

Appendix I

SOC

I.1 SIMULINK implementation

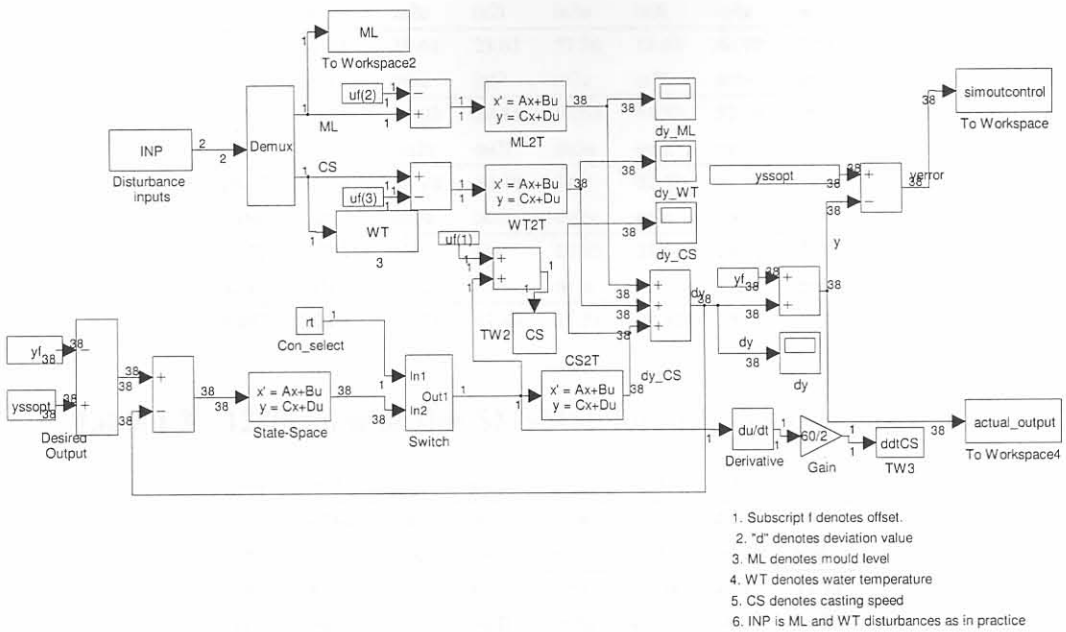


Figure I.1 SIMULINK realization for the SOC controller synthesis.

I.2 1280mm wide slabs results

I.2.1 Tabled results

Table I.1 1280mm wide slab design values for the proportional gains $k_{i,1}$.

in1u	in1l	in2u	in2l	in3u	in3l	in4u	in4l
604	1810	474.3	1110	1100	1323	900	1052
in5u	in5l	in6u	in6l	in7u	in7l	in8u	in8l
1800	1566	835.6	1398	993.5	1286	941.9	2234
ou1u	ou1l	ou2u	ou2l	ou3u	ou3l	ou4u	ou4l
585.6	1344	389.7	1159	827.4	1168	899.8	2046
ou5u	ou5l	ou6u	ou6l	ou7u	ou7l	ou8u	ou8l
793.9	107.6	NA	NA	517.2	898.9	663.4	1066
nl1u	nl1l	nl2u	nl2l	nr1u	nr1l	nr2u	nr2l
551.2	464.9	342	480.5	293.6	520.6	610	520.5

Table I.2 1280mm wide slab design values for the integral gains $k_{i,2}$.

in1u	in1l	in2u	in2l	in3u	in3l	in4u	in4l
37.25	82.45	19.61	23.62	57.36	14.62	40.99	7.655
in5u	in5l	in6u	in6l	in7u	in7l	in8u	in8l
158.8	20.26	34.03	28.85	57.63	41.83	52.76	66.33
ou1u	ou1l	ou2u	ou2l	ou3u	ou3l	ou4u	ou4l
24.03	46.29	24.18	42.76	34.2	22.58	41.59	62.11
ou5u	ou5l	ou6u	ou6l	ou7u	ou7l	ou8u	ou8l
39.72	0.2084	NA	NA	23.95	25.61	24.33	28.09
nl1u	nl1l	nl2u	nl2l	nr1u	nr1l	nr2u	nr2l
9.197	10.08	9.873	12.43	11.51	18.52	15.03	17.07

Table I.3 1280mm wide slab SMSMSE for each controller in the loop.

in1u	in1l	in2u	in2l	in3u	in3l	in4u	in4l
5.404	4.902	4.8	6.061	4.781	7.75	4.611	10.27
in5u	in5l	in6u	in6l	in7u	in7l	in8u	in8l
4.842	8.315	4.836	6.332	4.63	7.138	4.897	11.73
ou1u	ou1l	ou2u	ou2l	ou3u	ou3l	ou4u	ou4l
4.625	4.654	5.122	4.597	4.728	5.764	5.667	6.291
ou5u	ou5l	ou6u	ou6l	ou7u	ou7l	ou8u	ou8l
5.243	5.505	NA	NA	6.663	6.475	8.052	6.337
nl1u	nl1l	nl2u	nl2l	nr1u	nr1l	nr2u	nr2l
4.668	6.424	10.37	7.812	8.258	9.03	4.601	5.357

3.2 Time-domain results

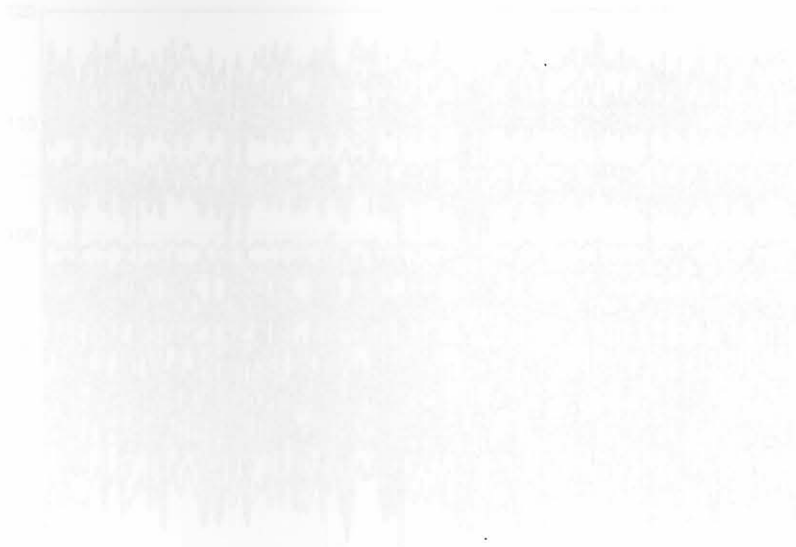


Table I.4 1280mm wide slab MSE for each output using the ou2l controller.

in1u	in1l	in2u	in2l	in3u	in3l	in4u	in4l
7.168	1.439	2.123	13.01	1.291	49.41	0.7046	191.3
in5u	in5l	in6u	in6l	in7u	in7l	in8u	in8l
0.7297	41.19	1.281	12.87	0.8113	12.04	2.732	17.51
ou1u	ou1l	ou2u	ou2l	ou3u	ou3l	ou4u	ou4l
1.06	0.9161	8.004	0.001855	1.068	10.79	6.871	5.764
ou5u	ou5l	ou6u	ou6l	ou7u	ou7l	ou8u	ou8l
5.139	3.402	NA	NA	20.02	15.98	28.15	13.42
nr1u	nr1l	nr2u	nr2l	nr1u	nr1l	nr2u	nr2l
0.7659	39.29	107.5	51.53	66.2	47.57	0.9056	12.98

