible]	14.[illegible]	[illegible]	5.17	20.12	74.71
10-14	[illegible].64	[illegible]	[illegible].72	[illegible].17	21.74	[illegible]	[illegible].28	[illegible].02	87.70
14-20	[illegible]	[illegible]	[illegible]	[illegible]	10.5[illegible]	[illegible]	1.16	4.[illegible]	[illegible]
Average	[illegible].99	[illegible]	[illegible].34	[illegible].89	15.6[illegible]	81.42	[illegible].20	11.24	[illegible].55

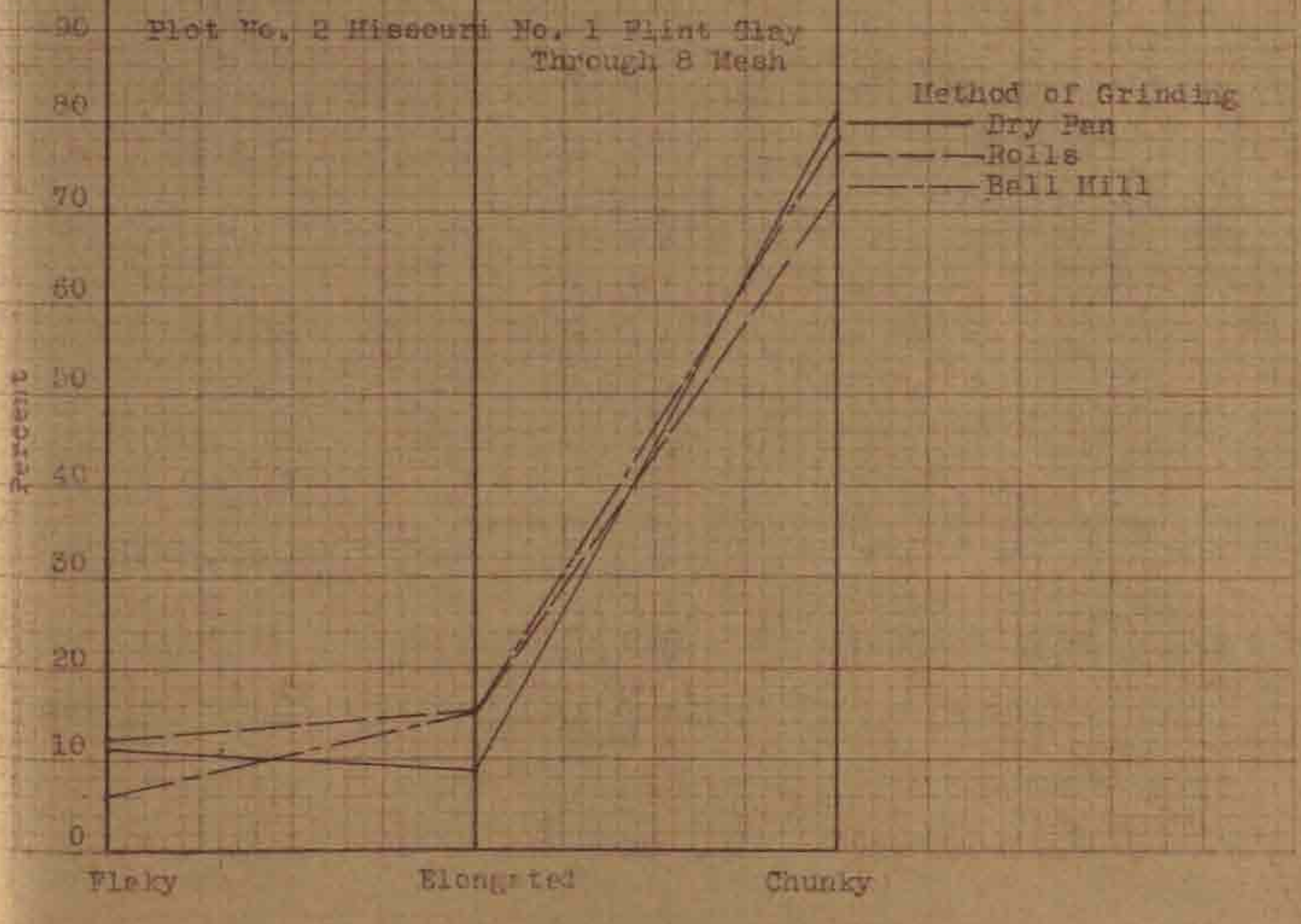
Table No. 12 St. Louis Surface Clay 14.3%-- Cheltenham Clay (c) 85.7% Through 10 Mesh

	Dry Pan			Wet Pan			Disintegrator		
Mesh	Flaky	Elongated	Chunky	Flaky	Elongated	Chunky	Flaky	Elongated	Chunky
--	--	--	--	--	--	--	--	--	--
on 14	7.41	24.07	68.52	0	9.09	90.91	8.69	19.56	71.75
14-20	3.89	11.69	84.42	2.33	2.33	95.35	8.82	20.59	70.59
Average	5.65	17.88	76.47	1.16	5.71	93.13	8.76	20.07	71.17

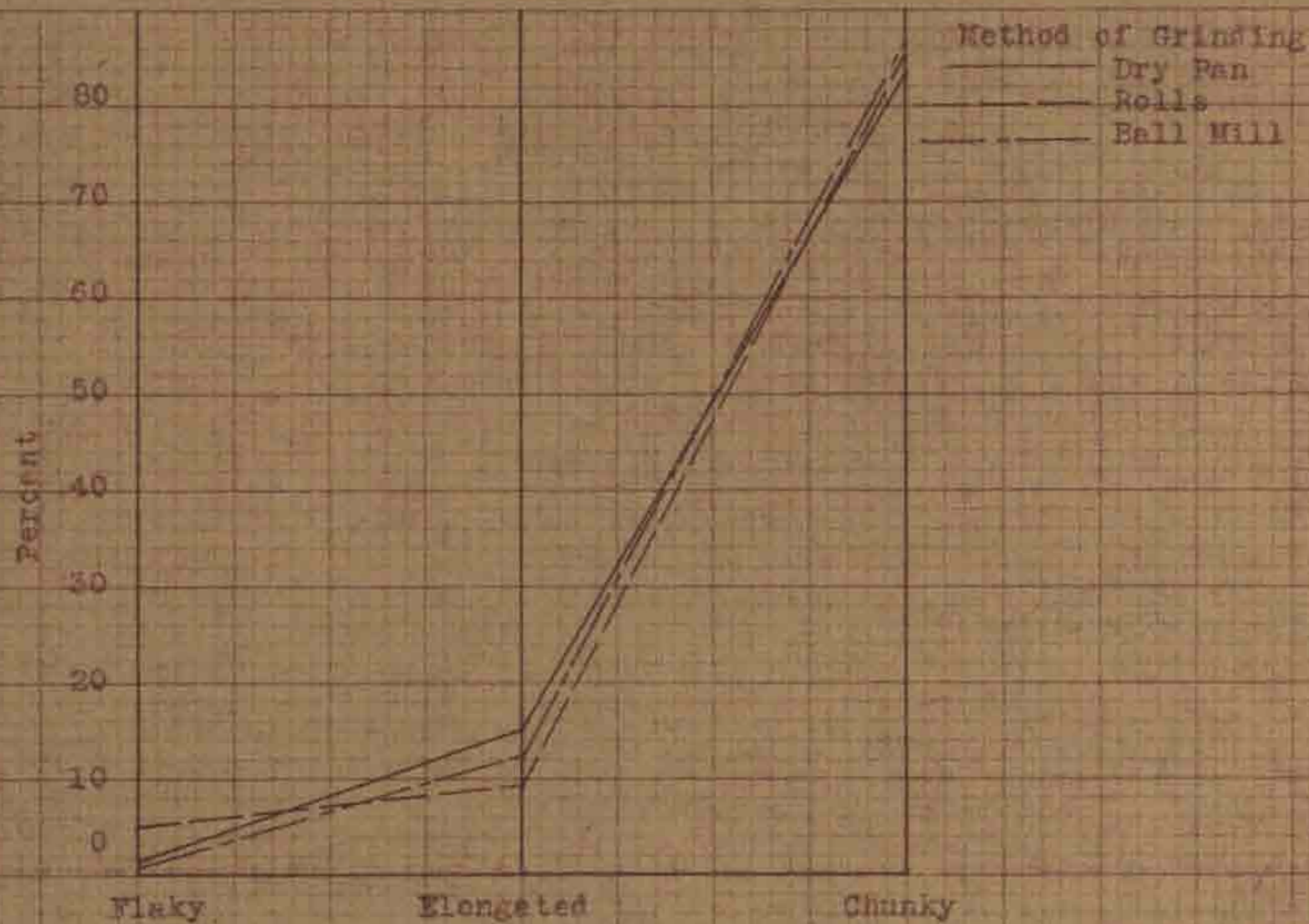
Table No. 13 St. Louis Surface Clay (a) Through 10 Mesh

