

APPENDIX D

Flatbed Scanner Threshold Optimization Details and Test Results

Threshold Optimization

Table D-1. Summary of flatbed scanner threshold optimization results.

Sample #	Mode		Optimized Threshold		Target		Optimization Output	
	Black	White	Air Content	Void Freq.	Air Content	Void Freq.	Air Content	Void Freq.
1	41	213	66	72	0.0169	0.044	0.0169	0.0447
2	43	214	86	80	0.0564	0.31	0.0561	0.3136
3	41	213	96	94	0.0401	0.206	0.0403	0.2023
4	40	211	86	82	0.0405	0.245	0.0407	0.2511
5	43	214	66	74	0.0356	0.08	0.0356	0.0796
6	43	213	82	82	0.0458	0.241	0.0457	0.2392
7	41	212	92	86	0.0364	0.218	0.0365	0.2128
8	41	213	84	88	0.0595	0.283	0.0597	0.2775
9	42	213	31	41	0.0525	0.236	0.0529	0.2334
10	42	214	80	84	0.0567	0.275	0.0572	0.2715
11	41	212	84	84	0.0427	0.242	0.0422	0.2389
12	42	212	90	86	0.0519	0.397	0.0520	0.3934
13	43	214	65	70	0.0338	0.096	0.0335	0.0961
14	39	214	100	100	0.055	0.338	0.0556	0.3397
15	42	211	78	76	0.0701	0.369	0.0706	0.3636
16	40	214	96	86	0.0371	0.128	0.0369	0.1302
17	43	214	74	82	0.0573	0.277	0.0577	0.2802
18	42	213	96	86	0.0321	0.11	0.0320	0.1101
19	42	214	59	72	0.0604	0.171	0.0604	0.1722
20	40	213	96	88	0.0635	0.259	0.0641	0.2557
21	42	215	94	80	0.0383	0.221	0.0384	0.2205
22	42	213	59	72	0.0422	0.114	0.0427	0.1113
23	41	212	102	90	0.0456	0.226	0.0454	0.2260
24	43	214	94	86	0.0499	0.205	0.0500	0.2055
25	41	213	78	84	0.0442	0.201	0.0445	0.2028

Sample #	Mode		Optimized Threshold		Target		Optimization Output	
	Black	White	Air Content	Void Freq.	Air Content	Void Freq.	Air Content	Void Freq.
26	42	213	76	80	0.0611	0.288	0.0615	0.2856
27	40	212	88	88	0.0727	0.55	0.0713	0.5429
28	39	212	76	84	0.0529	0.227	0.0541	0.2319
29	43	212	57	76	0.0316	0.124	0.0324	0.1194
30	42	212	161	177	0.0279	0.071	0.0281	0.0711
Min.	39	211	31	41	0.0169	0.044	0.0169	0.0447
Max.	43	215	161	177	0.0727	0.55	0.0713	0.5429
Avg.	41.5	213.0	83.1	84.3	0.047	0.225	0.0472	0.2241
STD	1.2	1.0	21.6	20.2	0.013	0.107	0.0130	0.1063
COV (%)	2.9	0.5	26.0	24.0	27.7	47.7	27.6	47.5

Note: Selected threshold values are shown in **bold** numbers; STD = standard deviation, COV = coefficient of variation.

