2

TRN: ZA8500368

MINTEK

REPORT

No. M20D

THE SEPARATION OF ORE FROM COOKE INTO HIGH- AND LOW-GRADE FRACTIONS

by

R.N. Guest

12th February, 1982
Reissued 31st March, 1984

COUNCIL FOR MINERAL TECHNOLOGY
200 Hans Strijdom Road
RANDBURG
South Africa

MINTEK

(ORE-DRESSING DIVISION)

REPORT
No. M20D

THE SEPARATION OF ORE FROM COOKE INTO HIGH- AND LOW-GRADE FRACTIONS

Investigators	R.N. Guest and J. Nyai
Director of Division	I.J. Corrans
Assistant Director	P.W. Overbeek
Programme No.	006
Project No.	088811B
Project Report No.	1
Sponsor	Johannesburg Consolidated Investment Co. Ltd

When originally issued, this report was confidential. It has now been declassified with the permission of the sponsor.

12th February, 1982
Reissued 31st March, 1984

All correspondence to Mintek, Private Bag X3015, Randburg, 2125 South Africa

ISBN 0 86999 663 0

SYNOPSIS

The separation of the ore by sizing alone was not very successful, and the recovery of uranium to the high-grade fraction did not exceed 73 per cent.

The use of a combination of size and gravity separation was attempted, and the tailing from the gravity circuit contained 33,9 per cent of the uranium at a grade of 60 g/t.

The circuit recommended includes autogenous grinding to liberate part of the ore matrix containing the values into the fine fraction. This should be followed by heavy-medium separation for the recovery of the high-grade portion of the coarse fraction. The size at which this heavy-medium separation is carried out should be determined.

SAMEVATTING

Die skeiding van die erts net volgens grootte was nie baie geslaagd nie en die herwinning van uraan tot die hoëgraadse fraksie het nie 73 persent oorskry nie.

Daar is 'n kombinasie van grootte- en swaartekragskeiding toegepas en die uitskot van die swaartekragkring het 33,9 persent van die uraan met 'n graad van 60 g/t bevat.

Die kring wat aanbeveel word, sluit outogene maling om die deel van die ertsmatriks wat die waardevolle materiaal bevat, in die fyn fraksie in te bevry, in. Dit behoort deur swaarmediumskeiding gevolg te word vir die herwinning van die hoëgraadse gedeelte van die growwe fraksie. Die grootte waarby hierdie swaarmediumskeiding uitgevoer word, moet bepaal word.

CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

1. INTRODUCTION

The feed to the plant at Cooke Section of the Randfontein Estates Gold Mine is currently 250 000 t per month. The Johannesburg Consolidated Investment Co. Ltd (JCI) wishes to double the capacity of the plant by 1984 by splitting the existing circuit into two separate circuits, one for the treatment of ore rich in uranium, and the other for the treatment of ore with a low uranium content. Mr J. Forbes of JCI asked the Council for Mineral Technology (Mintek) to investigate the possibility of separating the ore into a high- and a low-grade fraction.

2. EXPERIMENTAL METHODS

Most of the uranium in the conglomerate ore is present in the softer matrix that cements the pebbles together, which suggested that it might be possible for the ore to be separated into high- and low-grade fractions by a sizing operation as is the practice at several other locations. It was envisaged that autogenous or pebble milling could be used to separate the matrix from the pebbles by attrition, which would give a high-grade fines fraction and a low-grade coarse fraction consisting mainly of pebbles.

If this operation were not completely successful, Mintek would investigate the possible use of gravity separation or heavy-medium separation (HMS), but not as thoroughly. At present, an HMS pilot plant using a Dyna Whirlpool is being tested on site at the mine by the Davy Equipment Company.

2.1. Grinding and Sizing

The ore received was crushed to material smaller than 100 mm and then graded into three fractions, with the following particle sizes: larger than 50 mm, from 50 to 25 mm, and smaller than 25 mm. This was done because it is difficult for a representative sample to be obtained from material in which the particle sizes vary widely. The correct proportion of material from each size fraction was then combined to form a representative sample of 300 kg to be used as a charge for the mill.

