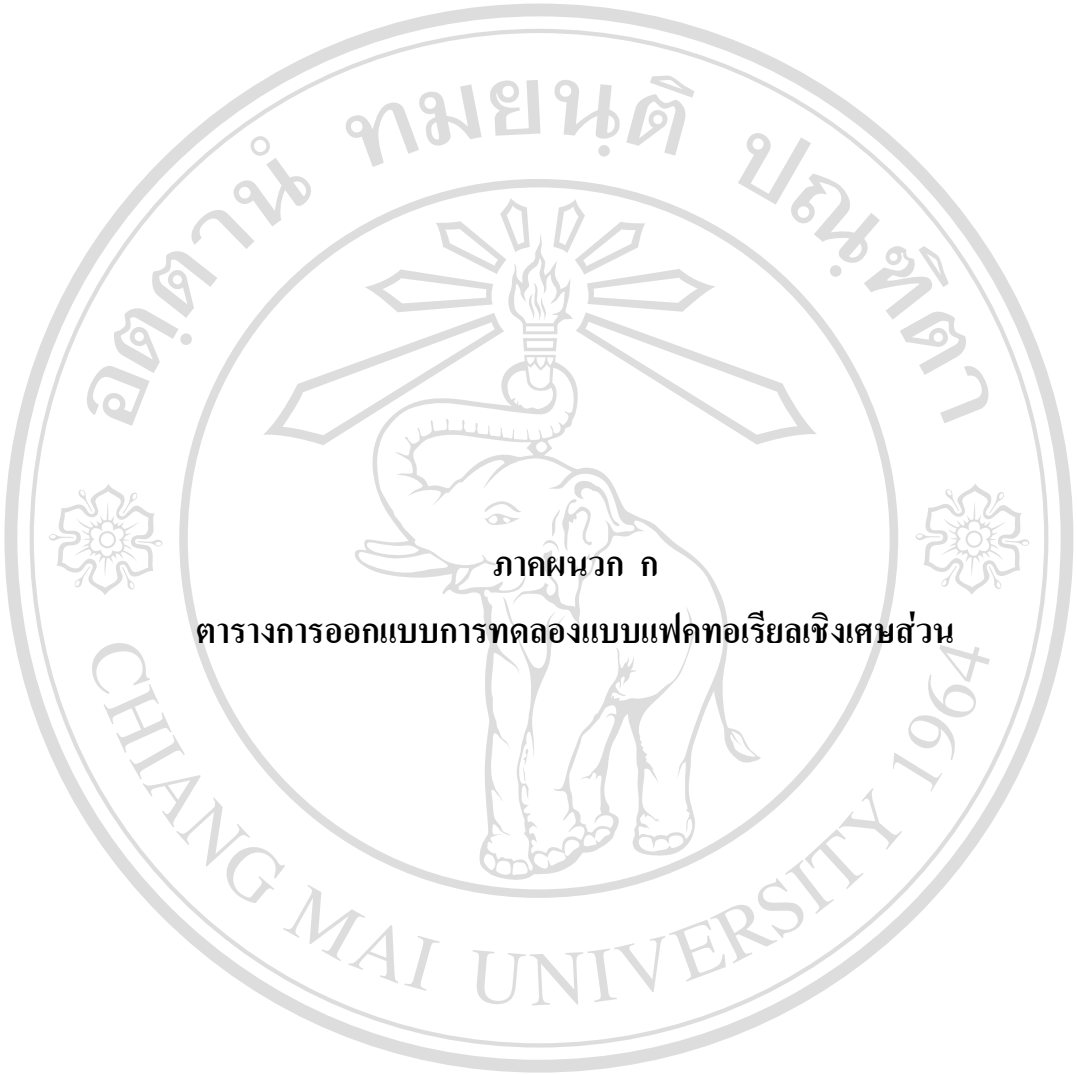
ภาคผนวก



ภาคผนวก ก

ตารางการออกแบบการทดลองแบบแฟคทอเรียลเชิงเศษส่วน

ตาราง ก.1 ตารางความเป็นไปได้ในการออกแบบการทดลองแบบแฟคทอเรียล

Available Factorial Designs (with Resolution)