	Dry Pan			Rolls			Ball Mill			Wet Pan			Disintegrator		
Mesh	Flaky	Elongated	Chunky	Flaky	Elongated	Chunky	Flaky	Elongated	Chunky	Flaky	Elongated	Chunky	Flaky	Elongated	Chunky
--	--	--	--	--	--	--	--	--	--	--	--	--			
on 14	3.12	14.06	82.82	2.86	10.00	87.14	2.63	11.41	85.96	1.89	3.77	94.34	0	9.30	90.70
14-20	1.52	6.06	92.42	3.06	3.06	93.88	2.83	2.83	94.34	1.78	3.58	94.64	3.70	3.70	92.60
Average	2.32	10.06	87.62	2.96	6.53	90.51	2.73	7.12	90.15	1.83	3.67	94.50	1.85	6.50	91.65

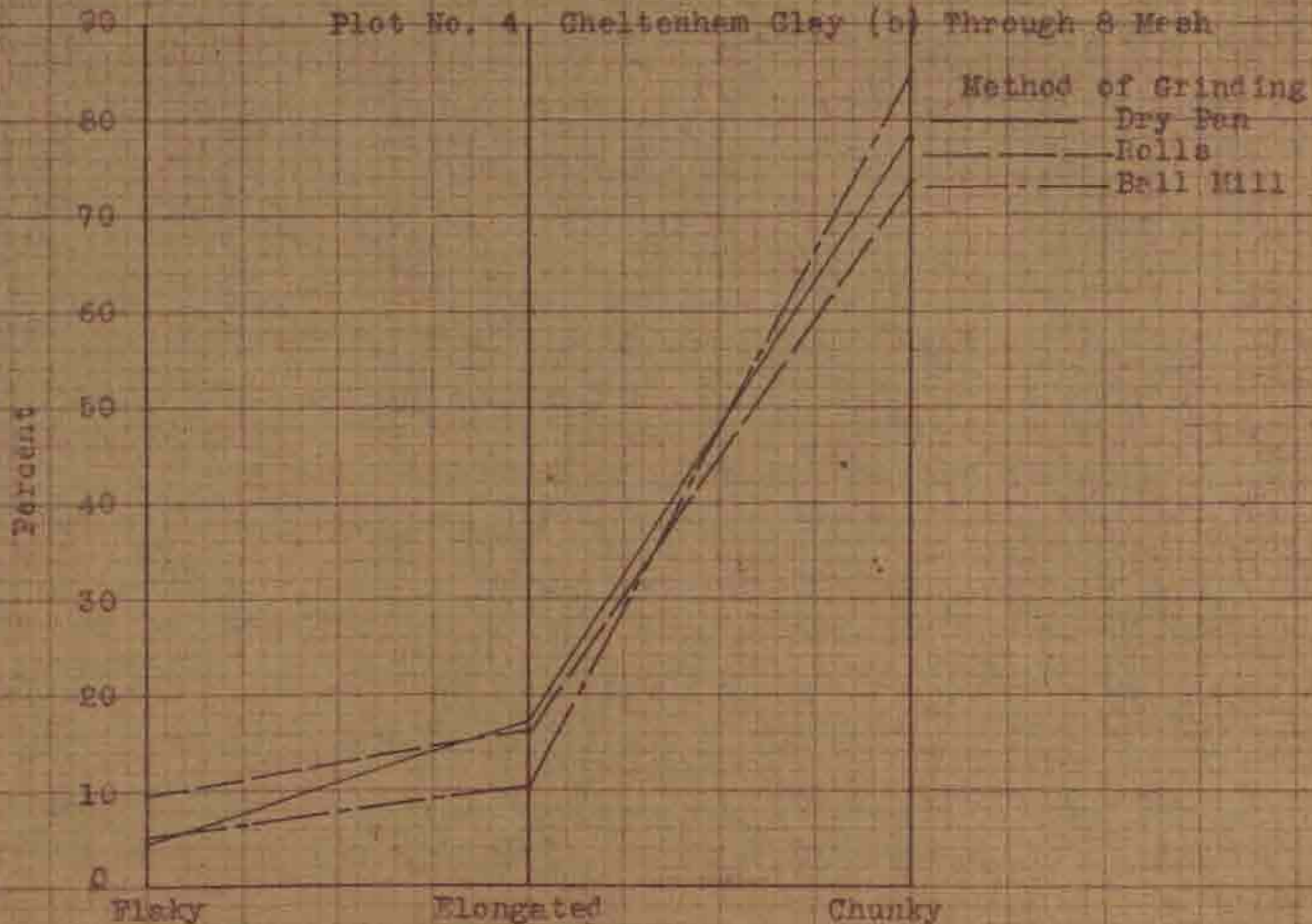

Plot No. 1 Semi Flint Clay (b)
Through 8 Mesh
Method of Grinding
Dry pan
Rolls
Ball Mill
Percent
80
70
60
50
40
30
20
10
0
Flaky
Elongated
Chunky