I.2.2 Time-domain results

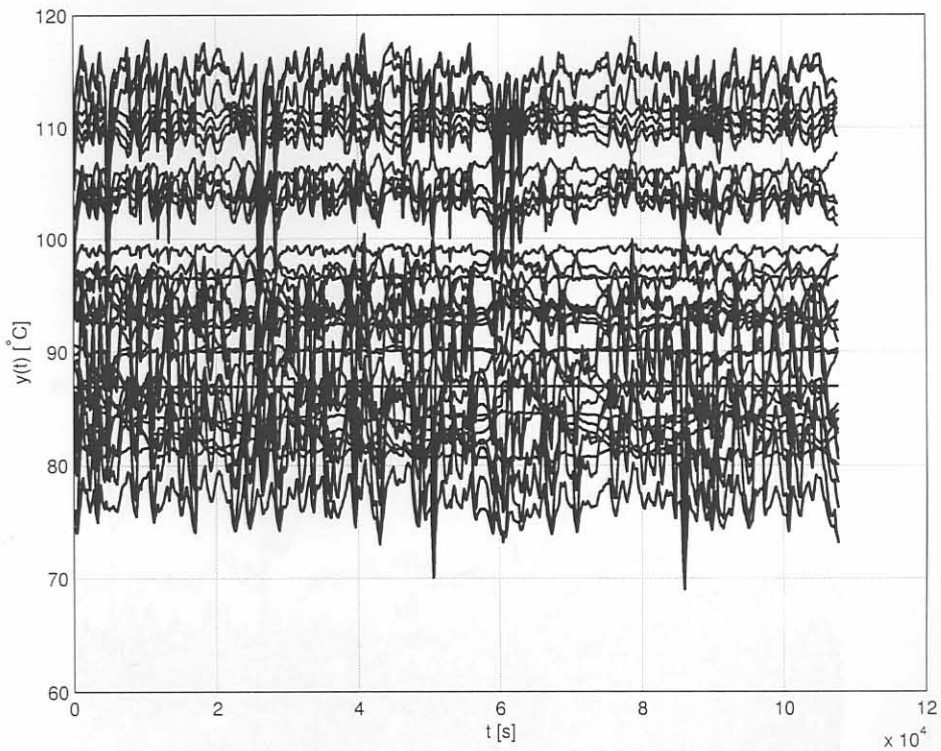


Figure I.2 Thermocouple temperature outputs for 1280mm wide slabs when thermocouple ou2l is used in a feedback configuration.

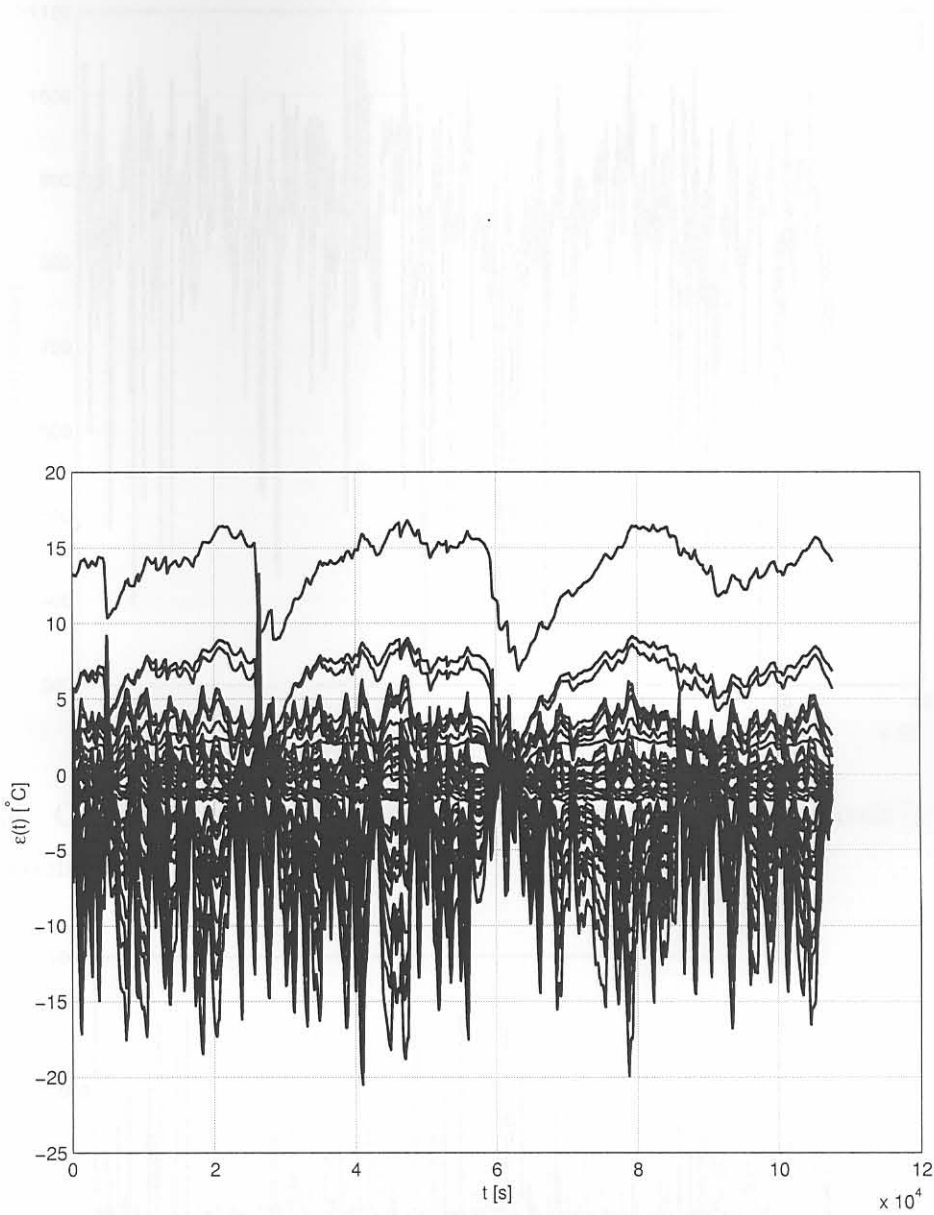


Figure I.3 Thermocouple temperature errors for 1280mm wide slabs when thermocouple ou21 is used in a feedback configuration.

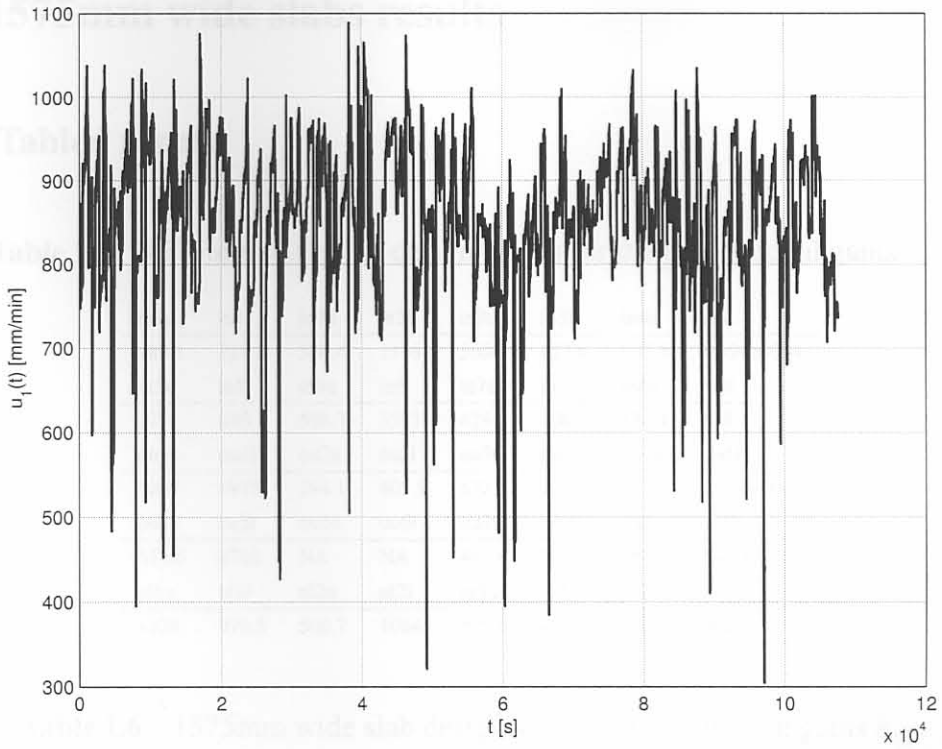


Figure I.4 Control signal for 1280mm wide slabs when thermocouple ou2l is used in a feedback configuration.