	Factors													
Run	2	3	4	5	6	7	8	9	10	11	12	13	14	15
4	Full	III												
8		Full	IV	III	III	III								
16			Full	V	IV	IV	IV	III	III	III	III	III	III	III
32				Full	VI	IV	IV	IV	IV	IV	IV	IV	IV	IV
64					Full	VII	V	IV	IV	IV	IV	IV	IV	IV
128						Full	VIII	VI	V	V	IV	IV	IV	IV

Available Resolution III Plackett-Burman Designs

Factors	Runs	Factors	Runs	Factors	Runs
2-7	12,20,24,28,...,48	20-23	24,28,32,36,...,48	36-39	40,44,48
8-11	12,20,24,28,...,48	24-27	28,32,36,40,44,48	40-43	44,48
12-15	20,24,28,36,...,48	28-31	32,36,40,44,48	44-47	48
16-19	20,24,28,32,...,48	32-35	36,40,44,48		

ตาราง ก.2 การออกแบบการทดลองแบบแฟคทอเรียลเชิงเศษส่วน 2_{IV}^{7-3}

Fractional Factorial Design

Factors:	7	Base Design:	7, 16	Resolution with blocks:	IV
Runs:	22	Replicates:	1	Fraction:	1/8
Blocks:	2	Center pts (total):	6		