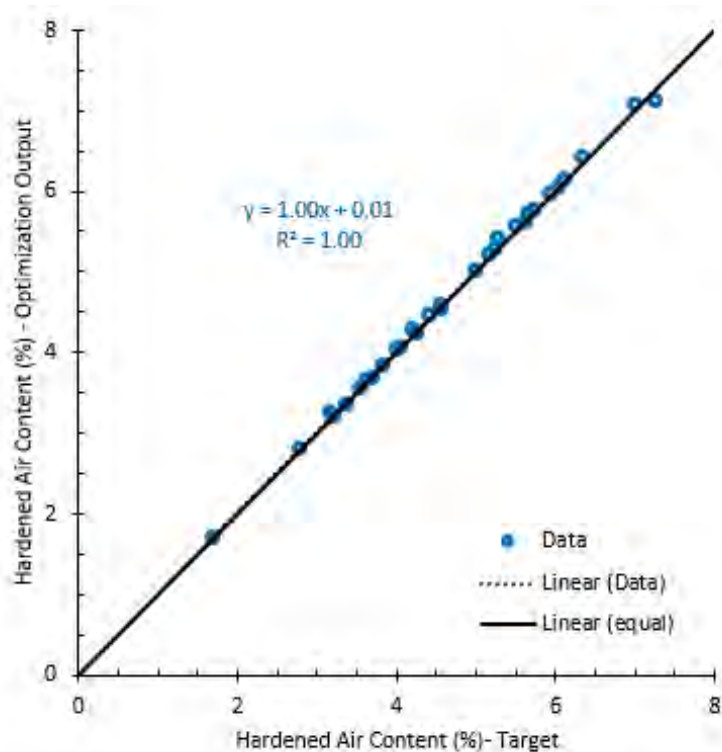


Figure D-1. Comparison between the target and output air content for air content threshold optimization.

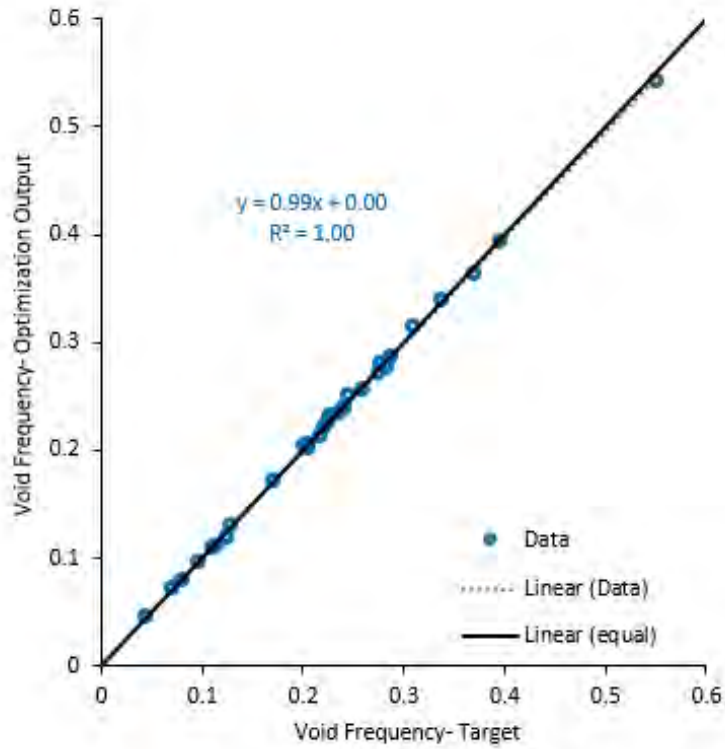


Figure D-2. Comparison between the target and output air content for void frequency threshold optimization.

Flatbed Scanner Threshold Optimization: Sensitivity Analysis

Table D-2. Selected threshold values for sensitivity analysis.

Test Scenario	Threshold Setting		Threshold Value	
	Air Content	Void Freq.	Air Content	Void Freq.
1 Baseline	Optimized	Optimized	83.1	84.3
2 Air Content +5%	+5%	Optimized	87.3	84.3
3 Air Content -5%	-5%	Optimized	78.9	84.3
4 Void Freq. +5%	Optimized	+ 5%	83.1	88.5
5 Void Freq. -5%	Optimized	- 5%	83.1	80.1