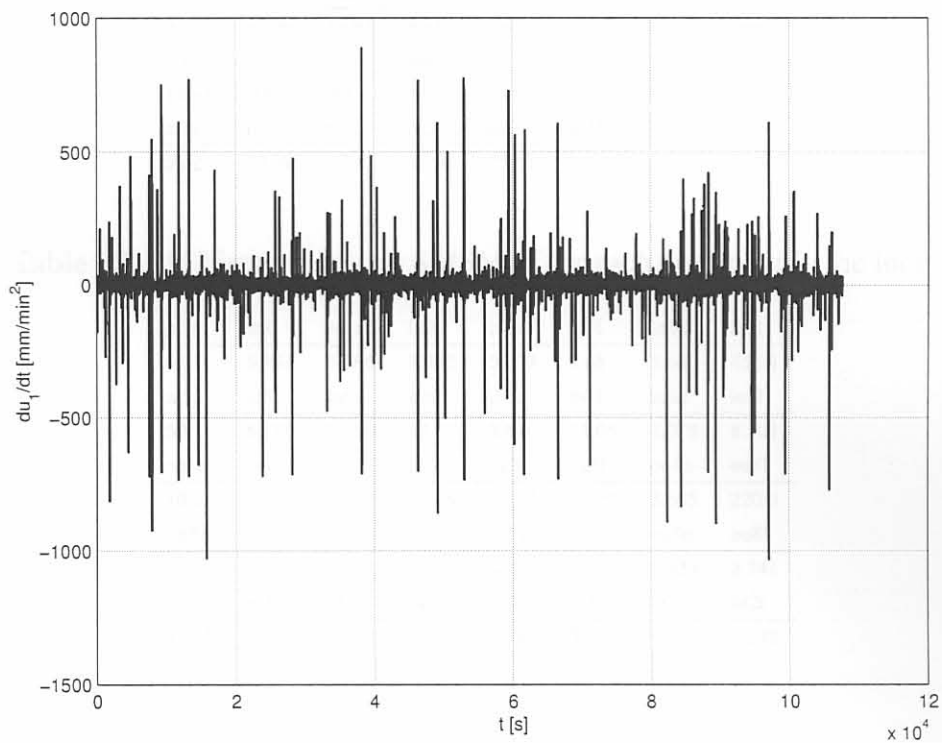


Figure I.5 Slab acceleration for 1280mm wide slabs when thermocouple ou2l is used in a feedback configuration.

I.3 1575mm wide slabs results

I.3.1 Tabled results

Table I.5 1575mm wide slab design values for the proportional gains $k_{i,1}$.

in1u	in1l	in2u	in2l	in3u	in3l	in4u	in4l
485.1	728.3	386.4	1196	360	627.6	607.5	8.594e+004
in5u	in5l	in6u	in6l	in7u	in7l	in8u	in8l
375	830	598.7	5593	429.8	1069	530.4	528.1
ou1u	ou1l	ou2u	ou2l	ou3u	ou3l	ou4u	ou4l
1003	1975	394.1	603.9	632.5	1014	637.2	3.086e+004
ou5u	ou5l	ou6u	ou6l	ou7u	ou7l	ou8u	ou8l
514.6	4706	NA	NA	483.6	729.5	667.6	556.1
nl1u	nl1l	nl2u	nl2l	nr1u	nr1l	nr2u	nr2l
1238	976.3	500.7	1084	876.6	495.4	1019	802.9

Table I.6 1575mm wide slab design values for the integral gains $k_{i,2}$.

in1u	in1l	in2u	in2l	in3u	in3l	in4u	in4l
21.15	15.39	19.3	39.76	14.86	24.05	22.01	2163
in5u	in5l	in6u	in6l	in7u	in7l	in8u	in8l
8.776	25.1	19.64	166.4	12.02	31.98	16.79	17.39
ou1u	ou1l	ou2u	ou2l	ou3u	ou3l	ou4u	ou4l
33.26	32.69	13.91	9.388	20.96	23.07	22.58	756.5
ou5u	ou5l	ou6u	ou6l	ou7u	ou7l	ou8u	ou8l
14.31	109.1	NA	NA	21.94	19.12	21.4	13.43
nl1u	nl1l	nl2u	nl2l	nr1u	nr1l	nr2u	nr2l
58.2	27.59	17.43	50.92	25.11	14.24	21.96	14.14

Table I.7 1575mm wide slab SMSMSE for each controller in the loop.

in1u	in1l	in2u	in2l	in3u	in3l	in4u	in4l
5.871	9.941	6.386	8.455	5.699	7.68	5.66	453.4
in5u	in5l	in6u	in6l	in7u	in7l	in8u	in8l
5.9	6.118	5.669	37.78	5.846	11.05	7.078	8.108
ou1u	ou1l	ou2u	ou2l	ou3u	ou3l	ou4u	ou4l
10.23	16.01	5.822	7.288	5.722	10.21	5.695	220.9
ou5u	ou5l	ou6u	ou6l	ou7u	ou7l	ou8u	ou8l
5.622	11.34	NA	NA	6.43	5.887	5.823	8.741
nl1u	nl1l	nl2u	nl2l	nr1u	nr1l	nr2u	nr2l
12.71	12.37	8.734	9.054	8.284	5.954	14.52	12.49

Time-domain results



Table I.8 1575mm wide slab MSE for each output using the ou5u controller.

in1u	in1l	in2u	in2l	in3u	in3l	in4u	in4l
7.774	60.98	20.7	16.56	2.993	20.08	3.049	50.05
in5u	in5l	in6u	in6l	in7u	in7l	in8u	in8l
4.656	3.397	2.28	43.45	6.3	37.46	20.71	32.92
ou1u	ou1l	ou2u	ou2l	ou3u	ou3l	ou4u	ou4l
29.06	65.92	4.463	32.95	4.705	42.56	4.637	67.52
ou5u	ou5l	ou6u	ou6l	ou7u	ou7l	ou8u	ou8l
0.02098	10.22	NA	NA	17.94	1.404	4.795	52.45
nl1u	nl1l	nl2u	nl2l	nr1u	nr1l	nr2u	nr2l
39.54	90.94	113.7	36.32	37.48	12.09	75.99	122.9