Design Generators: E = ABC, F = BCD, G = ACD

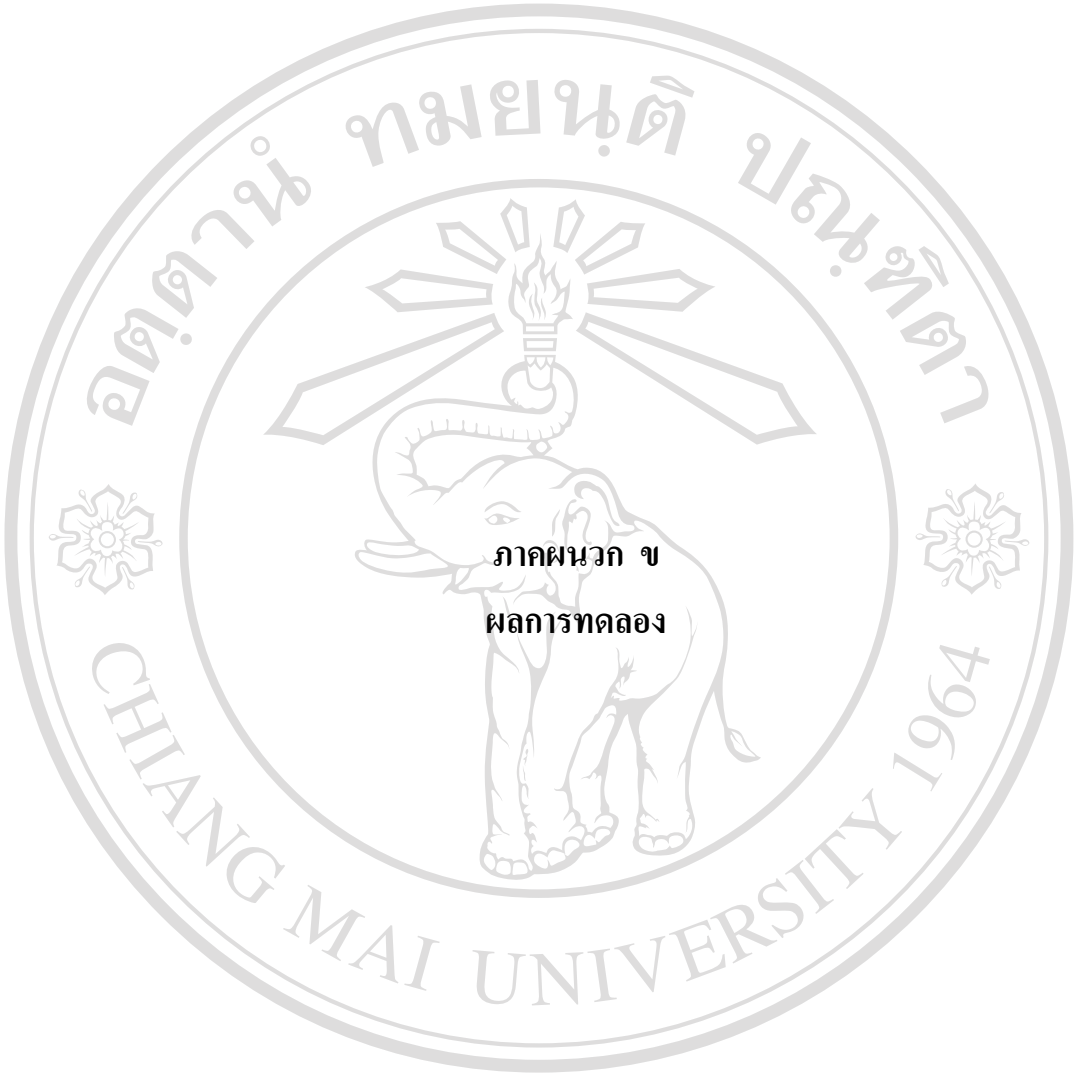
Block Generators: ABD

Alias Structure

I + ABCE + ABFG + ACDG + ADEF + BCDF + BDEG + CEFG

Blk = ABD + ACF + AEG + BCG + BEF + CDE + DFG + ABCDEFG

A + BCE + BFG + CDG + DEF + ABCDF + ABDEG + ACEFG
B + ACE + AFG + CDF + DEG + ABCDG + ABDEF + BCEFG
C + ABE + ADG + BDF + EFG + ABCFG + ACDEF + BCDEG
D + ACG + AEF + BCF + BEG + ABCDE + ABDFG + CDEFG
E + ABC + ADF + BDG + CFG + ABEFG + ACDEG + BCDEF
F + ABG + ADE + BCD + CEG + ABCEF + ACDFG + BDEFG
G + ABF + ACD + BDE + CEF + ABCEG + ADEFG + BCDFG
AB + CE + FG + ACDF + ADEG + BCDG + BDEF + ABCEFG
AC + BE + DG + ABDF + AEFG + BCFG + CDEF + ABCDEG
AD + CG + EF + ABCF + ABEG + BCDE + BDFG + ACDEFG
AE + BC + DF + ABDG + ACFG + BEFG + CDEG + ABCDEF
AF + BG + DE + ABCD + ACEG + BCEF + CDFG + ABDEFG
AG + BF + CD + ABDE + ACEF + BCEG + DEFG + ABCDFG
BD + CF + EG + ABCG + ABEF + ACDE + ADFG + BCDEFG