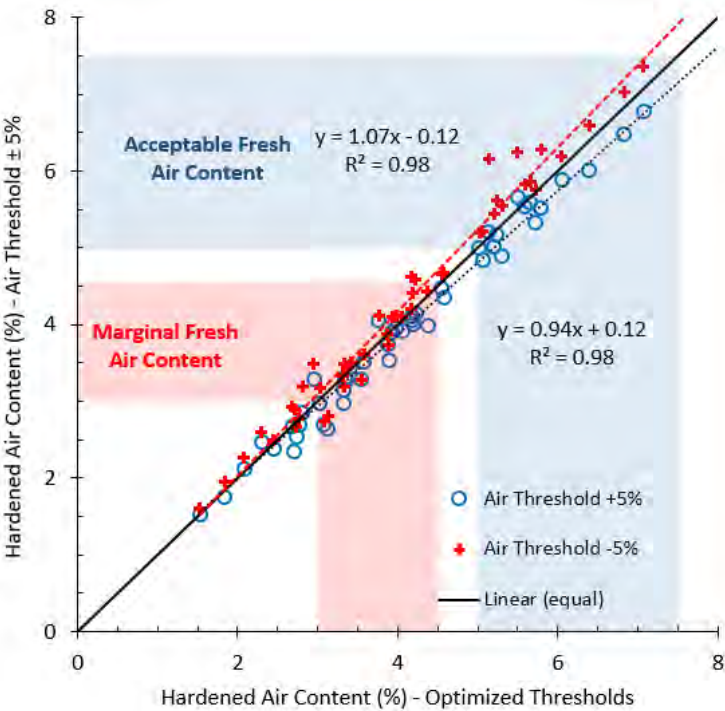


Figure D-3. Effect of variation in air content threshold on hardened air measurements with flatbed scanner.

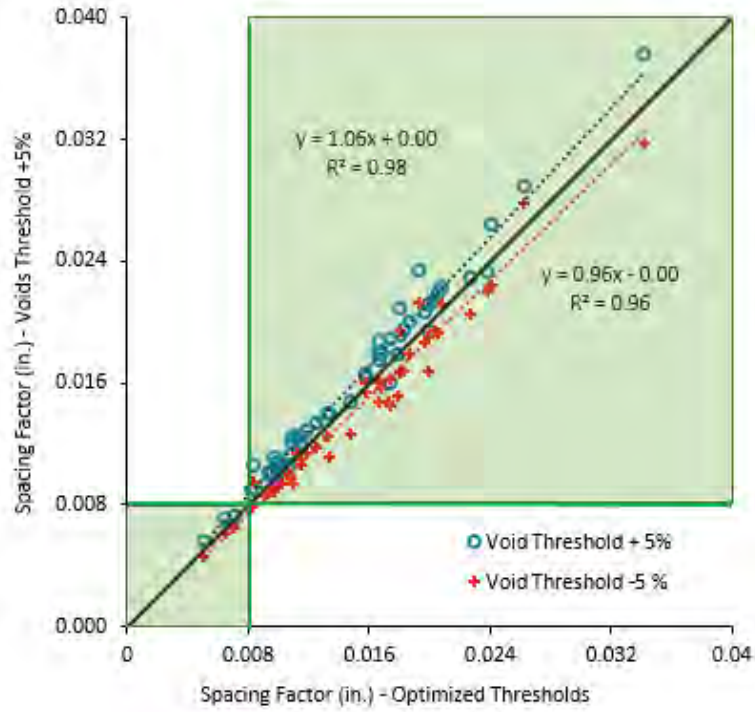


Figure D-4. Effect of variation in void frequency threshold on spacing factor measurements with flatbed scanner.

Flatbed Scanner Raw Data

Table D-3. Flatbed scanner results.