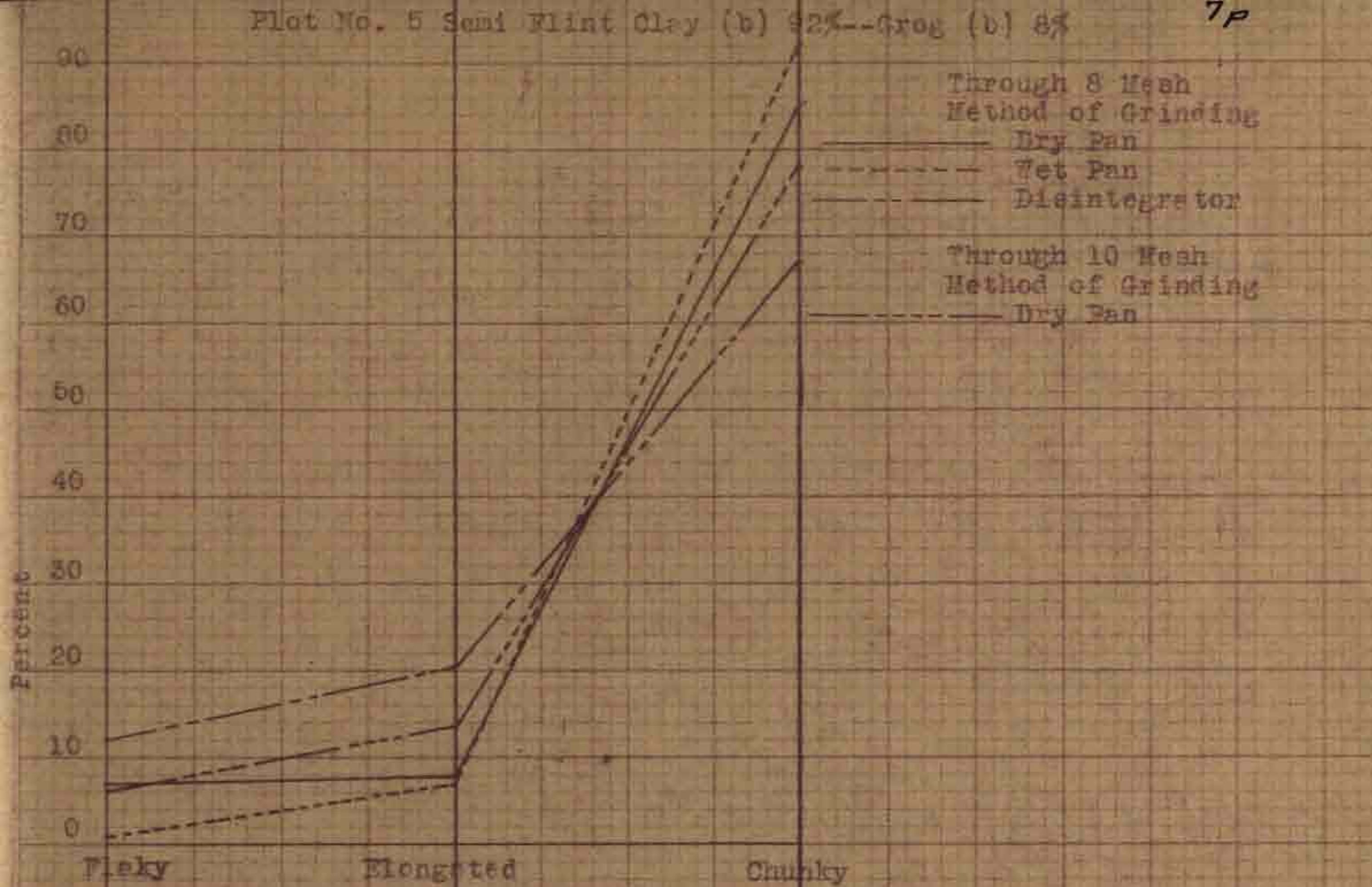

Plot No. 2 Missouri No. 1 Flint Clay
Through 8 Mesh
Method of Grinding
Dry Pan
Rolls
Ball Mill
Percent
90
80
70
60
50
40
30
20
10
0
Flaky
Elongated
Chunky