ภาคผนวก ข

ผลการทดลอง

ตาราง ข.1 ผลการทดลองจากการออกแบบการทดลองแฟคทอเรียลเชิงเศษส่วน 2_{IV}^{7-3}

Std	Run	Ct pt.	Block	A	B	C	D	E	F	G	1	2	3	4	5	6	7	8	Ave
1	19	1	1	-	-	-	-	-	-	-	123.4	124.3	121.7	124.4	121.5	121.0	120.4	119.0	122.4
2	9	1	1	+	-	-	-	+	-	+	123.6	120.8	122.6	122.8	123.1	123.3	125.3	123.6	122.5
3	18	1	1	-	+	-	-	+	+	-	122.7	121.6	120.9	121.8	121.3	120.3	123.5	123.3	122.0
4	7	1	1	+	+	-	-	-	+	+	122.4	122.5	122.0	122.7	121.2	123.9	125.8	120.9	122.1
5	12	1	1	-	-	+	-	+	+	+	124.7	125.6	122.2	125.1	122.7	123.8	122.8	125.2	121.9
6	1	1	1	+	-	+	-	-	+	-	122.5	120.6	123.1	123.1	121.5	123.1	123.4	124.7	121.5
7	6	1	1	-	+	+	-	-	-	+	122.8	119.7	123.3	121.5	120.9	121.6	122.1	120.7	122.4
8	13	1	1	+	+	+	-	+	-	-	121.9	120.5	122.7	122.0	124.8	122.5	121.5	123.0	122.1
9	16	1	1	-	-	-	+	-	+	+	121.9	122.3	120.7	123.4	121.4	119.9	121.6	122.7	122.8
10	15	1	1	+	-	-	+	+	+	-	122.4	119.7	122.8	123.1	124.3	124.8	122.0	122.7	121.6
11	3	1	1	-	+	-	+	+	-	+	122.1	121.3	124.5	121.2	121.4	121.1	122.8	122.5	122.4
12	2	1	1	+	+	-	+	-	-	-	120.8	122.6	122.0	122.6	124.6	120.8	121.7	122.4	121.9
13	5	1	1	-	-	+	+	+	-	-	123.0	122.7	126.0	122.2	120.4	121.5	123.6	119.8	122.0
14	11	1	1	+	-	+	+	-	-	+	120.7	124.0	124.4	122.6	119.9	118.8	119.7	121.3	122.0
15	10	1	1	-	+	+	+	-	+	-	120.0	121.1	122.5	119.0	120.7	120.6	123.4	122.1	122.8
16	14	1	1	+	+	+	+	+	+	+	120.6	120.0	123.6	121.8	122.3	123.0	121.8	121.5	122.3
17	4	0	1	0	0	0	0	0	0	0	122.0	123.1	120.7	122.4	122.3	121.0	121.2	121.6	122.2
18	17	0	1	0	0	0	0	0	0	0	123.4	121.7	122.1	120.7	122.6	122.5	123.8	121.1	122.0
19	8	0	1	0	0	0	0	0	0	0	123.3	123.1	120.8	121.0	122.5	120.9	122.6	123.2	122.3
20	38	1	2	-	-	-	-	-	-	-	124.4	120.4	122.7	122.7	122.9	121.5	123.3	121.3	122.4
21	28	1	2	+	-	-	-	+	-	+	122.5	120.3	122.1	124.6	124.7	124.0	122.7	122.9	122.4
22	37	1	2	-	+	-	-	+	+	-	121.0	122.2	120.9	121.2	121.2	123.7	122.1	122.7	122.0
23	26	1	2	+	+	-	-	-	+	+	123.1	119.5	121.0	122.9	122.5	121.3	123.9	121.0	122.3
24	31	1	2	-	-	+	-	+	+	+	122.5	122.3	122.0	122.5	122.0	120.7	122.9	122.0	121.9
25	20	1	2	+	-	+	-	-	+	-	123.0	123.0	122.3	122.9	122.1	121.0	121.8	121.0	121.4
26	25	1	2	-	+	+	-	-	-	+	122.7	121.0	122.2	121.9	120.4	122.4	121.6	120.8	122.5
27	32	1	2	+	+	+	-	+	-	-	121.4	121.8	121.4	122.1	122.4	121.8	121.0	121.0	122.2
28	35	1	2	-	-	-	+	-	+	+	122.2	124.1	124.1	121.4	120.5	122.6	121.7	123.9	122.9
29	34	1	2	+	-	-	+	+	+	-	121.8	123.0	122.4	123.7	123.7	121.9	123.4	123.2	121.5
30	22	1	2	-	+	-	+	+	-	+	122.1	121.1	123.0	121.7	123.6	122.6	121.1	123.0	122.3
31	21	1	2	+	+	-	+	-	-	-	122.4	122.5	123.0	121.1	120.6	121.4	120.5	124.4	122.0
32	24	1	2	-	-	+	+	+	-	-	119.6	124.2	122.1	122.0	121.7	119.1	122.7	122.6	122.0
33	30	1	2	+	-	+	+	-	-	+	121.2	122.8	123.5	123.1	122.1	124.3	124.0	121.8	122.1
34	29	1	2	-	+	+	+	-	+	-	121.6	121.8	122.4	124.0	120.7	123.6	121.1	121.6	122.8
35	33	1	2	+	+	+	+	+	+	+	121.7	122.5	121.8	121.6	118.8	121.3	122.3	121.8	122.2
36	23	0	2	0	0	0	0	0	0	0	122.5	123.3	124.8	123.5	123.0	123.2	121.6	122.4	122.2
37	36	0	2	0	0	0	0	0	0	0	123.0	122.8	121.4	122.1	121.3	122.3	119.3	122.5	122.1
38	27	0	2	0	0	0	0	0	0	0	121.5	121.6	122.7	121.0	121.3	122.6	121.3	120.9	122.4