I.3.2 Time-domain results

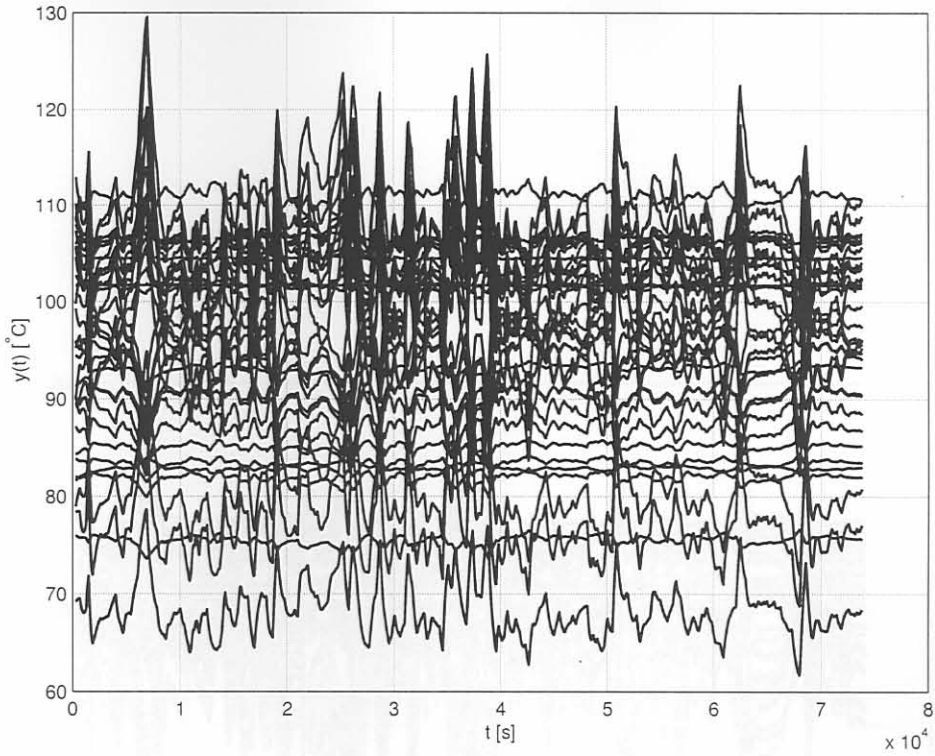


Figure I.6 Thermocouple temperature outputs for 1575mm wide slabs when thermocouple ou5u is used in a feedback configuration.

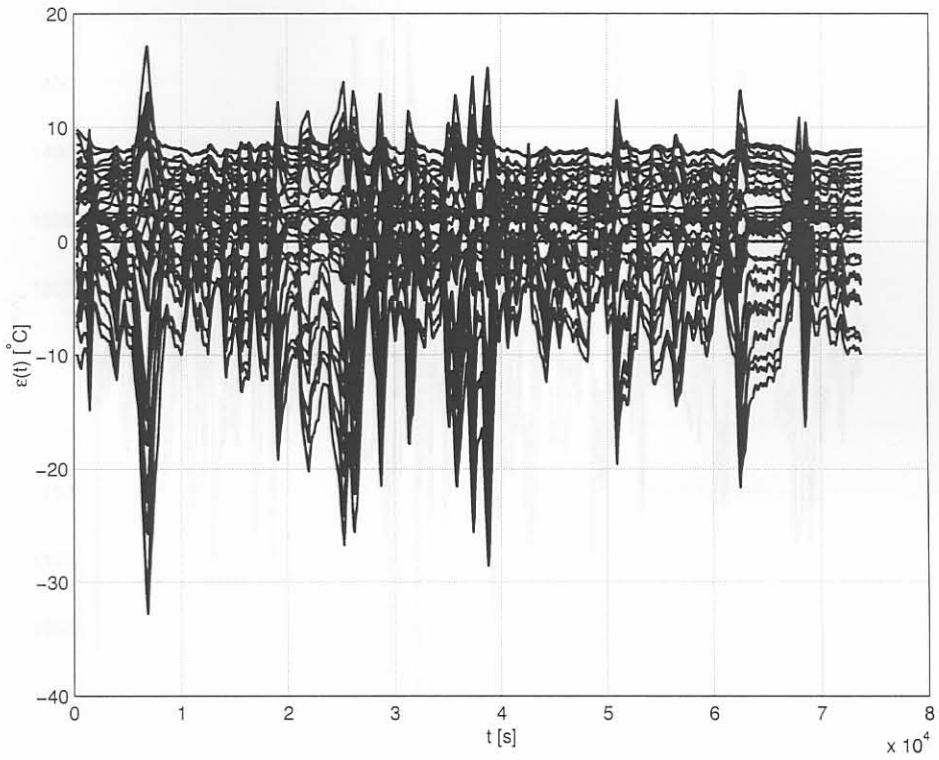


Figure I.7 Thermocouple temperature errors for 1575mm wide slabs when thermocouple ou5u is used in a feedback configuration.

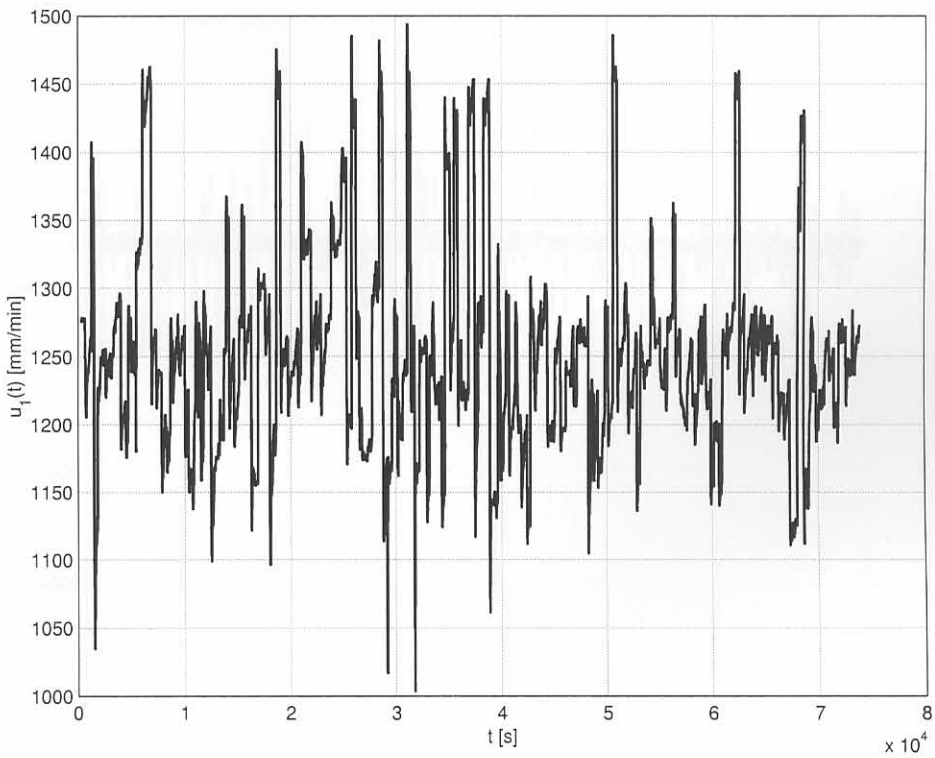


Figure I.8 Control signal for 1575mm wide slabs when thermocouple ou5u is used in a feedback configuration.