The choice of mill for the grinding was limited, since some of the high-grade fines produced would become lodged behind the liner plates if a small conventional mill or an autogenous mill were used, which could cause the results to be biased. The mill that was finally chosen was 850 by 1200 mm in size, and had a smooth inner shell onto which six triangular lifters of 40 mm thickness had been welded. This mill had no crevices in which fine material could become trapped. Batch milling was employed for 1, 3, 6, and 16 hours respectively. The whole charge was then removed and screened into various size fractions. The whole of the coarser size fraction was crushed to fine material before a smaller representative sample was removed for fine pulverization to make it suitable for analysis.

2.2. Gravity Separation

A portion of the size fraction between 6 and 12 mm was taken from the sample that had been ground for 16 hours, and was used in a gravity-separation test. This portion was crushed to material smaller than 0,5 mm and concentrated on a laboratory shaking table to give a concentrate, a tailing, and a slimes fraction.

Another portion of the material between 6 and 12 mm from the same sample was separated, without any further size reduction, with heavy liquids at densities of 2,65 and 2,70.

3. RESULTS

3.1. Separation into Coarse and Fine Fractions

The analysis of the size fractions from the mill feed and from the products from the various grinds is given in Tables 1 to 5, which also show the distribution of uranium and the cumulative results.

So that a standard method could be obtained by which the various tests could be compared, the results from Tables 1 to 5 were plotted in Figures 1 to 5 respectively. The cumulative mass smaller than the indicated particle size was plotted against the cumulative grade and distribution, and the grade and distribution of the coarse and fine fractions (each 50 per cent by mass) was obtained for each test. These figures are shown in Table 6.

3.2. Gravity Separation

3.2.1. Tabling Test

The results of the tabling test (Table 7) show that a low-grade tailing assaying 60 g of U_3O_8 per ton was rejected, and that this tailing contained only 33,9 per cent of the uranium in the sample. These results would probably be reproduced if the other coarse size fractions were crushed and treated in the same way.

The upgrading by heavy liquids of this size range is good, almost 80 per cent of the uranium being recovered in a mass of 17,8 per cent.

3.2.2. *Heavy-liquid Separation*

The results of the heavy-liquid separation test, which was carried out so that it could be ascertained how a coarse size fraction would behave in a heavy medium, are given in Table 8.

4. CONCLUSIONS

With lengthy grinding times, the mill that was used yielded a product containing coarse pebbles and fairly fine 'powder' with very little material in the intermediate sizes. This indicates that the comminution was the result mainly of attrition, with very little impact grinding taking place, and that the main comminution process was the wearing away of the outer layers of the larger pebbles.

It had been hoped that the low-grade coarse product would have a U_3O_8 grade of 50 g/t or less. However, this was not the case with the milling conditions applied, and recoveries of uranium to the high-grade fraction (50 per cent by mass) ranged between 60 and 75 per cent.

Gravity-separation tests were carried out on only one coarse size fraction. The low-grade table tailing produced assayed 60 g of U_3O_8 per ton and contained 33,9 per cent of the uranium in the feed to the table. Further work on gravity separation is recommended.

In the heavy-liquid separation tests, there was rejection of 82,2 per cent of the material between 6 and 12 mm at a relative density of 2,70. This rejected tailing contained 20,8 per cent of the uranium present at a grade of 36 g/t. It seems likely that a combination of size separation and heavy-medium separation could be successfully employed at Cooke for the separation of the feed into high- and low-grade fractions. More testwork is recommended so that the ideal particle size for heavy-medium separation can be determined.

TABLE 1

Separation of size fractions of mill feed

Particle size	Mass, %	U_3O_8, g/t	Distn, %
75 mm	15,3	177	13,1
50 mm	21,2	151	15,4
25 mm	15,3	175	12,9
12 mm	12,8	184	11,4
6 mm	11,1	203	10,9
1,18 mm	11,9	225	12,9
300 μm	5,0	233	5,6
150 μm	2,0	287	2,8
106 μm	0,9	356	1,5
75 μm	0,8	382	1,5
53 μm	0,5	420	1,0
38 μm	0,4	440	0,8
<38 μm	2,8	756	10,2
Total	100,0	207	100,0