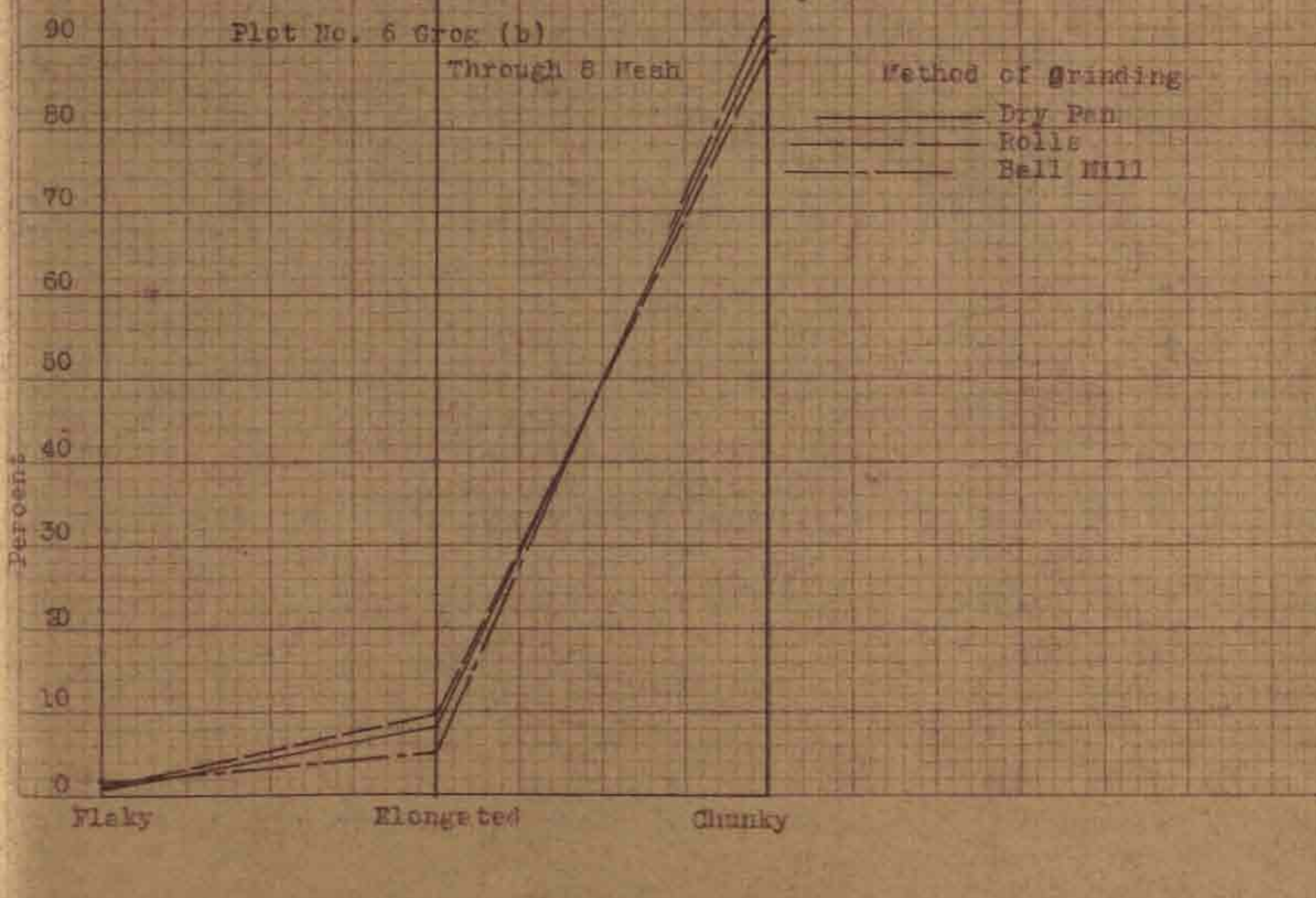
Plot No. 3 Grog (a) Through 8 Mesh

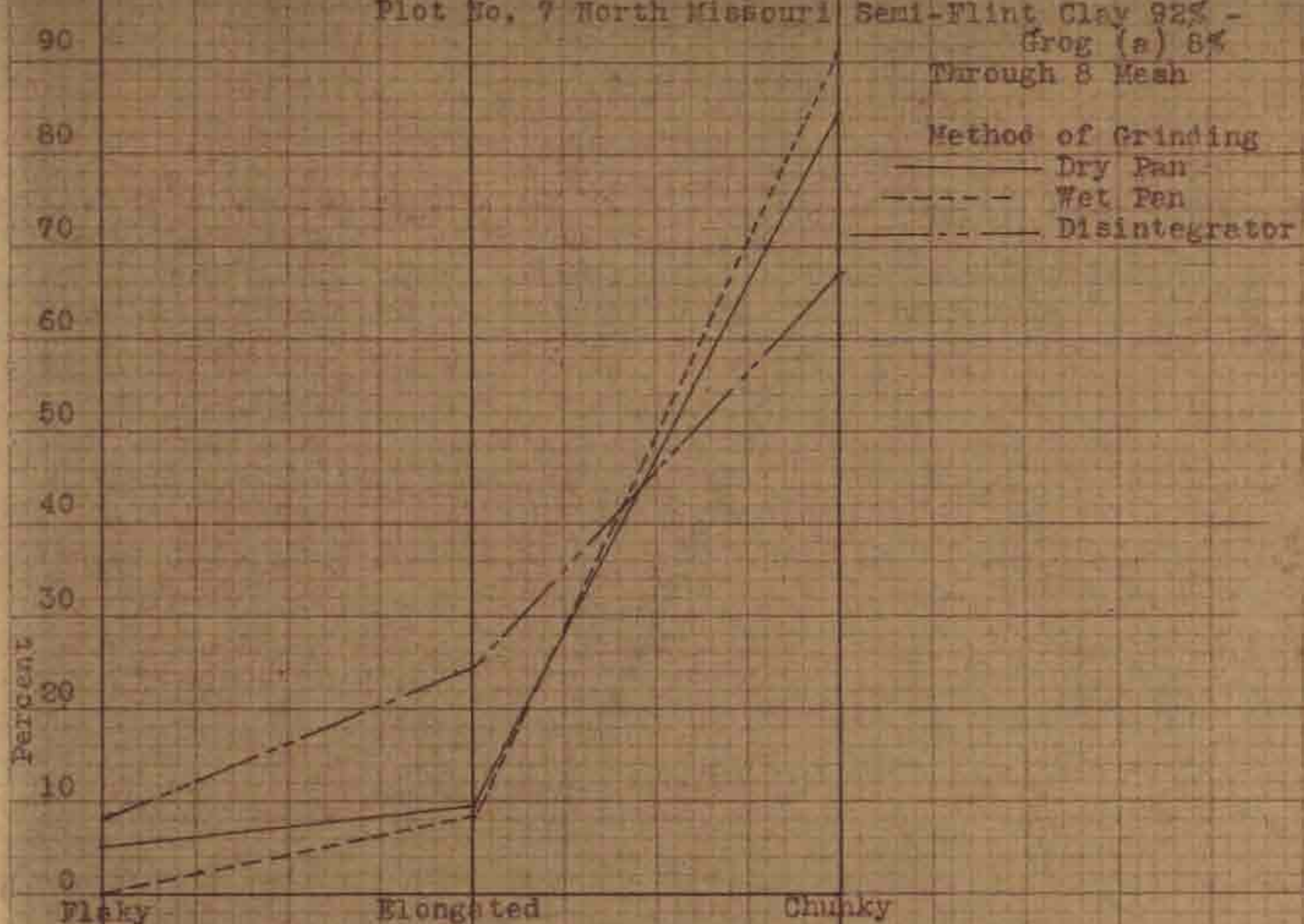


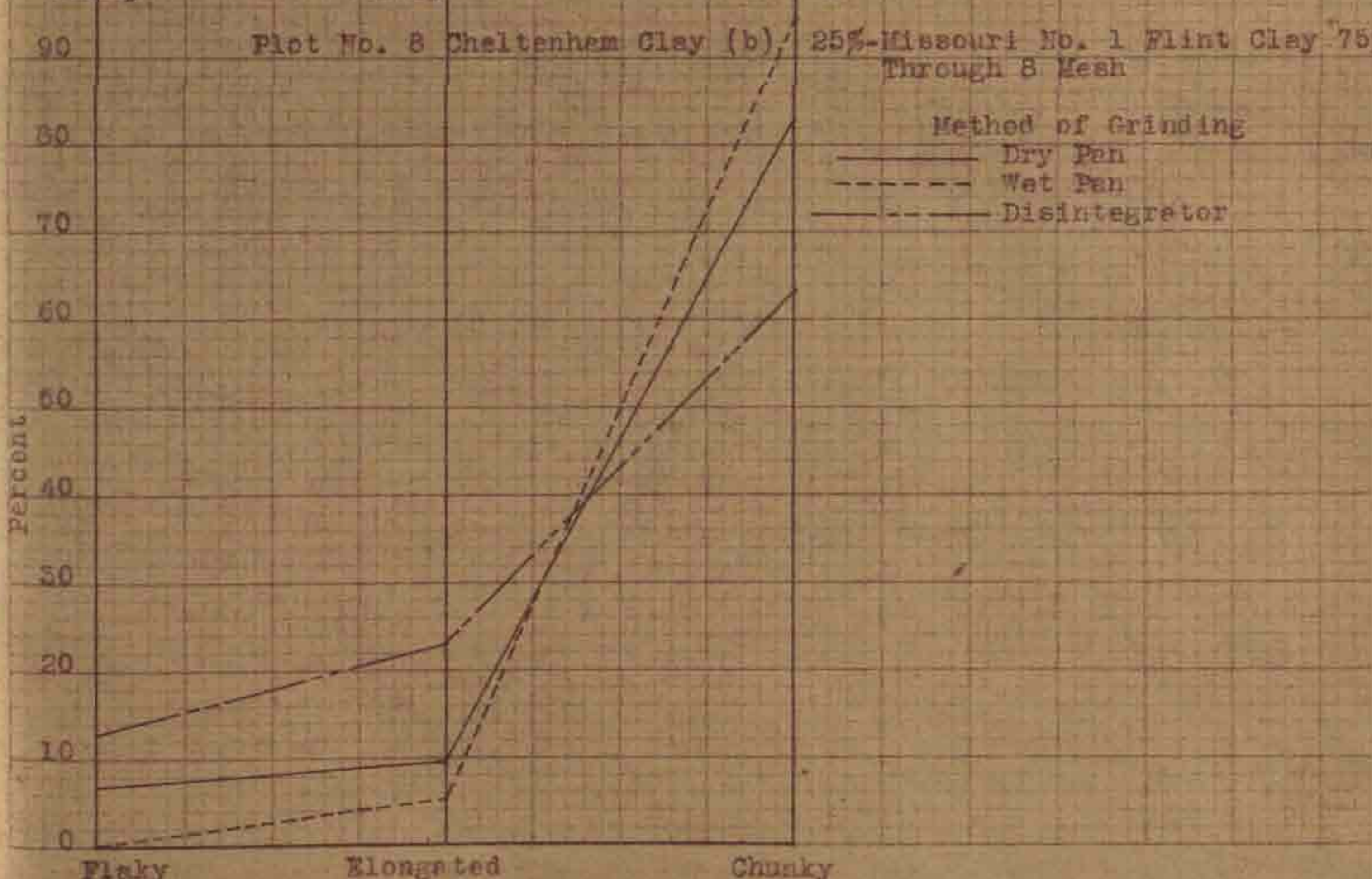
Plot No. 4 Cheltenhem Clay (b) Through 8 Mesh