Mix.	Air (%)	S.F. (in.)	S.S. (in.⁻¹)
1	2.26	0.026	267
2	5.66	0.010	483
3	3.58	0.018	310
4	3.75	0.018	333
5	2.66	0.019	348
6	3.91	0.010	589
7	3.50	0.012	460
8	4.85	0.009	429
9	2.30	0.017	574
10	2.97	0.015	396
11	2.58	0.023	279
12	4.00	0.013	437
13	2.42	0.018	371
14	5.65	0.007	673
15	2.75	0.016	396
16	4.99	0.010	508
17	2.81	0.021	305
18	4.80	0.011	470
19	2.56	0.021	307
20	6.82	0.006	691
21	3.82	0.011	503
22	6.39	0.008	556
23	2.59	0.029	229
24	6.62	0.010	447
25	2.73	0.023	282
26	4.44	0.008	655
27	4.06	0.017	312
28	5.69	0.012	411
29	2.90	0.013	495
30	5.59	0.009	531
31	2.41	0.016	429
32	4.92	0.010	493
33	3.84	0.013	424
34	5.03	0.010	513
35	2.70	0.021	315
36	3.65	0.015	396
37	3.60	0.008	714
38	6.90	0.014	325
39	3.25	0.022	323
40	5.06	0.016	269

Mix.	Air (%)	S.F. (in.)	S.S. (in.⁻¹)
41	2.97	0.015	538
42	4.35	0.010	424
43	3.14	0.025	239
44	7.07	0.011	404
45	5.40	0.010	470
46	4.57	0.011	465
47	4.19	0.011	480
48	5.60	0.010	–
49	4.10	0.018	295
50	6.98	0.014	305
51	2.70	0.028	229
52	6.34	0.011	495
53	2.08	0.020	429
54	3.78	0.012	363
55	3.76	0.023	244
56	5.72	0.011	447
57	2.99	0.027	231
58	8.25	0.005	691
59	3.02	0.026	236
60	5.24	0.011	465
61	3.81	0.020	272
62	5.03	0.010	500
63	2.60	0.033	201
64	3.77	0.017	343
65	3.62	0.013	368
66	5.59	0.013	422
67	4.21	0.021	246
68	5.53	0.014	356
69	2.57	0.020	323
70	3.61	0.018	310
71	4.55	0.012	442
72	5.50	0.008	587
73	4.01	0.010	561
74	8.17	0.005	747
75	3.32	0.017	353
76	6.73	0.008	577
77	4.24	0.019	282
78	4.52	0.015	363
79	2.95	0.018	345
80	5.33	0.007	668
81	3.73	0.023	246
82	4.62	0.014	371
83	3.08	0.024	254

Mix.	Air (%)	S.F. (in.)	S.S. (in.⁻¹)
84	3.98	0.020	287
85	2.92	0.026	241
86	4.56	0.019	274
87	3.67	0.017	338
88	3.96	0.013	442
89	3.85	0.017	566
90	5.56	0.009	325
91	3.87	0.019	292
92	5.23	0.009	564
93	2.39	0.019	356
94	3.97	0.013	439
95	3.98	0.017	325
96	5.14	0.010	521
97	3.36	0.014	406
98	5.82	0.007	696
99	3.41	0.024	241
100	6.05	0.015	318
101	1.53	0.034	241
102	3.65	0.008	765
103	3.93	0.011	483
104	5.79	0.009	528
105	1.84	0.017	437
106	6.29	0.008	587
107	3.54	0.018	318
108	2.68	0.017	401
109	3.18	0.013	467
110	3.38	0.014	442
111	2.69	0.025	259
112	4.64	0.007	752
113	1.95	0.024	307
114	2.36	0.015	485
115	4.04	0.017	325
116	10.64	0.004	706
117	3.33	0.013	592
118	4.17	0.009	467
119	2.45	0.021	328
120	4.17	0.010	579
121	2.77	0.020	325
122	2.83	0.012	538
123	3.36	0.026	224
124	5.20	0.013	373
125	2.70	0.018	348
126	6.30	0.007	683

Mix.	Air (%)	S.F. (in.)	S.S. (in.⁻¹)
127	2.74	0.020	320
128	4.94	0.008	655
129	2.71	0.018	356
130	4.37	0.010	528
131	2.71	0.026	244
132	5.38	0.010	490
133	3.13	0.019	315
134	5.02	0.012	429
135	3.02	0.020	302
136	3.34	0.016	389
137	5.32	0.009	554
138	3.58	0.011	533
139	5.40	0.009	536
140	5.72	0.010	490
141	3.69	0.014	401
142	4.22	0.010	574
143	3.89	0.017	330
144	5.30	0.007	706

Note: S.F. = spacing factor, S.S. = specific surface.