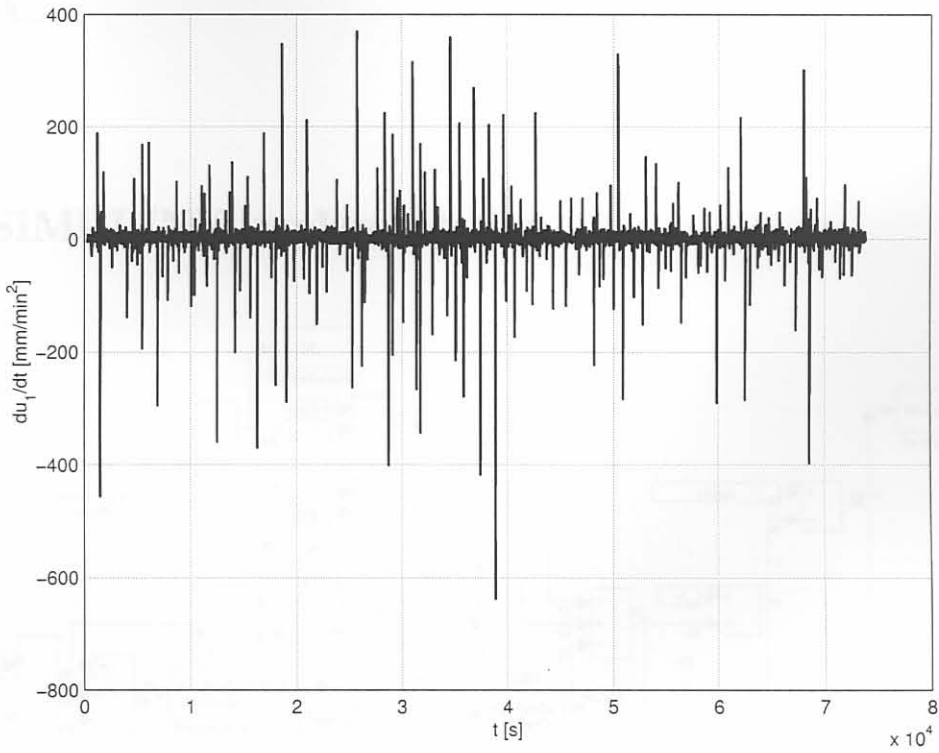


Figure I.9 Slab acceleration for 1575mm wide slabs when thermocouple ou5u is used in a feedback configuration.

Appendix J

WCC

J.1 SIMULINK implementation

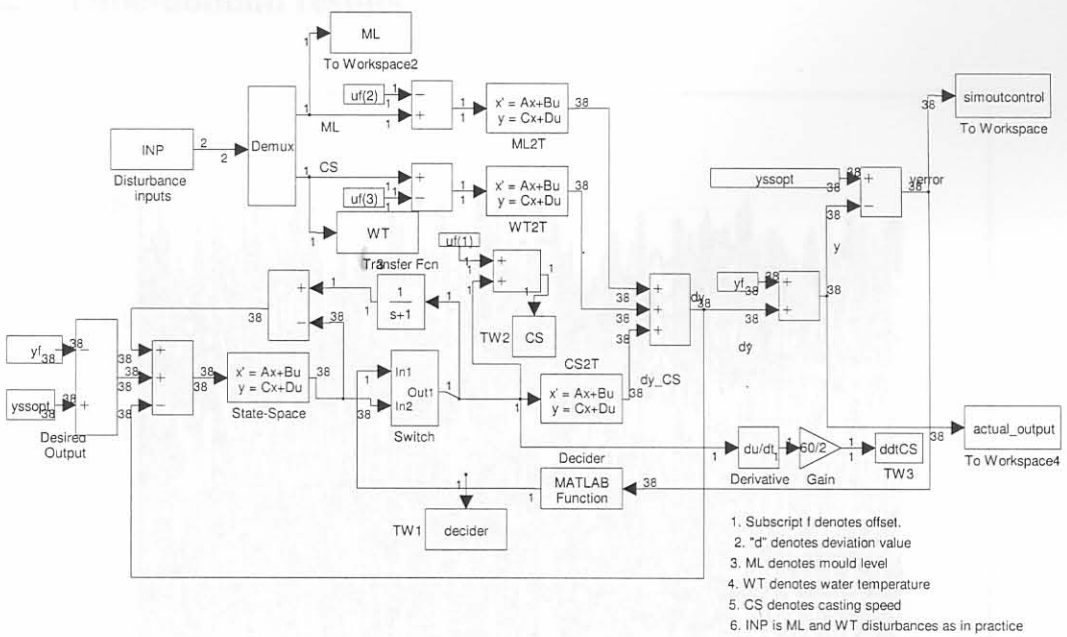


Figure J.1 SIMULINK realization for the WCC controller synthesis. Note that a fast unity gain filter with a time constant of 1 second has been added to break the algebraic loop in SIMULINK.

J.2 1280mm wide slab results

J.2.1 Tabled results

Table J.1 1280mm wide slab MSE for each output using WCC.

in1u	in1l	in2u	in2l	in3u	in3l	in4u	in4l
17.33	5.375	18.75	10.06	8.153	29.1	9.471	127.9
in5u	in5l	in6u	in6l	in7u	in7l	in8u	in8l
3.277	26.52	8.622	8.381	8.975	12.33	10.79	21.35
ou1u	ou1l	ou2u	ou2l	ou3u	ou3l	ou4u	ou4l
17.48	7.38	23.67	6.235	10.46	7.834	13.82	4.713
ou5u	ou5l	ou6u	ou6l	ou7u	ou7l	ou8u	ou8l
13.01	2.207	NA	NA	31.37	26.06	39.27	22.88
nl1u	nl1l	nl2u	nl2l	nr1u	nr1l	nr2u	nr2l
14.88	65.34	126	70.13	82.1	57.04	17.64	28.98

J.2.2 Time-domain results

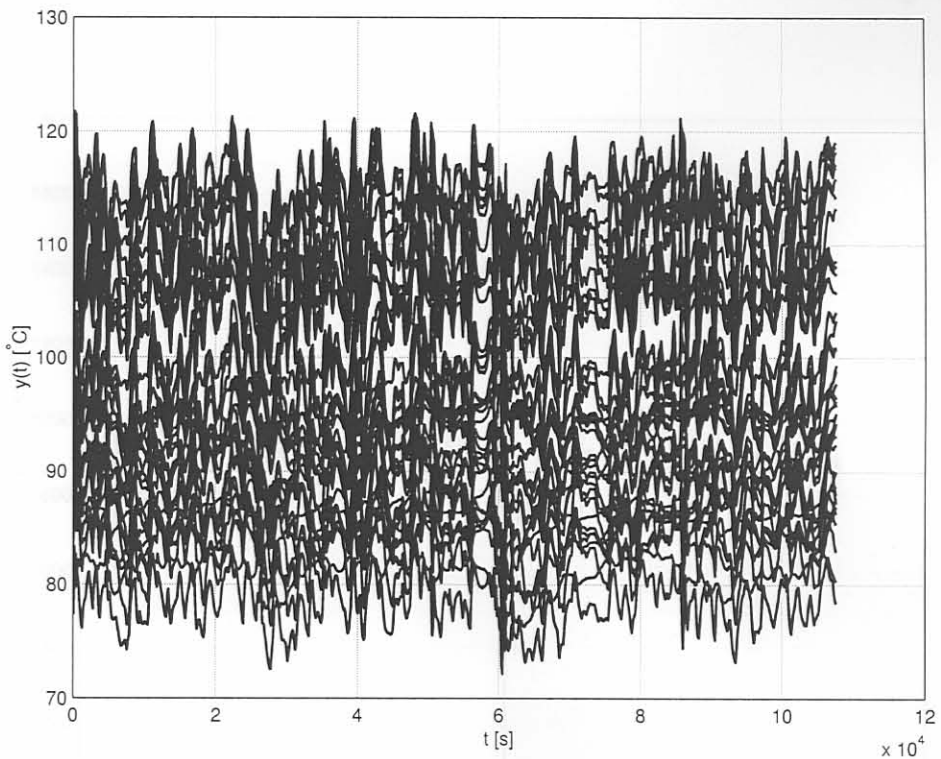


Figure J.2 Outputs for 1280mm wide slabs and the worst-case control configuration.