ภาคผนวก ค

การแก้ปัญหาในการผลิตงานฉีดพลาสติก

ตาราง ค.1 แนวทางการแก้ปัญหาในการผลิตงานฉีดพลาสติก

Problem	Solutions
Short Shots	1. Check cushion 2. Increase injection pressure 3. Increase injection speed 4. Raise melt temperature by: o Raising cylinder temperature(s) o Increasing screw speed (unfilled only) o Raising back pressure (unfilled only) 5. Raise mould temperature 6. Increase booster time 7. Use lubricated material 8. Increase size of sprue/runners/gates 9. Check cavity vents for blockage
Flashing	1. Lower material temperature by: o Lowering cylinder temperature(s) o Decreasing screw speed o Lowering back pressure 2. Decrease injection pressure/speed 3. Decrease injection hold time/booster time 4. Check mould closure 5. Check press platens for parallelism 6. Move mould to larger (clamp) press
Splay marks, Silver streaks, Splash marks	1. Dry material before use 2. Check for contamination 3. Check for drooling 4. Raise mould temperature 5. Decrease injection speed

	6. Lower material temperature by: o Lowering cylinder temperature o Decreasing screw speed o Lowering back pressure 7. Lower nozzle temperature 8. Shorten overall cycle 9. Open gate(s)
Nozzle drool	1. Lower nozzle temperature 2. Increase "Decompress" time 3. Lower material temperature by: o Lowering cylinder temperature o Decreasing screw speed o Lowering back pressure 4. Reduce plunger forward time 5. Reduce back pressure 6. Decrease mould open time 7. Dry material 8. Use nozzle with small orifice 9. Use reverse-taper nozzle valve (Nylon)
Nozzle freeze-off	1. Raise nozzle temperature 2. Decrease cycle time 3. Raise mould temperature Use nozzle with larger orifice
Discoloration	1. Purge heating cylinder 2. Lower material temperature by: o Lowering cylinder temperature o Decreasing screw speed o Lowering back pressure

	3. Lower nozzle temperature 4. Shorten overall cycle 5. Check hopper and feed zone for contamination 6. Check for proper cooling of ram and feed zone 7. Move mould to smaller shot size press 8. Provide additional vents in mould
Burn marks	1. Decrease injection speed 2. Decrease booster time 3. Improve venting in mould cavity 4. Alter position/increase gate size
Sticking in cavity or core	1. Decrease injection pressure 2. Decrease injection hold 3. Decrease booster time 4. Adjust feed or constant cushion 5. Increase mould closed time (cavity) 6. Decrease mould closed time (core) 7. Lower mould temperature 8. Decrease cylinder and nozzle temperature (cavity) 9. Check mould for undercuts/insufficient draft
Sticking sprue bushing	1. Check size & alignment of holes in nozzle/sprue bushing 2. Decrease injection pressure 3. Decrease injection hold time 4. Decrease booster time 5. Increase die closed time 6. Raise nozzle temperature 7. Increase mould temperature at sprue bushing 8. Provide more effective sprue puller
Weld lines	1. Increase injection pressure 2. Increase injection hold time 3. Increase injection speed

	4. Raise mould temperature 5. Raise material temperature 6. Vent the cavity in the weld area 7. Provide an overflow well adjacent to weld area 8. Change gate location to after flow pattern
Sinks/Voids	1. Increase injection pressure 2. Increase injection hold time 3. Use booster and maximum injection speed (Sinks) 4. Raise mould temperature (Voids) 5. Lower mould temperature (Sinks) 6. Decrease injection speed (Voids) 7. Decrease cushion 8. Increase size of sprue/runner/gates 9. Relocate gates nearer heavy sections
Wrapage, Part distortion	1. Equalize temperature in both halves of mould 2. Observe mould for uniformity of part ejection 3. Check handling of parts after ejection 4. Increase injection hold time 5. Increase pressure/Decrease pressure 6. Raise/Lower mould temperature 7. Increase die close time 8. Lower material temperature 9. Try differential mould temperatures to counteract warp 10. Jig the part and cool uniformly
Brittleness	1. Lower material temperature by: o Lowering cylinder temperature o Decrease screw speed o Lowering back pressure 2. Check for contamination 3. Dry material before use