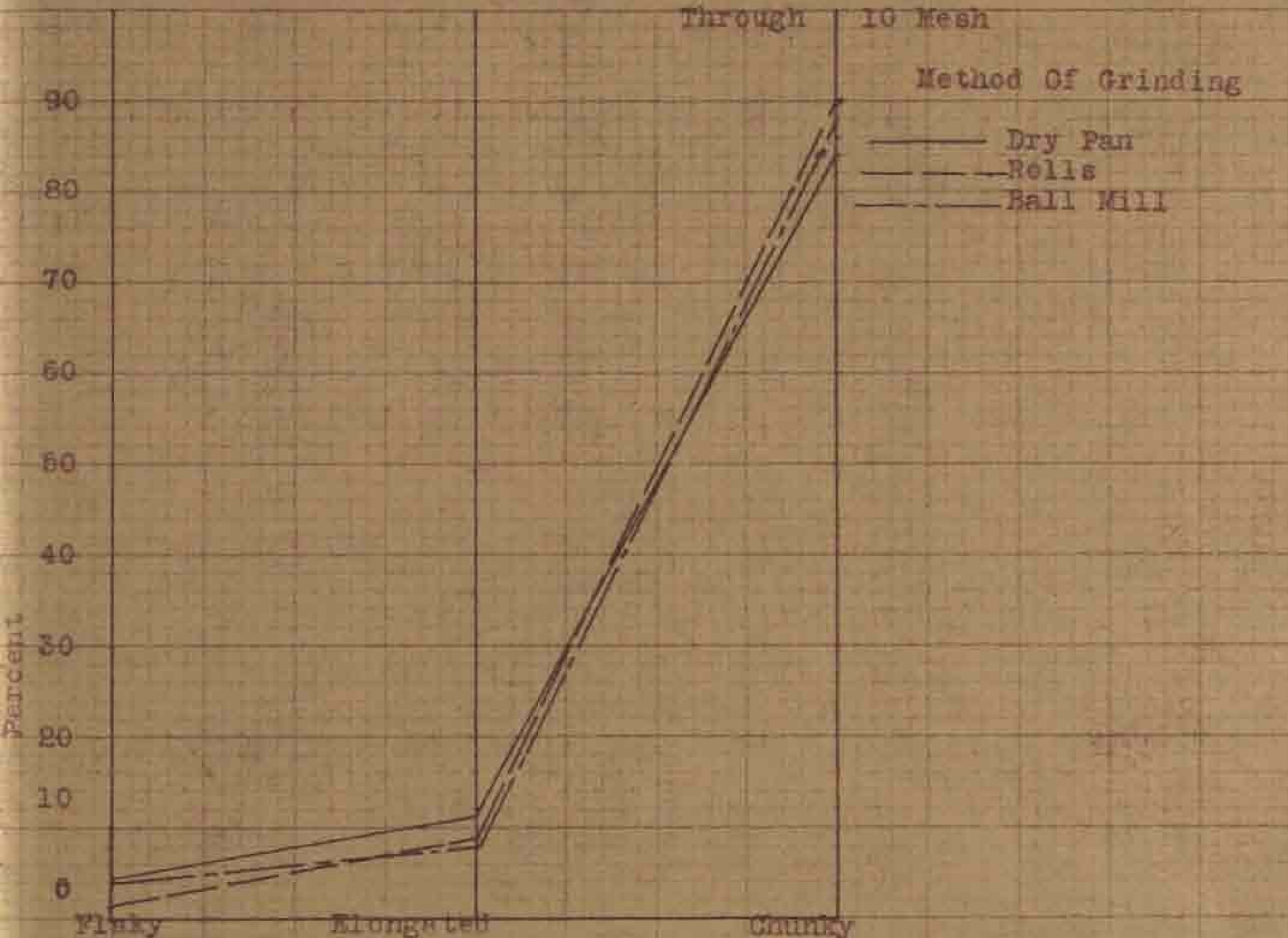

Plot No. 5 Semi Flint Clay (b) 92%--Grog (b) 8%
Through 8 Mesh
Method of Grinding
Dry Pan
Wet Pan
Disintegrator
Through 10 Mesh
Method of Grinding
Dry Pan
Percent
0
10
20
30
40
50
60
70
80
90
Flaky
Elongated
Chunky


Plot No. 6 Grog (b)
Through 8 Mesh
Method of Grinding
Dry Pan
Rolls
Ball Mill
Percent
0
10
20
30
40
50
60
70
80
90
Flaky
Elongated
Chunky

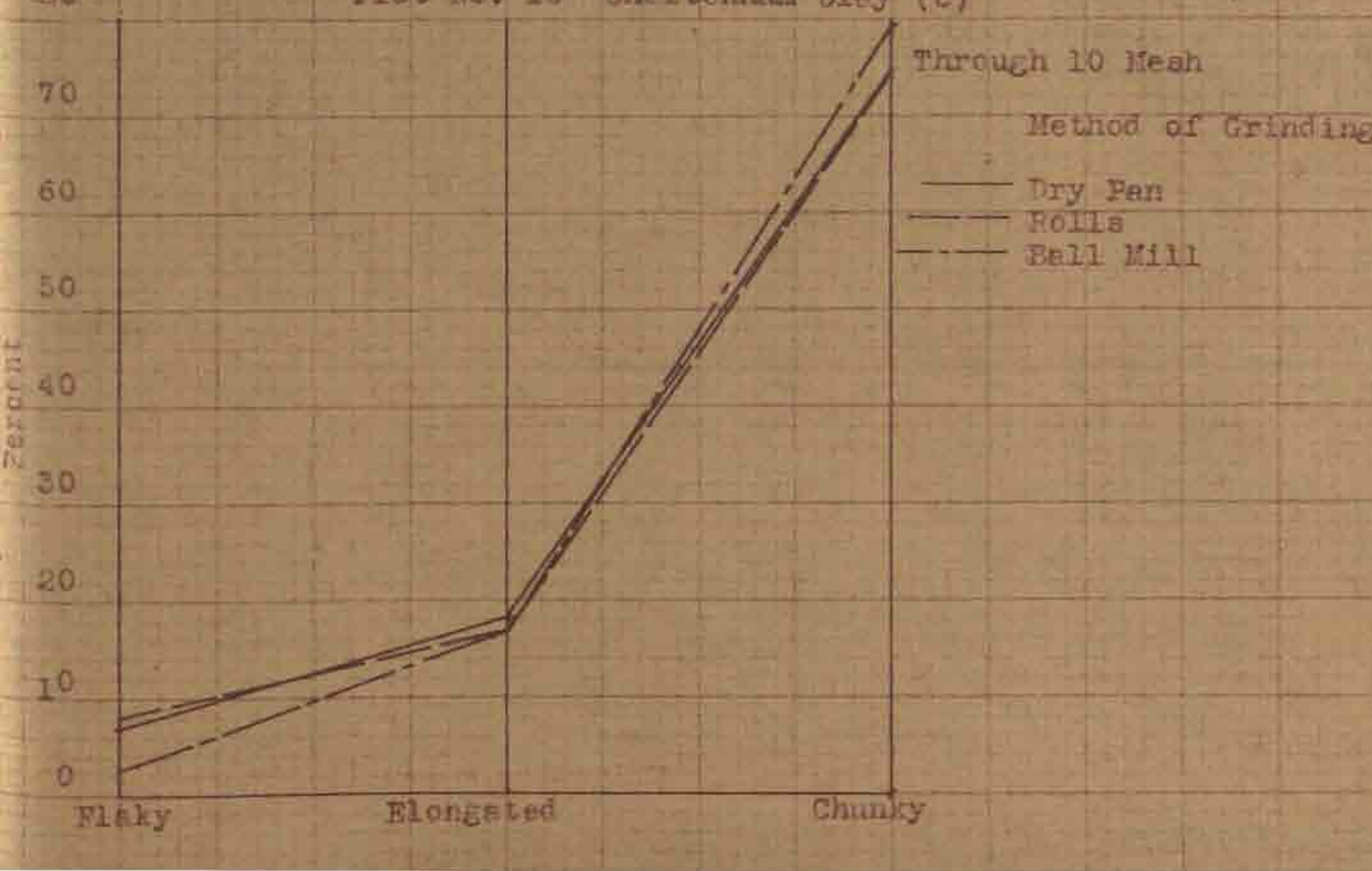

Plot No. 7 North Missouri Semi-Flint Clay 92% - Grog (a) 8%
Through 8 Mesh
Method of Grinding
Dry Pan
Wet Pan
Disintegrator
Percent
0
10
20
30
40
50
60
70
80
90
Flaky
Elongated
Chunky


Plot No. 8 Cheltenham Clay (b), 25%-Missouri No. 1 Flint Clay 75
Through 8 Mesh
Method of Grinding
Dry Pan
Wet Pan
Disintegrator
Percent
0
10
20
30
40
50
60
70
80
90
Flaky
Elongated
Chunky

