

## Image Analysis

### Introduction

A fully automatic optical microscopy method for image analysis of large sample areas has been developed. Digital images are analysed using customized computer software. The method is very general and can be used to find size distributions of phases or pores in any non-transparent material. Images of samples may be acquired during daytime and analysed in batch by the computer during night.

The main feature of the image analysis method is that adjacent frames are captured. The objects entirely inside each frame are measured while the objects cut by the frame edges are saved and measured after four frames have been analysed and merged. This process continues recursively, allowing arbitrarily large pores/grains to be measured. There is virtually no upper limit to what pore/grain sizes that can be measured.

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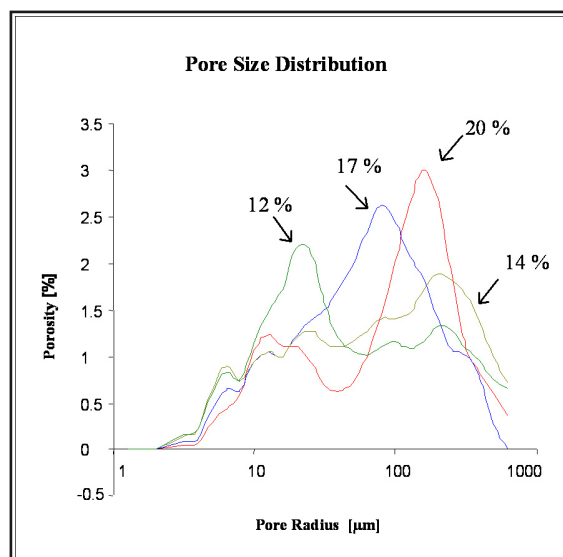
### Porosity in Anode Samples

1	3	9	11	65	67	73	75	129	131	137	139
2	4	10	12	66	68	74	76	130	132	138	140
5	7	13	15	69	71	77	79	133	135	141	143
6	8	14	16	70	72	78	80	134	136	142	144
17	19	25	27	81	83	89	91	145	147	153	155
18	20	26	28	82	84	90	92	146	148	154	156
21	23	29	31	85	87	93	95	149	151	157	159
22	24	30	32	86	88	94	96	150	152	158	160
33	35	41	43	97	99	105	107	161	163	169	171
34	36	42	44	98	100	106	108	162	164	170	172
37	39	45	47	101	103	109	111	165	167	173	175
38	40	46	48	102	104	110	112	166	168	174	176
49	51	57	59	115	121	123	127	177	179	185	187
50	52	58	60	114	116	122	124	178	180	186	188
53	55	61	63	117	119	125	127	181	183	189	191
54	56	62	64	118	120	126	128	182	184	190	192

The image analysis has mostly been used to analyse porosity in carbon materials. The samples are impregnated with a fluorescent epoxy under vacuum. This gives good contrast between the pores and the bulk phase using ultraviolet light. With 40 mmØ samples, a 40 x magnification of 192 frames are usually sufficient, covering a 28 x 28 mm<sup>2</sup> area.

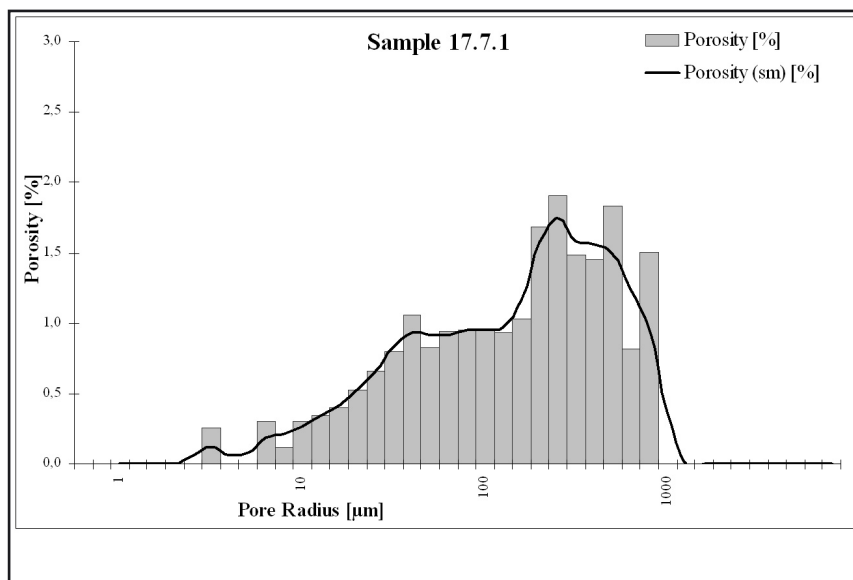
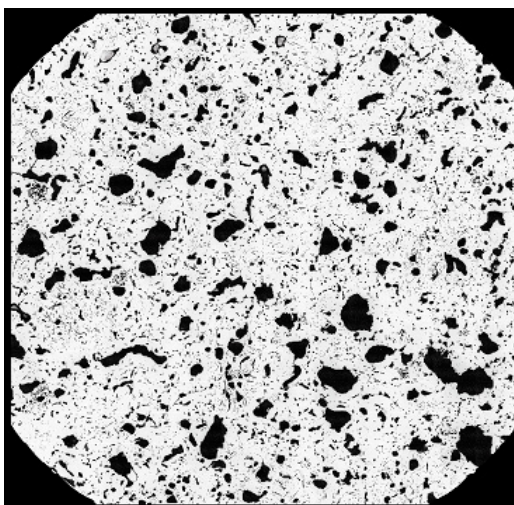
The size distribution of pores in the range of 1 µm to 10 mm radius are determined. In addition, a relative measure of pore surface area and connectivity are determined. Increased accuracy for the smallest pores can be achieved by overlapping measurements at high and low magnification.

The Figure to the right shows pore size distribution of bench scale laboratory baked anodes with different pitch contents.



## Results

To determine the size distribution, all objects with a specified radius are analysed as a group. The percentage surface area covered by objects with similar radius is used in the calculation of the size distribution. The sum of all values is thus equivalent to the bulk percentage. The overview image gives visual information of cracks and clustering of pores. Microsoft Excel templates are developed for standardized reports.



Porosity (smoothed)	%
1	0
1.26	0
1.58	0
2	0.0000
2.51	0.0637
3.16	0.1275
3.98	0.0637
5.01	0.0764
6.31	0.1826
7.94	0.2121
10	0.2687
12.59	0.3484
15.85	0.4161
19.95	0.5255
25.12	0.6604
31.62	0.8309
39.81	0.9369
50.12	0.9147
63.1	0.9182
79.43	0.9522
100	0.9512
125.89	0.9672
158.49	11.726
199.53	15.764
251.19	17.463
316.23	15.828
398.11	15.523
501.19	14.824
630.96	12.417
794.33	0.9543
1000	0.3751
1258.93	0.0000
7943.28	0.0000
Sum	211.016
SF pores	0.07639
SF carbon	0.02336
<b>Porosity</b>	<b>21.10</b>
<b>Connectivity</b>	<b>0.10</b>
Sample name	17.7.1
Start overlap	5 µm
Stop overlap	25 µm

## Reference

S. Rørvik, H.A. Øye, and M. Sørli, "Characterization of Porosity in Cokes by Image Analysis", Light Metals 2001, 603-609.

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