Particle size	Cumulative amount passing indicated particle size		
	Mass, %	U_3O_8, g/t	Distn, %
75 mm	84,7	213	86,9
50 mm	63,5	234	71,5
25 mm	48,2	252	58,6
12 mm	35,4	277	47,2
6 mm	24,3	311	36,3
1,18 mm	12,4	393	23,4
300 μm	7,4	500	17,8
150 μm	5,4	579	15,0
106 μm	4,5	624	13,5
75 μm	3,7	676	12,0
53 μm	3,2	717	11,0
38 μm	2,8	756	10,2

TABLE 2

Separation of size fractions of product after milling for 1 hour

Particle size	Mass, %	U_3O_8, g/t	Distn, %
75 mm	17,2	199	15,6
50 mm	14,3	154	10,1
25 mm	11,7	173	9,2
12 mm	12,4	179	10,2
6 mm	7,3	166	5,5
1,18 mm	0,5	129	0,3
300 μm	1,2	96	0,5
150 μm	4,0	98	1,8
106 μm	3,8	123	2,1
75 μm	5,0	161	3,7
53 μm	5,6	207	5,3
38 μm	3,0	238	3,3
<38 μm	14,0	506	32,4
Total	100,0	219	100,0
	Cumulative amount passing indicated particle size		
Particle size	Mass, %	U_3O_8, g/t	Distn, %
75 mm	82,8	223	84,4
50 mm	68,5	237	74,3
25 mm	56,8	251	65,1
12 mm	44,4	271	54,9
6 mm	37,1	291	49,4
1,18 mm	36,6	293	49,1
300 μm	35,4	300	48,6
150 μm	31,4	326	46,8
106 μm	27,6	354	44,7
75 μm	22,6	396	41,0
53 μm	17,0	459	35,7
38 μm	14,0	506	32,4

TABLE 3

Separation of size fractions of product after milling for 3 hours

Particle size	Mass, %	U_3O_8, g/t	Distn, %
75 mm	13,8	130	8,9
50 mm	18,5	160	14,7
25 mm	12,4	125	7,7
12 mm	7,3	147	5,3
6 mm	4,8	150	3,6
1,18 mm	0,7	108	0,4
75 μm	7,2	122	4,3
53 μm	6,8	170	5,7
38 μm	4,6	185	4,2
<38 μm	23,9	382	45,2
Total	100,0	202	100,0
	Cumulative amount passing indicated particle size		
Particle size	Mass, %	U_3O_8, g/t	Distn, %
75 mm	86,2	213	91,1
50 mm	67,7	228	76,4
25 mm	55,3	251	68,7
12 mm	48,0	267	63,4
6 mm	43,2	280	59,8
1,18 mm	42,5	283	59,4
75 μm	35,3	315	55,1
53 μm	28,5	350	49,4
38 μm	23,9	382	45,2

TABLE 4

Separation of size fractions of product after milling for 6 hours

Particle size	Mass, %	U_3O_8, g/t	Distn, %
75 mm	15,2	117	8,7
50 mm	14,8	135	9,7
25 mm	9,7	131	6,2
12 mm	9,3	133	6,0
6 mm	3,3	133	2,1
1,18 mm	0,5	91	0,2
75 μm	2,7	150	2,0
53 μm	5,6	148	4,0
38 μm	5,2	163	4,1
<38 μm	33,7	348	57,0
Total	100,0	206	100,0
Particle size	Cumulative amount passing indicated particle size		
	Mass, %	U_3O_8, g/t	Distn, %
75 mm	84,8	222	91,3
50 mm	70,0	240	81,6
25 mm	60,3	258	75,4
12 mm	51,0	280	69,4
6 mm	47,7	290	67,3
1,18 mm	47,2	293	67,1
75 μm	44,5	301	65,1
53 μm	38,9	323	61,1
38 μm	33,7	348	57,0