Hardened Air Content Measurements: Flatbed Scanner vs. Fixed-Focus Optical Microscope

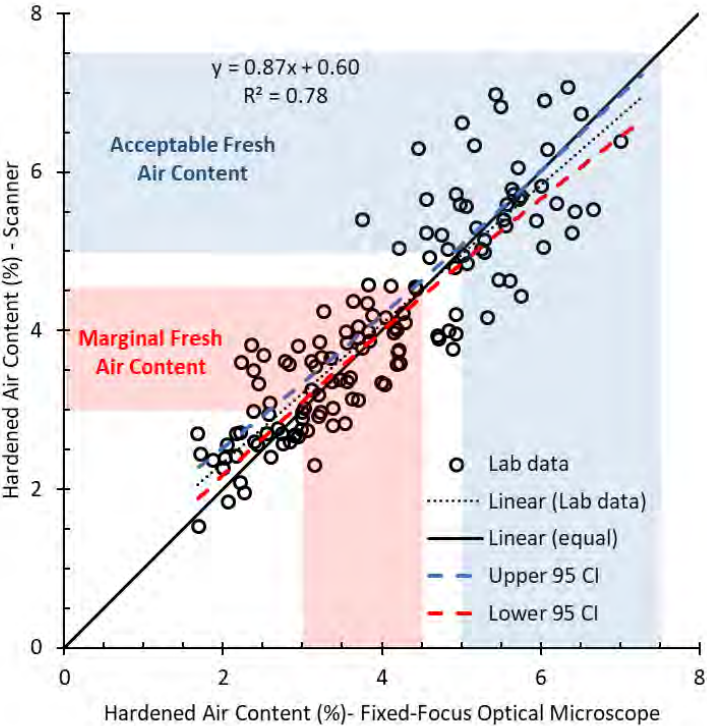


Figure D-5. Comparison between the hardened air content measured by flatbed scanner and fixed-focus optical microscope.