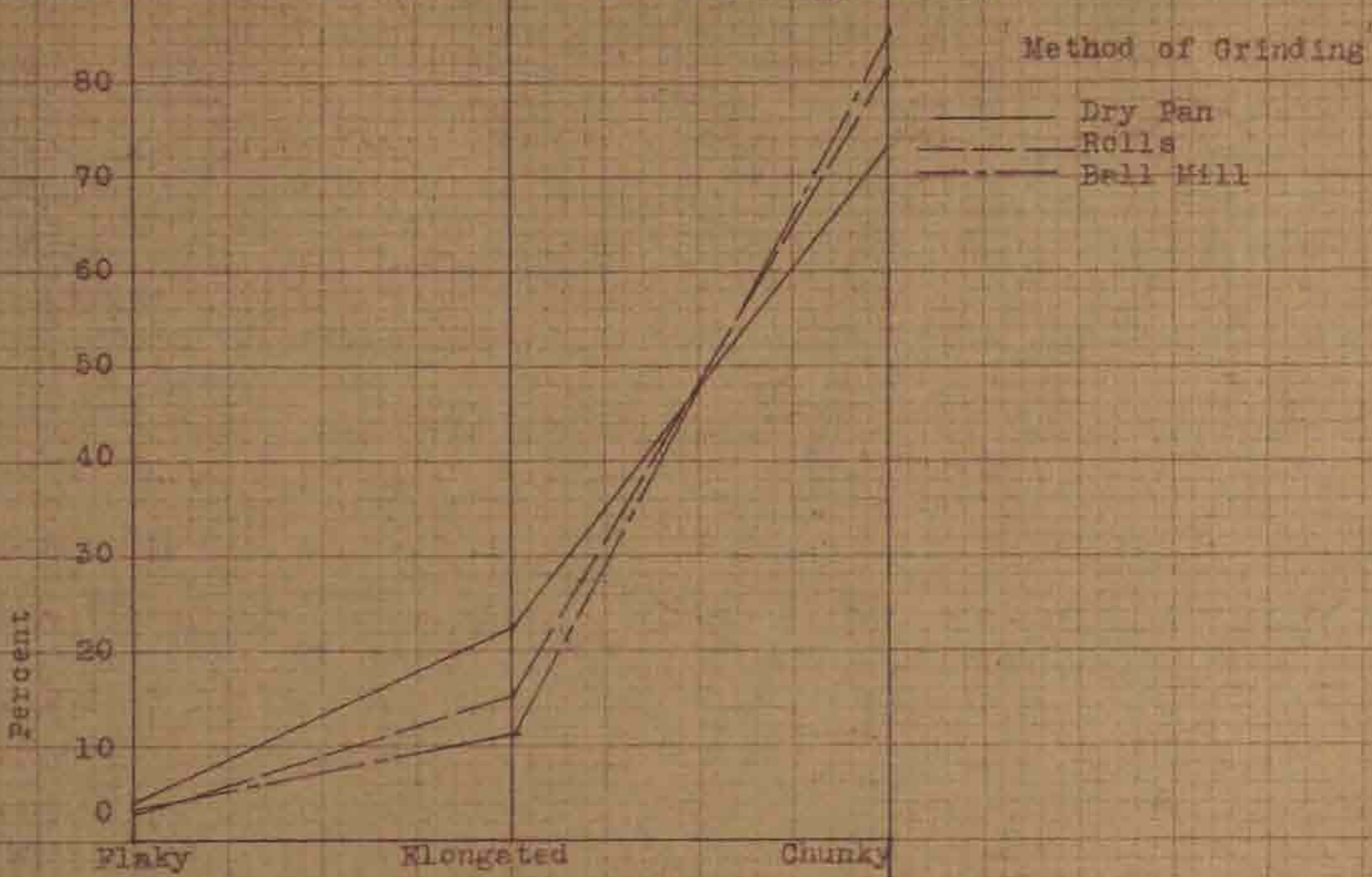
Plot No. 9 St. Louis Surface Clay



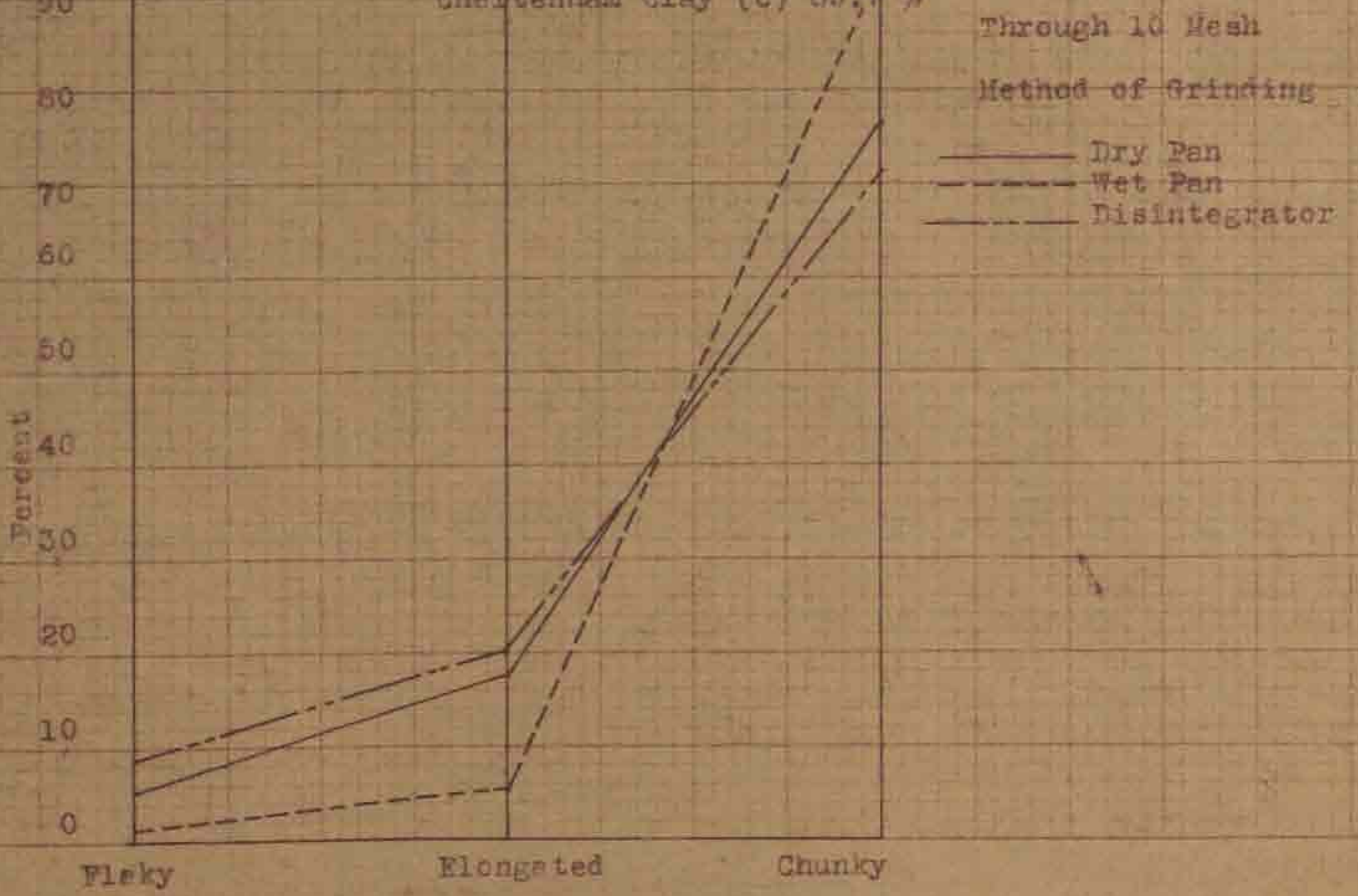
Plot No. 10 Cheltenham Clay (c)