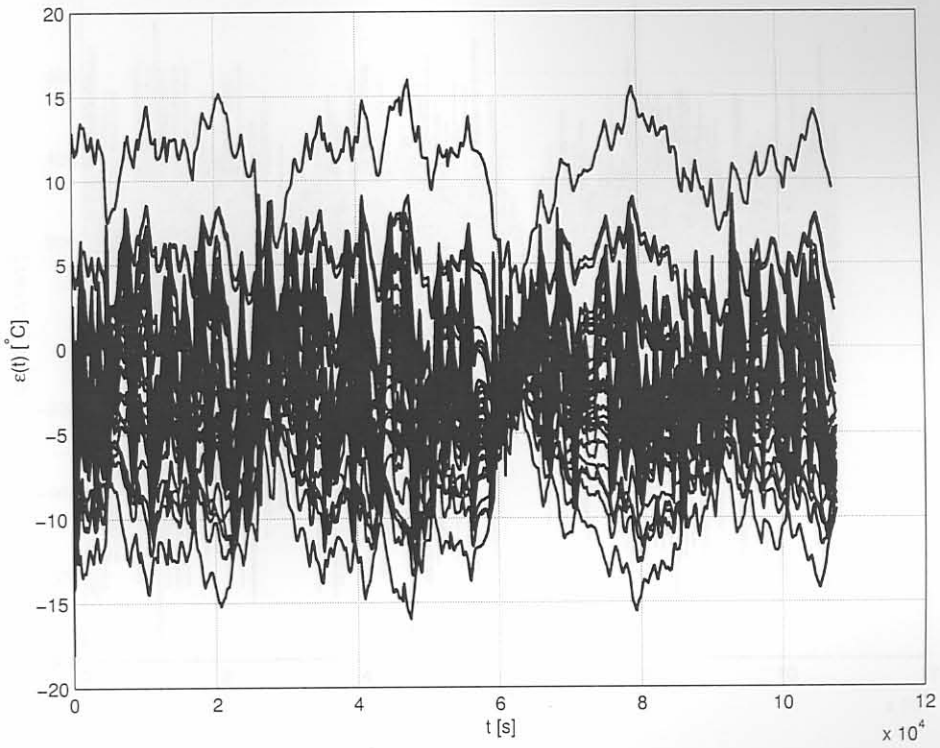


Figure J.3 Errors for 1280mm wide slabs and the worst-case control configuration.

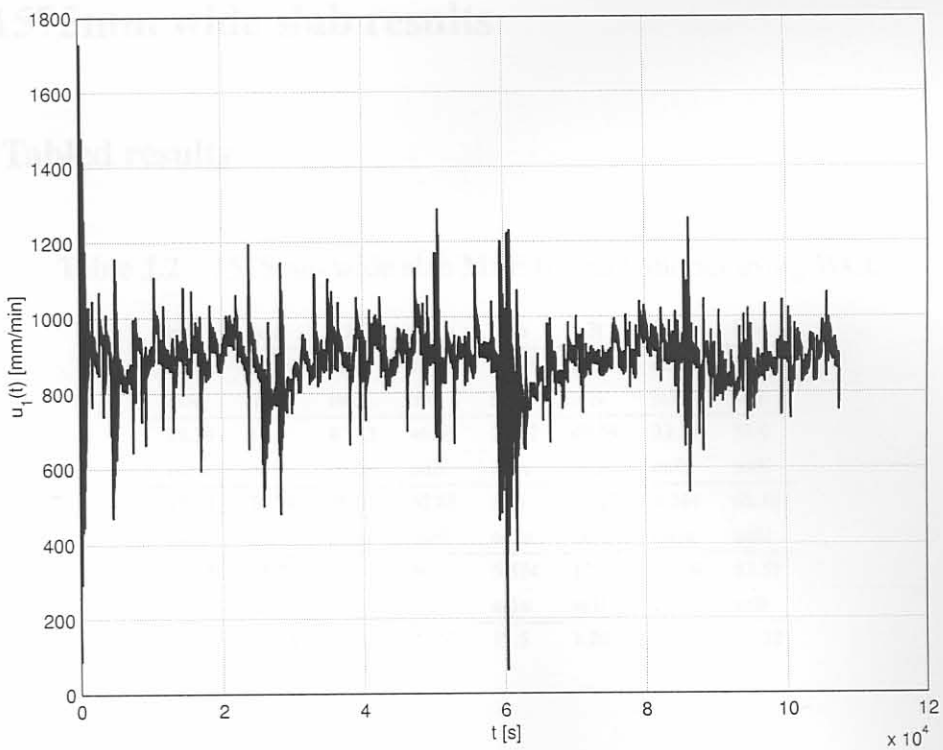


Figure J.4 Control signal for 1280mm wide slabs and the worst-case control configuration.

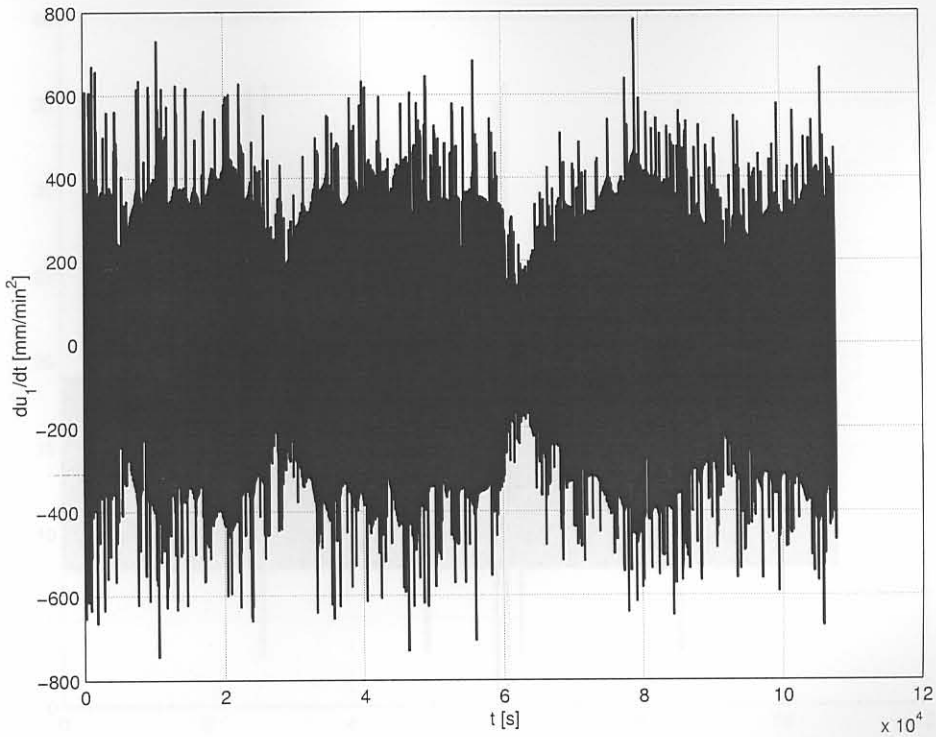


Figure J.5 Acceleration of the slab 1280mm wide slabs and the worst-case configuration.