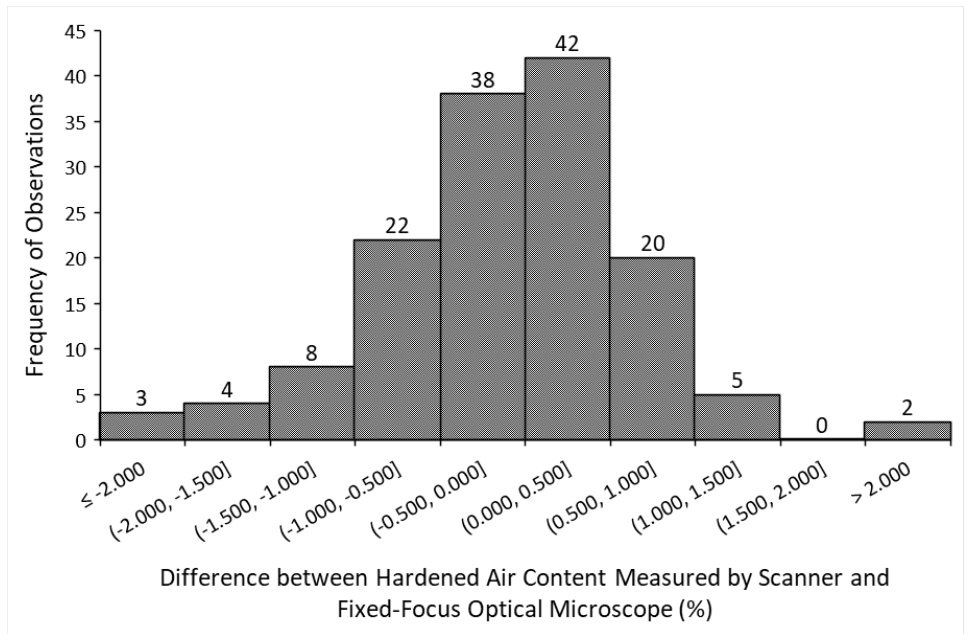


Figure D-6. Variation in hardened air content measured by flatbed scanner and fixed-focus optical microscope.

Spacing Factor Measurements: Flatbed Scanner vs. Fixed-Focus Optical Microscope

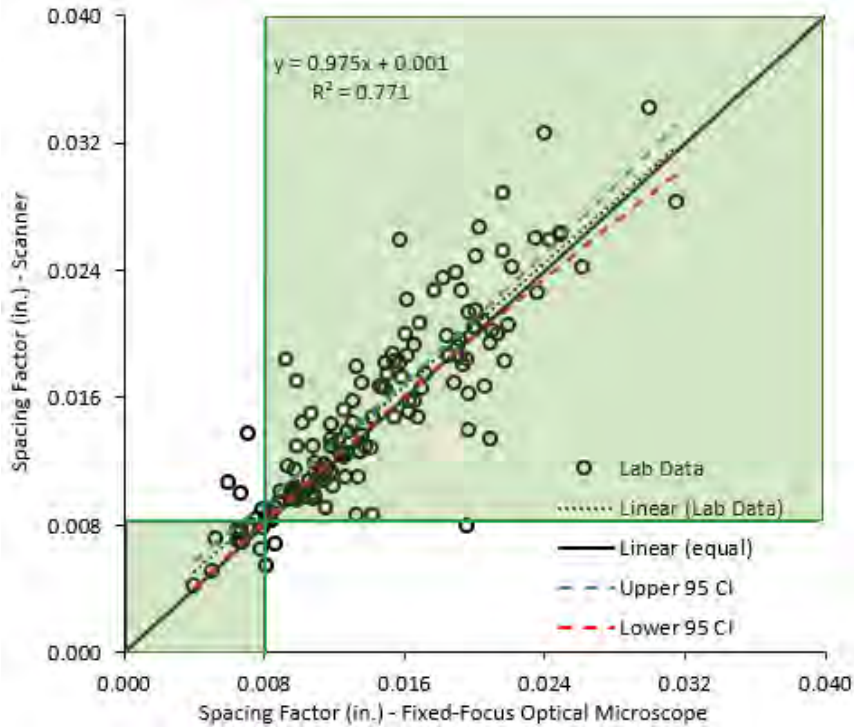


Figure D-7. Comparison between the spacing factor values measured by flatbed scanner and fixed-focus optical microscope.