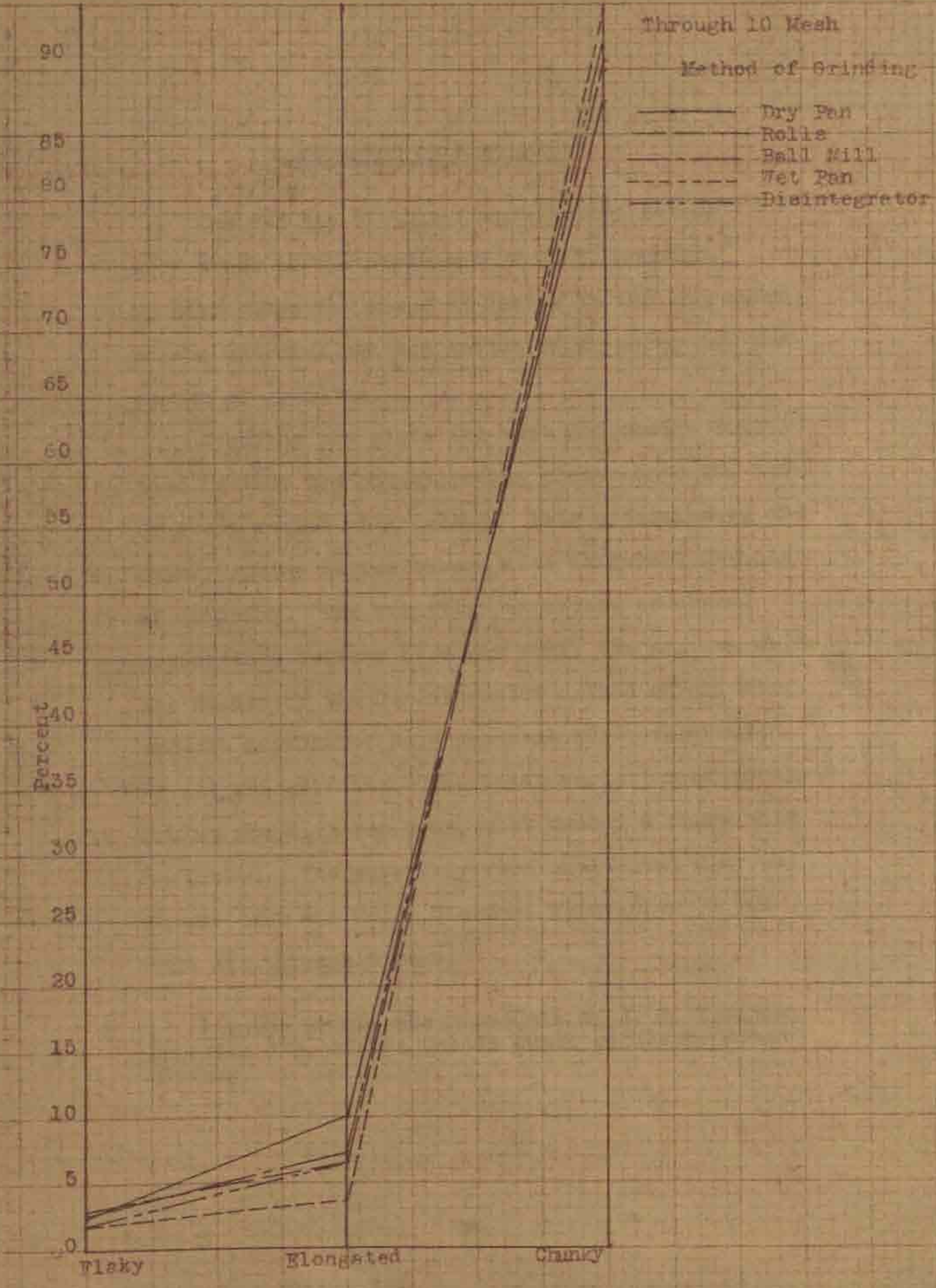
Plot No. 11 North Missouri Semi-Flint Clay
Through 8 Mesh



Plot No. 12 St. Louis Surface Clay 14.3% -
Cheltenham Clay (c) 85.7 %



Plot No. 13 St. Louis Surface Clay (a)



DISCUSSION OF RESULTS

The results of this investigation follow very close to the statement of J. F. McMahon.[1] He attributes the shape of grains to the character of the material and the method of grinding and the amount of grinding.

Studying the plots the most noticeable condition is that the chunky grains predominate the result of every method of grinding. This predominance of chunky grains varies though with different methods of grinding. The variation in amount of chunky grains lies between 63.4 per cent, the minimum which was caused by the disintegrator method of grinding and the maximum of 94.6 per cent which was caused by wet pan grinding. The total variation of chunky grains was 31.2 per cent, plot number 8 shows this variation. The materials were Cheltenham Clay (b) 25 per cent and No. 1 Missouri Flint Clay 75 per cent all through 8 mesh.

1. Texture of Ceramic Materials by J. F. McMahon. Bulletin 672, of the Canada Dept. of Mines, Mines Branch.

The variation between the maximum and minimum percentage of elongated grains was 20.83 percent. The maximum was 24.5 percent where disintegrator grinding was employed. This is shown on plot 7. The material was of the composition 92 percent North Missouri Semi-Flint Clay and 8 percent grog. The minimum percentage is shown on plot 13, which was that of St. Louis Surface Clay (a) resulting from wet pan grinding.

The disintegrator and wet pan grinding methods also produce the highest and lowest percentage of flaky grains respectively. This may be seen by again refering the reader to plot number 8.

Since several plots have been pointed out in the discussion of maximum and minimum percentage of grain shapes resulting from different grinding methods it shall also be pointed out that plots 2, 3, 6, 9, 10, and 13 show very little variation in grain shapes as the result of the grinding method employed, rolls, dry pan, and ball mill grinding were the grinding methods used.

The remaining seven plots which are 1, 4, 5, 7, 8, 11, and 12 show a variation of more than 10 percent in grain shapes due to different grinding methods used.

The curves show the results of grinding when rolls are used to be very nearly the same in every case. The percentage of flaky, elongated and chunky grains is not a constant amount, but one can see that the shape of the curves are almost identical, there being a small percent of flaky grains, with a small gradual increase to elongated grains and then the curve steepens to the percent of chunky grains which predominate for every method of grinding.

In grinding with rolls the grinding principle is rollaction, a small part of the grinding is also due to compression. It seems reasonable to state that grinding in which rollaction and compression are employed would produce grains which are flaky and elongated. There is no abrasion which would cause the grains to become round. As the clay is ground to smaller grain sizes the chunky grains begin to predominate and the longer the clay is ground to reduce it in size the amount of flaky and elongated grains are decreasing. The amount of flaky and elongated grains produced by grinding with rolls also depends upon the character of the clay. St. Louis Surface Clay will always have chunky grains predominating. This clay in it's natural state occurs as round or chunky grains. The clay crumbles easily and thus being easy to grind will, not alter the original grains shape to any great extent for the clay has under gone very little strain in grinding. In keeping with the statement that sufficient grinding of any clay will cause the chunky grains to increase, it may be stated that the surface clay upon the first application of grinding would have more chunky grains than the clay in its natural condition. This statement would not be true for clays which are brittle or tough and of large enough grain size to cause the grains to shatter.

The curves showing the resulting effects when employing the dry pan method of grinding vary considerably. Some of the curves take the same form as those showing the results of grinding with rolls. The curve showing the results of dry pan grinding

Missouri No. 1 Flint Clay, brings out a characteristic which is entirely different from the other curves, in that there is a decrease in elongated grains. The curve starts with about 11 per cent of flaky grains and decreases to 9 per cent of elongated grains and then increasing to the chunky grains which predominate. Naturally this result is attributed to the method of grinding and character of clay.