	4. Moisturize molded parts (Nylon) 5. Decrease amount of regrind in feed
Delaminating	1. Raise temperature of mould/material 2. Eliminate contamination 3. Dry material 4. Increase injection speed
Poor dimensional control	1. Set uniform cycle times 2. Maintain uniform feed/cushion from cycle to cycle 3. Fill mould as rapidly as possible 4. Check machine hydraulic and electrical systems for erratic performance 5. Increase gate size 6. Balance runners, gates and cavities layout 7. Reduce number of cavities
Unbelted pellets	1. Move mould to press with larger shot cavity 2. Use press with proper screw design preferred screw design characteristics: a. Metering zone --- Minimum 4-5 flights b. Zone distribution: 1/3 metering 1/3 feed Balance --- transition c. L/D ratio --- 20:1 or grater d. Compression ratio: 3:1 to 4:1 e. Check valve to prevent back flow f. Flight depth in metering zone no deeper than 3.3mm (for screws up to 100mm dia.)

ตาราง ค.2 เอกสารแนะนำการใช้งานจากผู้ส่งมอบเม็ดพลาสติก

Thermoplastic Polyurethane (TPU) Processing Information
SI

Properties	ETPU	TPU, Unspecified	TPU-Capro	TPU-Ester/Ether	TPU-PC	TPU-Polyester	TPU-Polyether
Specific Gravity (*g/cm³*)	1.2	0.880 to 1.33	1.15 to 1.19	1.13 to 1.25	1.15 to 1.20	1.17 to 1.26	1.09 to 1.18
Mold Shrinkage, Flow (*cm/cm*)	0.005	0.000040 to 0.015	0.013	0.012	0.0050 to 0.010	0.0056 to 0.0092	0.0047 to 0.0090
Melt Mass Flow Rate (*g/10 min*)	--	0.80 to 25	3.0 to 17	10	3.0 to 8.0	20 to 61	9.3 to 55
Drying Temperature (*°C*)	87.8 to 130	72.9 to 110	48.9 to 105	80.0 to 80.3	65.6	73.9 to 112	65.6 to 110
Drying Time (*hr*)	--	1.5 to 6.0	1.5 to 4.0	0.033	3.5	1.5 to 3.5	0.033 to 3.6
Suggested Max Moisture (*%*)	--	0.010 to 0.030	0.05	0.03	0.05	0.019 to 0.10	0.030 to 0.050
Suggested Max Regrind (*%*)	--	20	--	--	--	20 to 30	20
Injection Pressure (*MPa*)	--	84.3 to 86.2	9.86 to 11.0	72.4	--	9.89 to 80.5	9.56 to 75.3
Rear Temperature (*°C*)	--	169 to 186	180 to 220	175	154 to 191	184 to 212	183 to 223
Middle Temperature (*°C*)	--	180 to 191	199 to 200	181	--	192 to 216	190 to 225
Front Temperature (*°C*)	--	184 to 201	209 to 210	185	177 to 204	195 to 216	195 to 228
Nozzle Temperature (*°C*)	--	195 to 201	209 to 210	191	182 to 210	190 to 240	199 to 216
Processing (Melt) Temp (*°C*)	232 to 250	199 to 220	180 to 185	190 to 225	216 to 227	180 to 225	196 to 230
Mold Temperature (*°C*)	73.9 to 108	29.6 to 51.0	34.8 to 35.3	30	15.6 to 29.4	19.7 to 40.1	29.3 to 50.0

ประวัติผู้เขียน

ชื่อ-สกุล นายศราวุธ แปงยอง

วัน เดือน ปี เกิด 20 พฤษภาคม พ.ศ.2519

ประวัติการศึกษา

ระดับมัธยมศึกษา มัธยมศึกษาตอนปลาย
โรงเรียนจักรคำคณาทร ลำพูน พ.ศ. 2536

ระดับปริญญาตรี วิทยาศาสตรบัณฑิต สาขาเคมีอุตสาหกรรม
มหาวิทยาลัยเชียงใหม่ พ.ศ. 2541

ประวัติการทำงาน

เจ้าหน้าที่ควบคุมคุณภาพ บริษัทอิเล็กโทรเซรามิคส์ ไทยแลนด์ จำกัด
พ.ศ. 2541 - 2549

วิศวกรฝ่ายคุณภาพ บริษัท อโบทรอน ไทยแลนด์ จำกัด
พ.ศ. 2549 – 2552