TABLE 5

Separation of size fractions of product after milling for 16 hours

Particle size	Mass, %	U_3O_8, g/t	Distn, %
50 mm	8,0	56	2,4
25 mm	20,9	108	12,0
12 mm	8,3	125	5,5
6 mm	1,9	115	1,2
1,18 mm	0,1	133	0,1
75 μm	2,0	153	1,6
53 μm	3,7	94	1,9
38 μm	5,2	113	3,1
<38 μm	49,9	272	72,2
Total	100,0	188	100,0
Particle size	Cumulative amount passing indicated particle size		
	Mass, %	U_3O_8, g/t	Distn, %
50 mm	92,0	199	97,6
25 mm	71,1	226	85,6
12 mm	62,8	240	80,1
6 mm	60,9	243	78,9
1,18 mm	60,8	244	78,8
75 μm	58,8	247	77,2
53 μm	55,1	257	75,3
38 μm	49,9	272	72,2

TABLE 6

Results for the high- and low-grade fractions (each 50 per cent by mass)

Assumed average head value 204 g/t

Grinding time h	High-grade ore (fines)		Low-grade ore (coarse fraction)	
	U_3O_8, g/t	Distn, %	U_3O_8, g/t	Distn, %
0	250	60	158	40
1	260	60	148	40
3	262	65	146	35
6	284	69	124	31
16	270	73	138	27

TABLE 7

Results of tabling test

Product	Mass, %	U_3O_8, g/t	Distn, %
Concentrate	11,7	354	34,5
Slimes	20,3	187	31,6
Tailing	68,0	60	33,9
Total	100,0	120*	100,0

* Assayed head value 115 g/t

TABLE 8

Results of heavy-liquid test

Product	Mass, %	U_3O_8, g/t	Distn, %
Sink at r.d. 2.70	17,8	630	79,2
R.d. 2,7 to 2,65	55,0	46	17,9
Float at r.d. 2,65	27,2	15	2,9
Total	100,0	142	100,0