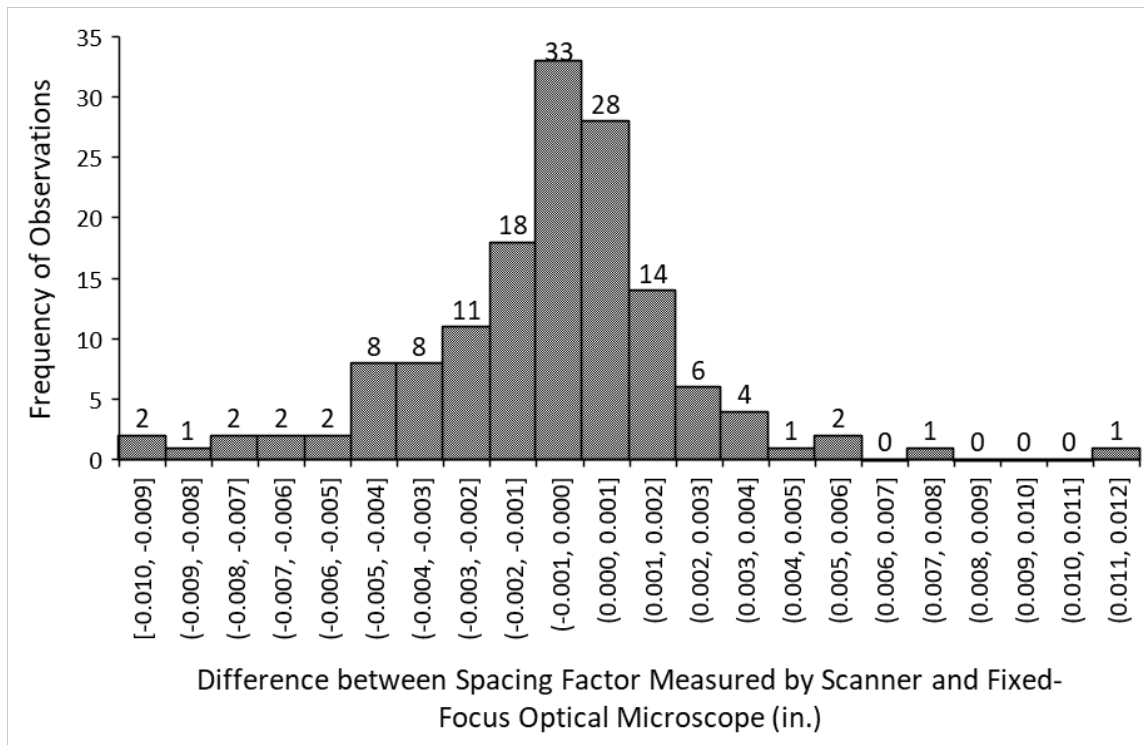


Figure D-8. Variation in spacing factor measurements by flatbed scanner and fixed-focus optical microscope.

Specific Surface Measurements: Flatbed Scanner vs. Fixed-Focus Optical Microscope

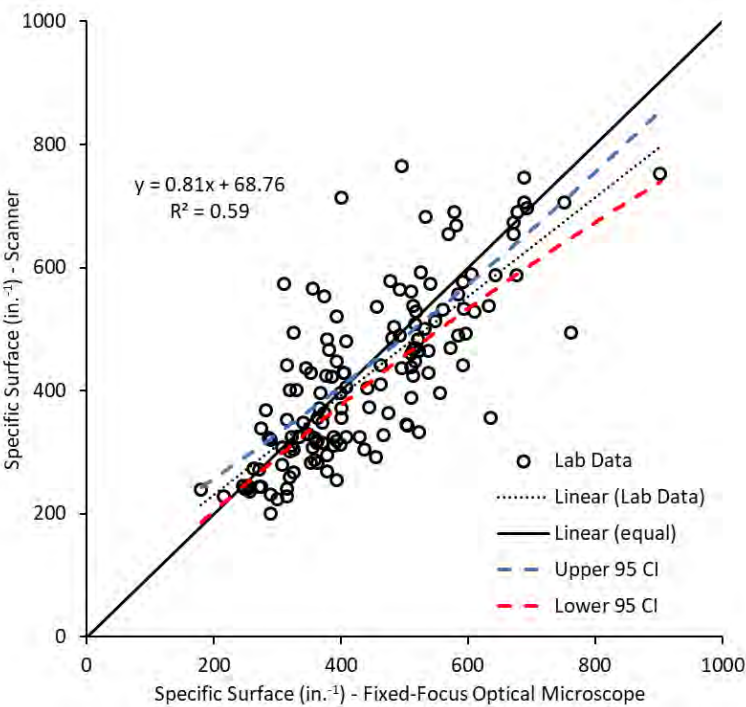


Figure D-9. Comparison between the specific surface values measured by flatbed scanner and fixed-focus optical microscope.