J.3 1575mm wide slab results

J.3.1 Tabled results

Table J.2 1575mm wide slab MSE for each output using WCC.

in1u	in1l	in2u	in2l	in3u	in3l	in4u	in4l
8.082	82.56	6.169	28.59	5.896	37.21	6.304	50.29
in5u	in5l	in6u	in6l	in7u	in7l	in8u	in8l
19.39	14.8	8.723	46.05	20.82	49.59	33.57	55.9
ou1u	ou1l	ou2u	ou2l	ou3u	ou3l	ou4u	ou4l
35.13	75.71	20.03	62.85	5.91	55.22	4.244	68.16
ou5u	ou5l	ou6u	ou6l	ou7u	ou7l	ou8u	ou8l
8.365	12.2	NA	NA	5.574	12.37	8.909	83.52
nl1u	nl1l	nl2u	nl2l	nr1u	nr1l	nr2u	nr2l
28.27	68.63	72.33	22.67	17.5	1.09	54.44	87.32

J.3.2 Time-domain results

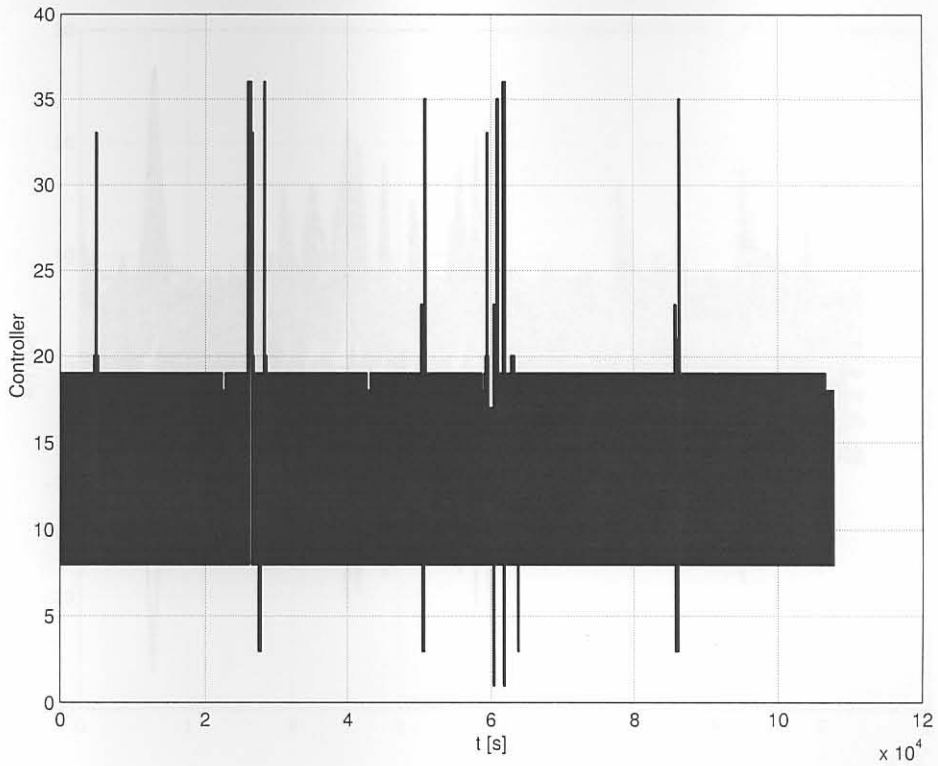


Figure J.6 Output of the switching criterion of 1280mm wide slabs and the worst-case control configuration.

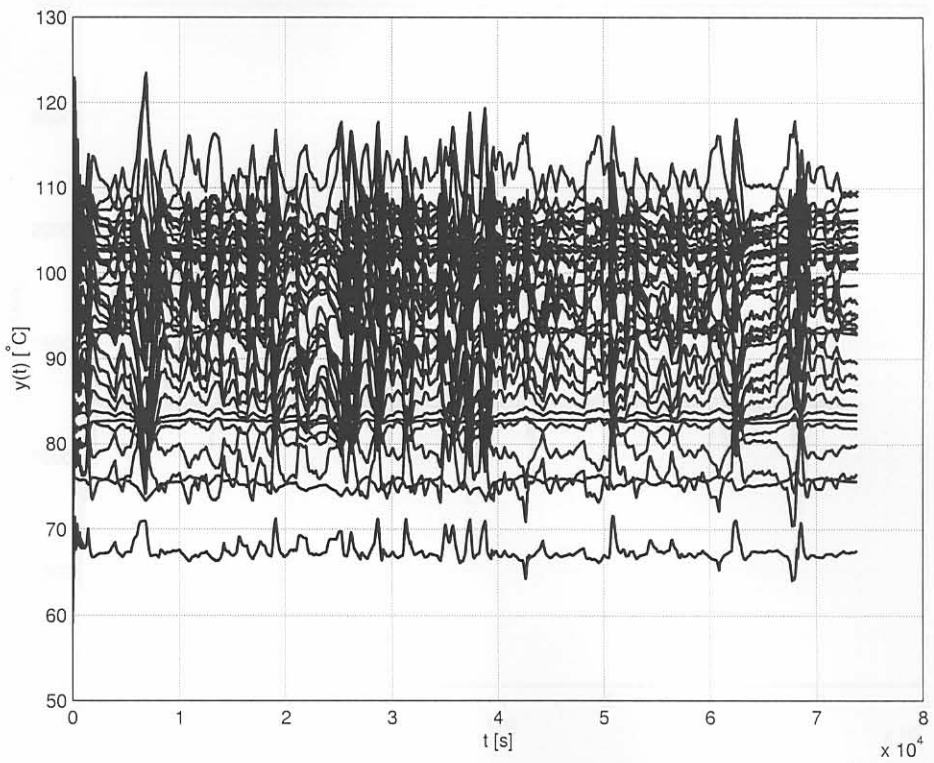


Figure J.7 Outputs for 1575mm wide slabs and the worst-case control configuration.

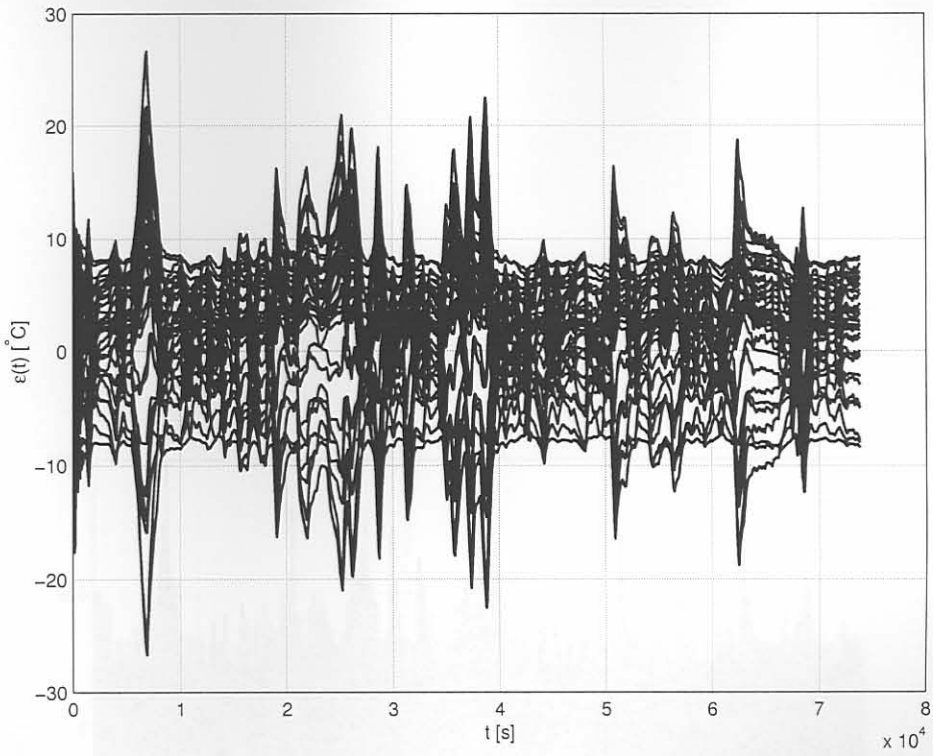


Figure J.8 Errors for 1575mm wide slabs and the worst-case control configuration.