R.d. = Relative density

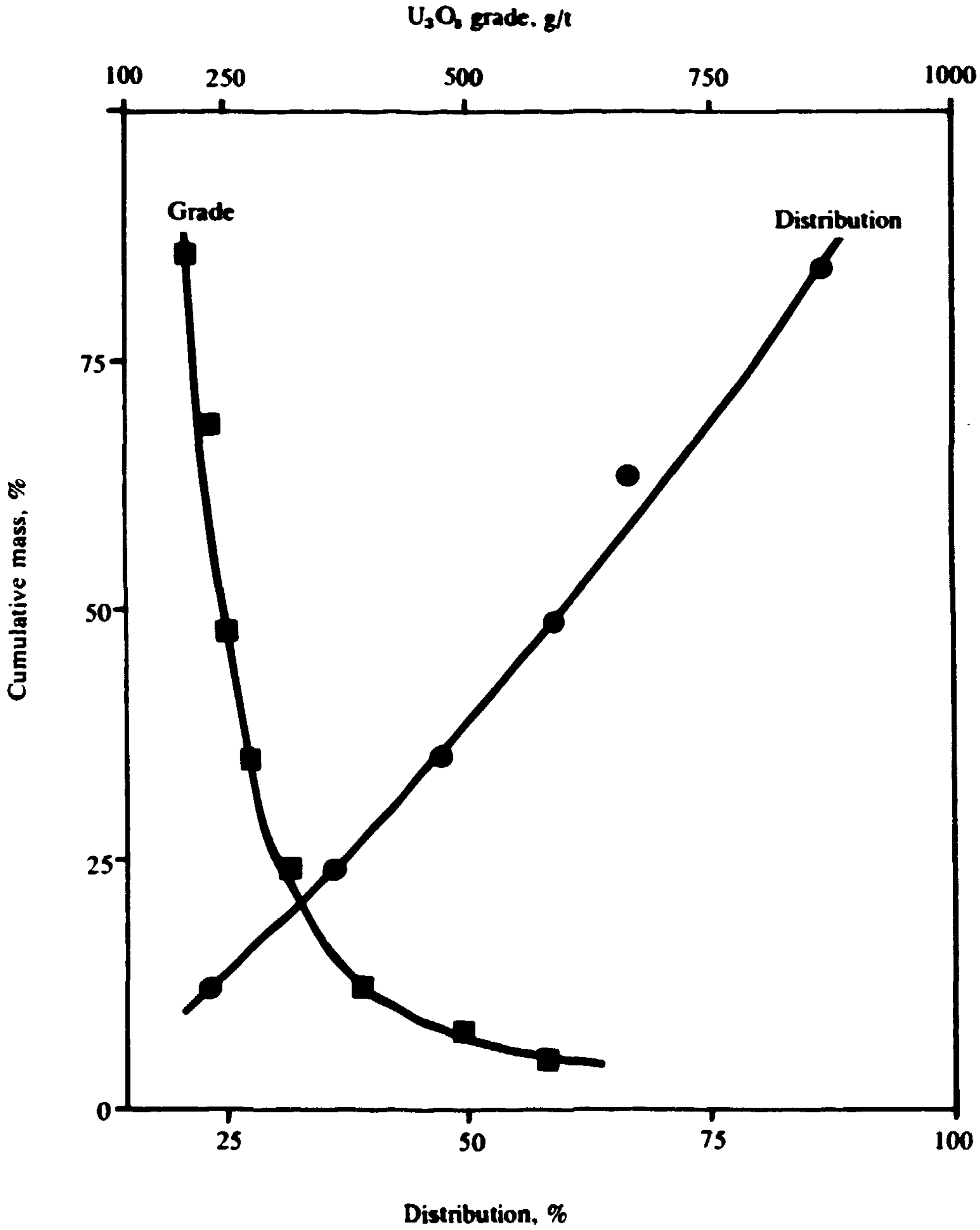

FIGURE 1. Cumulative results for the mill feed

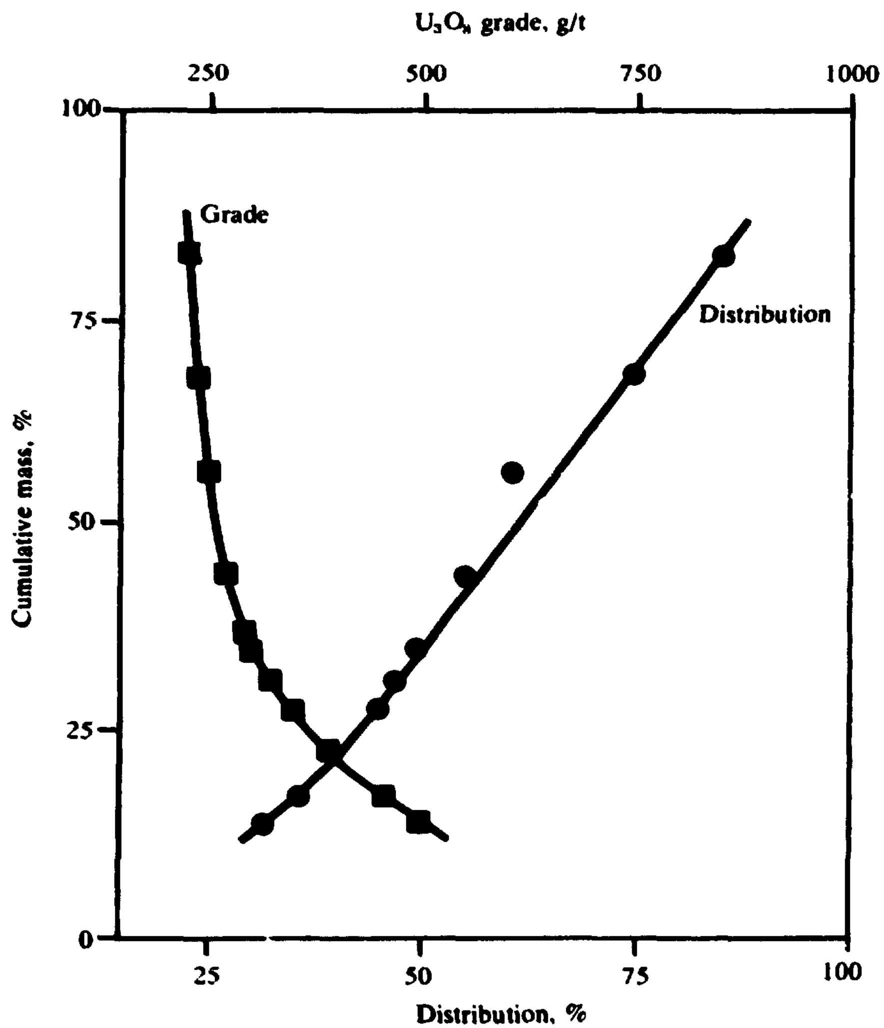