The main principles employed in dry pan grinding are compression and rollaction. In grinding such a clay as Missouri No. 1 Flint Clay which is hard and upon being ground would tend to break with a concoidal fracture will have more flaky and elongated grains, as will be noticed if one would examine table number 2. In looking over this table, it will be seen that the flakiness of grains increases as the grains become smaller and the amount of elongated grains decreases. As stated before, Missouri No. 1 Flint Clay is hard and it requires more grinding to put the clay through 8 mesh than a clay such as Cheltenham or the St. Louis Surface Clays, for this reason the chunky grains predominate, since the flaky and elongated grains have had ample opportunity to be converted to chunky grains.

Curves showing the results of the wet pan method of grinding bring out an interesting point that there are very few flaky grains regardless of what kind of clay was ground. The predominance of chunky grains is also less.

Wet pan grinding employs the same principles as that of the dry pan grinding. The difference in actual grinding is that the pan does not contain screen plates, and water is added. If the grinding is carried on sufficiently long the clay will begin to slake, the result being to break down the flaky and elongated grains and an increase in chunky grains brought about by rollaction on the moist clay.

The ball mill method of grinding employs the principle of attrition to reduce the size of the clay grains. So when having attrition or abrasion as the principle of grinding one would immediately think that there would be very few flaky and elongated grains. From the plots this is usually true, that the percent of flaky grains is less than that of any of the other methods of grinding.

The above reasoning does not always hold for elongated grains. If one will look at the tables and compare percentage of elongated grains for the three different screen analysis and ball mill grinding with respective screen analysis of the other milling methods used, it will be seen that there is a greater decline in elongated grains as the size of grain decreases. This rapid rate of decline is not approached by any of the other methods of grinding. Therefore the plots may not always bring out the fact that there would be a smaller per cent of elongated grains. One can see though by examining the individual data for each screen analysis and grinding method, that the chunky grains increase rapidly upon increased grinding. This increase is greater for ball mill grinding than for other methods of grinding.

The disintegrator method of grinding employs the principle of impact to grind the clay. There is a continuous shattering of clay grains until the clay has been reduced to sufficient size to pass through 8 or 10 mesh. With the disintegrator method of grinding now in mind, it will be easy to see why the resulting per cent of flaky and elongated grains is greater with this method of grinding and less predominence of chunky grains. The tabulated results, of grinding with a disintegrator, more plainly show the effect of the amount of grinding; there being a great increase of chunky grains on 20 mesh as compared to the per cent of chunky grains on 10 mesh screen.

A clay such as St. Louis Surface Clay which can be crumbled in the hands shows very little effect of elongated and flaky grains being in greater percentage when compared with the other methods of grinding the same clay. This can be attributed to the clays loose structure. Tough, hard, and brittle clays show the opposite results.

It has been stated that the shape of grains depends partly on the structure of the clay as well as upon the method of grinding. While discussing the results, with reference to the effect of grinding, something was also mentioned about the clay characteristics. It is deemed advisable to discuss the results of grinding with respect to character of clay even though there may be slight repetition of statements.

The St. Louis Surface Clay is a clay as the name indicates occurring as surface deposits in the St. Louis area, known as loess. This clay was deposited by the wind and its natural grain shape is such that the chunky or round grains predominate, due to the method of deposition. The original deposits have undergone no physical changes so there will be no alteration of grain shapes to change them to any other shape than chunky. The clay is loose and requires very little external force to reduce the size of the clay grains so they will pass through 8 or 10 mesh. Since this clay is easy to grind, there should be very little change in the resulting grain shape from original grain shape.

The Missouri No. 1 Flint Clay is hard and compact, and on breaking will break with a concoidal fracture. The clay when ground will have many flaky and elongated grains due to its being hard and its tendency to break with a glassy fracture.

The North Missouri Semi Flint Clay is compact but is not as hard as flint clay and does not break with a concoidal fracture, so, upon grinding, it should have less flaky and elongated grains.

Cheltenham clay is compact, but is slightly softer than Semi Flint Clay. The clay does not break with a concoidal fracture. There should be very little difference in the resulting grain shapes when compared with Semi Flint Clay. It might be stated that, due to this clay being slightly softer, there should be less flaky and elongated grains, but to no very noticeable extent.

When comparing the tabulated results of the different materials with respect to the three screen analysis, it will be seen that as the grain size decreases, the amount of chunky grains increases. The results are just opposite for elongated grains, for as the grain size decreases the amount of elongated grains also decrease in almost every case.

The tabulated results showing the per cent of different grain shapes for the three screen analysis bring out that no definite statement as has been made above could hold. The amount of flaky grains increases as the grain size decreases when the material is Missouri No. 1 Flint Clay. The clays that are more compact bring out the results to the greatest extent, but even loess shows the same results in a much modified degree. The method of grinding seems to also exert some tendencies on the amount of flaky grains either increasing or decreasing. The flaky grains increase in amount with a decrease in the size of the grains when the grinding is done with a disintegrator. With wet pan grinding there is a very slight tendency toward the per cent of flakiness of grains increasing. There is no definite statement which can be made when the grinding is dry pan, rolls, and ball mill. The variation in most cases is very small and it seems possible that the determining factor governing whether the flakiness of grains increases or decreases with decrease in grain size, would be the character of the clay.

CONCLUSIONS

The results show that the methods of grinding employed and the character of the clay have an effect on the resulting grain shapes produced when the clay is ground. Although the results show that the resulting grains, for some methods of grinding, will vary but little.

The curves have such a shape that there is a gradual increase in percentage of elongated grains and the chunky grains always predominating. The results of wet pan grinding have a more noticeable effect on the shape of grains produced, in that there is a very small per cent of flaky and elongated grains. There are no flaky grains at all in some cases and the chunky grains are in larger preponderance than for any of the other grinding methods. Disintegrator grinding has just the opposite grinding effect.

The character of the clay has an influence on the shape of the resulting clay grains when ground. When a clay is compact and hard, it will shatter upon being ground and the grains will be more flaky and elongated. A clay which breaks down easy, as for example St. Louis Surface Clay, will have few flaky and elongated grains.

When comparing the percentage of grain shapes with respect to the three different screen analysis which were on 10, through 10 and on 14, or through 14 and on 20, the smaller the size of the grains the greater was the per cent of chunky grains. Therefore the grain of any material can be rounded by sufficient grinding, employing any method of grinding.[1]

1. Texture of Ceramic Materials by J. F. McMahon, Canada Dept. of Mines, Mines Branch. Bulletin 672.

ABSTRACTS

Canada Dept. of Mines, Mines Branch Bulletin No. 672, Texture of Ceramic Materials by J. F. McMahon.

Round-Shaped Grains. Many materials such as some silica sands occur as round grains in nature, but the grains of any material can be rounded by sufficient grinding, either in ball mills, or even in wet pans. Therefore the product from any grinding apparatus is apt to be rounded grains.

Angular-Shaped Grains. These are the product of crushing machines. Any device that does its work with one or two blows and then sends its material on to the next operation tends to break down the shape of the particle and not wear its corners down as is the case with grinders.

Flaky grains are peculiar to certain types of material, and rather than being the product of machinery (that is to say controllable) are products of nature.

Clay grains (the ultimate grain of clay) are thought to have a platy or lamellar shape, though some ceramists claim that there is a great variation in clay grain shapes.

Bureau of Mines, Reports of Investigations, Determination of Flakiness of Ores, Serial No. 2899, by Coghill, Holmes, and Campbell.

The discharge from rolls was more flaky than the discharge from the ball mill.

Some evidence was obtained to justify a hypothesis that size of maximum flakiness in the discharge is a certain fraction of the size of the feed.

ACKNOWLEDGEMENT

This work has been done in connection with the research investigation of the Committee on Dry Press Process of the National Brick Manufacturers Association which has been carried on during the past year at the Missouri School of Mines and Metallurgy at Rolla, Missouri.

The writer wishes to take this opportunity to thank Professor C. M. Dodd for his generous aid and cooperation in making this investigation and report possible.