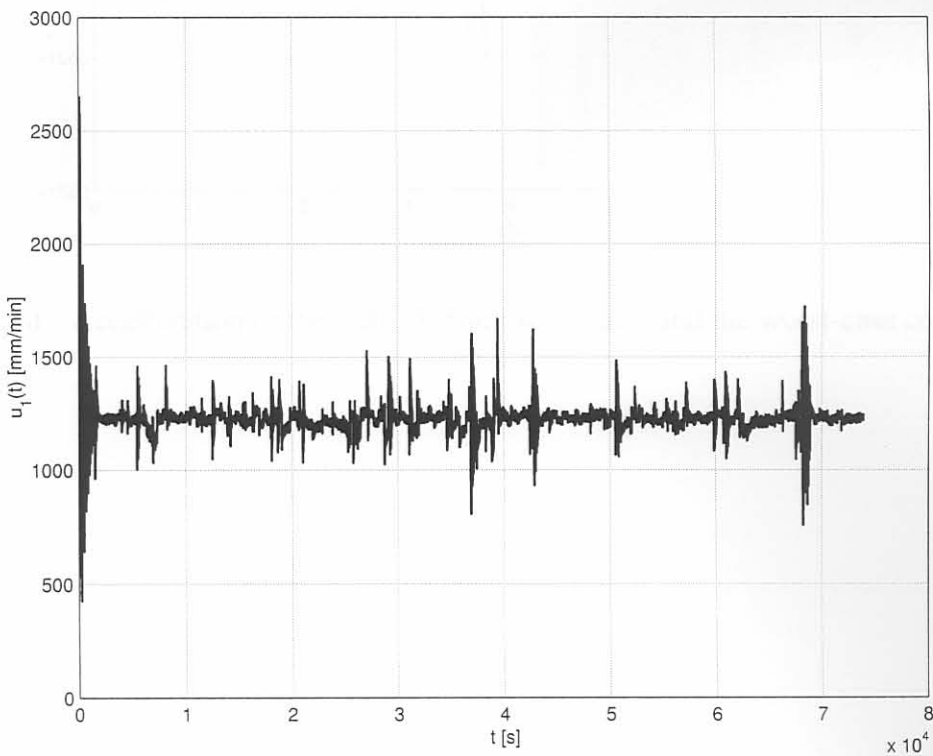


Figure J.9 Control signal for 1575mm wide slabs and the worst-case control configuration.

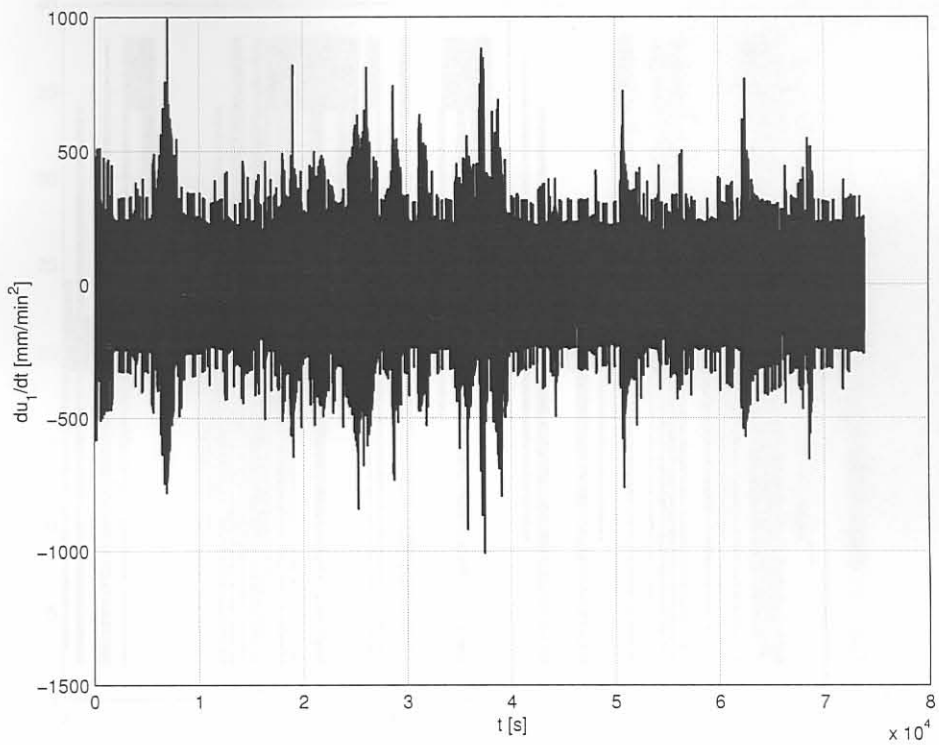


Figure J.10 Accelleration of the slab 1575mm wide slabs and the worst-case control configuration.

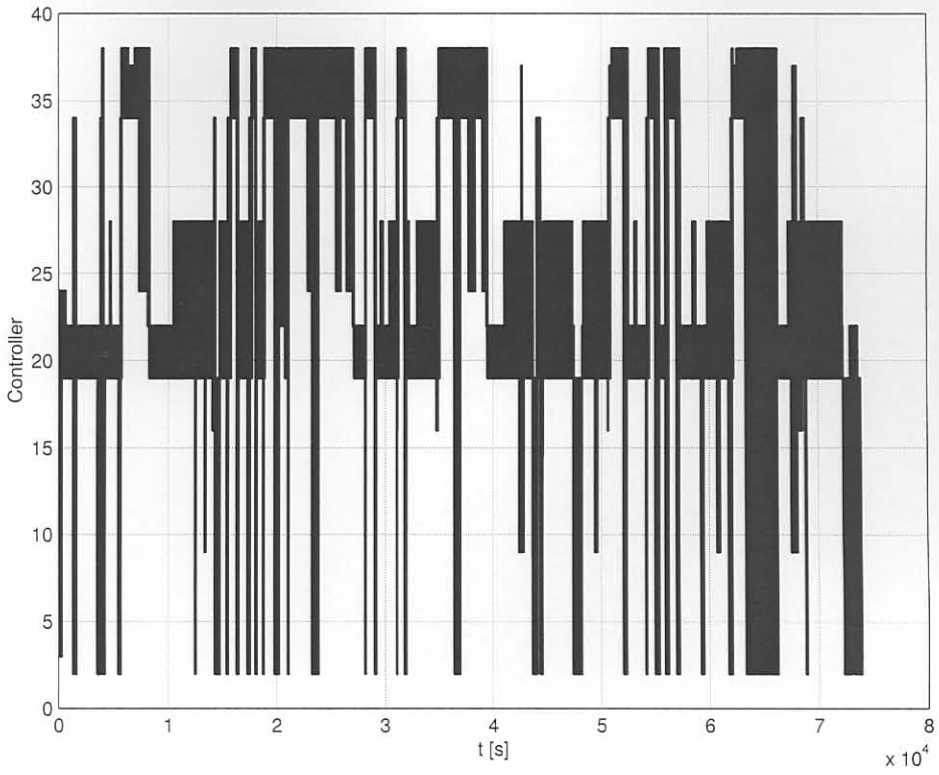


Figure J.11 Output of the switching criterion of 1575mm wide slabs and the worst-case control configuration.