FIGURE 2. Cumulative results for the product after a 1-hour grind

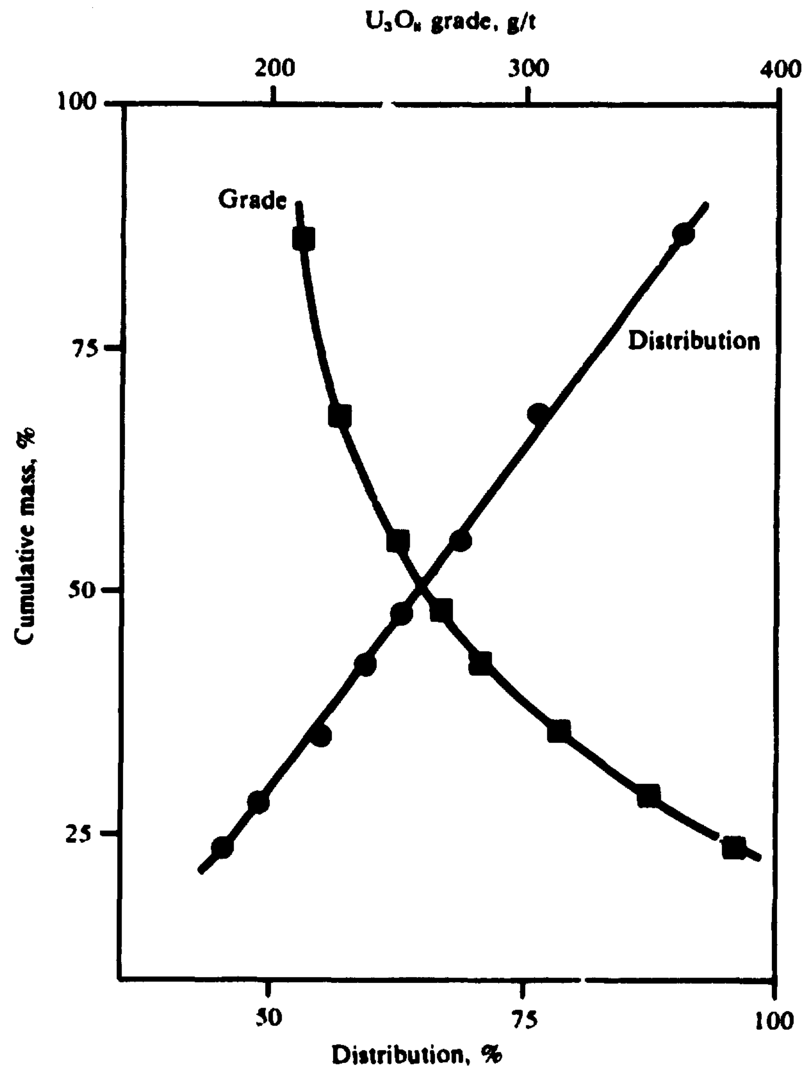

FIGURE 3. Cumulative results for the product after a 3-hour grind

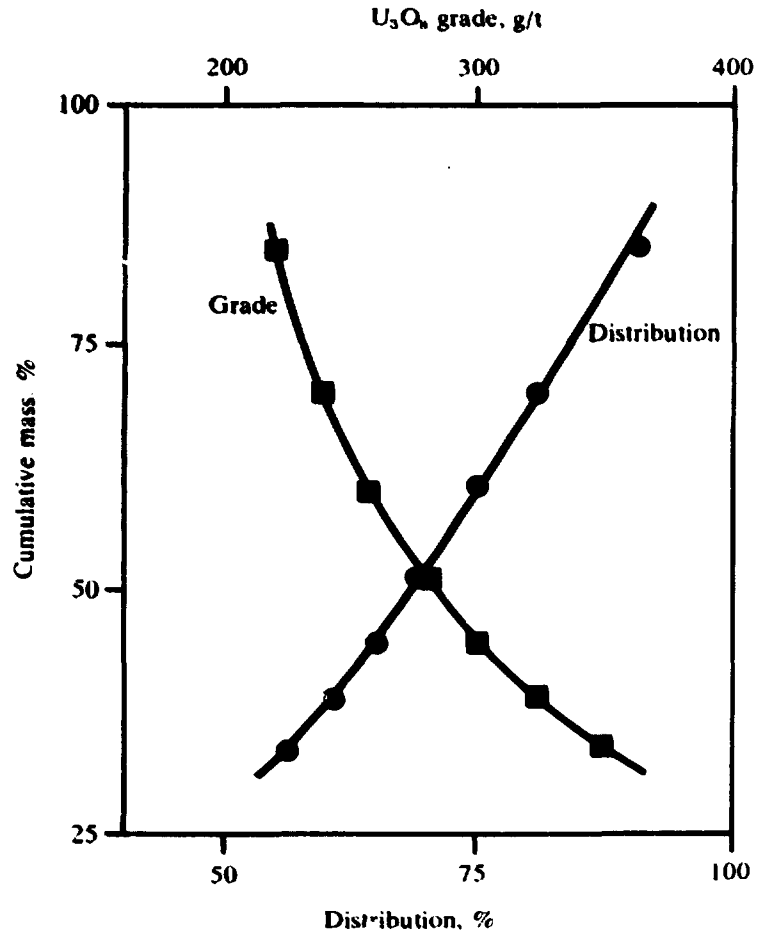

FIGURE 4. Cumulative results for the product after a 6-hour grind

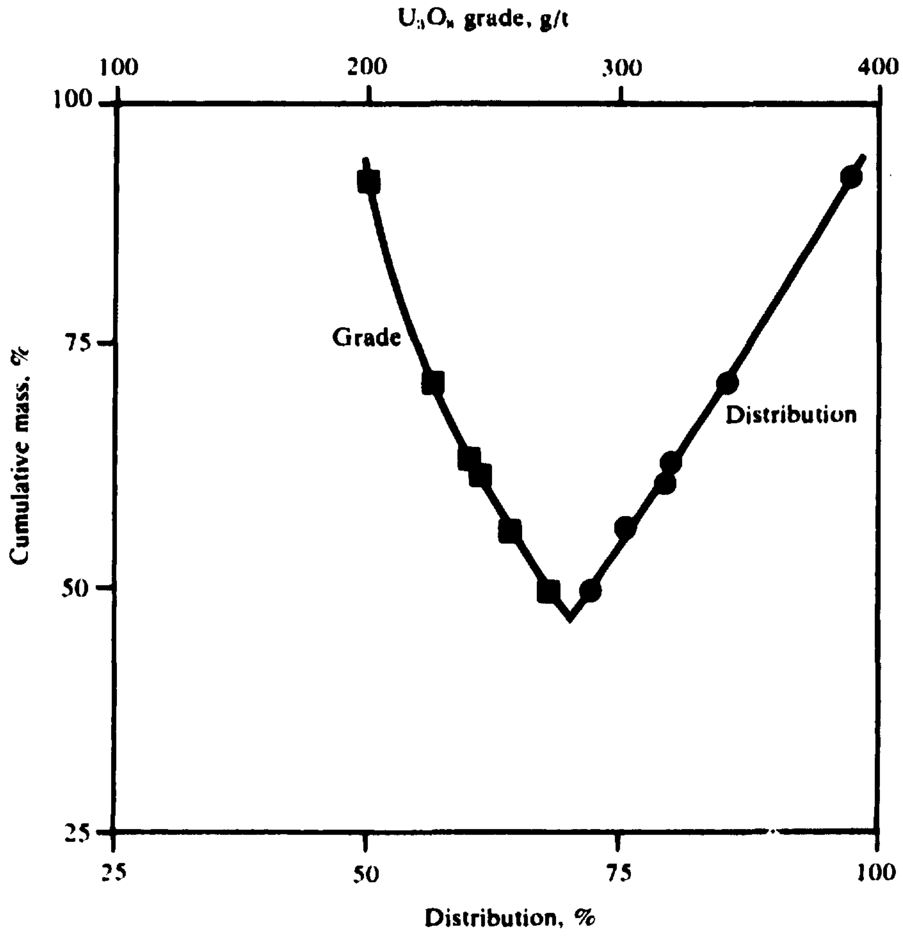

FIGURE 5. Cumulative results for the product after a 16-hour grind