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ภาคผนวก

ภาคผนวก ก

รายละเอียดสิทธิบัตรของ Ernst Frienderich

United States Patent [19]

Friederich

[11]   **4,101,617**

[45]   **Jul. 18, 1978**

[54] **METHOD FOR INJECTION MOLDING OF HOLLOW SHAPED BODIES FROM THERMOPLASTIC RESINS**

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[21] Appl. No.: **647,793**

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264/155; 425/533
[58] Field of Search 264/88, 89, 93, 94,
264/96-98, 45.1, 46.6, 55, DIG. 83, DIG. 1,
154, 155; 425/387.1, 533, 535

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Attorney, Agent, or Firm—Curtis, Morris & Safford

[57]   **ABSTRACT**

A method for making a hollow shaped body from a thermoplastic resin by injection molding, which method comprises injecting an amount of molten resin sufficient for the preparation of the hollow shaped body from an injection nozzle into a mold through an injection aperture in said mold, injecting gas under pressure through said injection nozzle and aperture to expand and distribute the molten resin over the interior surfaces of the mold, whereby said hollow shaped body is formed within said mold with a gas-entry opening in said hollow shaped body, cooling the hollow shaped resin body so formed to a temperature beneath the softening point of the resin, opening the interior of the hollow shaped body to equalize the pressure therein with ambient pressure, and then opening said mold to remove said hollow shaped body.

8 Claims, 3 Drawing Figures
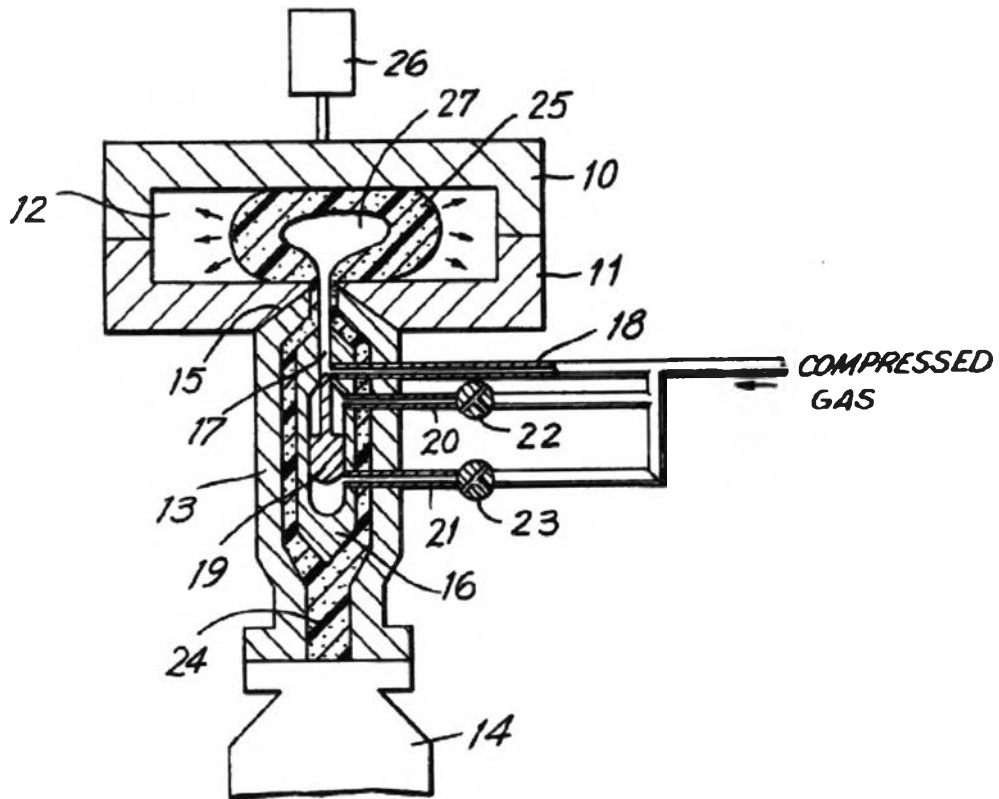
FIG. 1

FIG. 2

FIG. 3

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METHOD FOR INJECTION MOLDING OF HOLLOW SHAPED BODIES FROM THERMOPLASTIC RESINS

The present invention relates to a method for making hollow shaped bodies by a modified injection molding process.
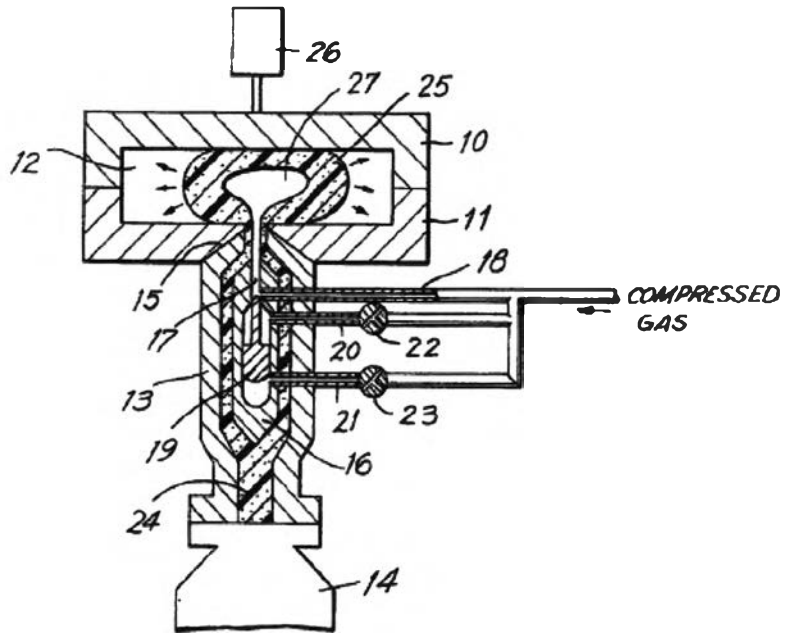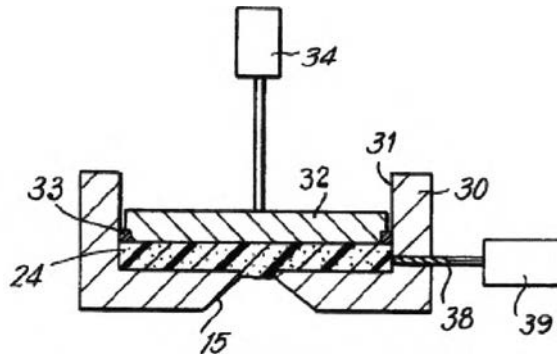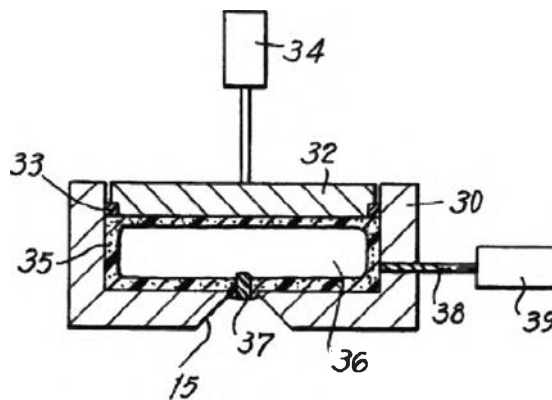
It is known in the art to prepare hollow bodies from thermoplastic resins by adhering or welding together two halves, which halves are usually mirror-symmetric and are formed, for example, by injection molding.

According to so-called "injection blowing" methods, hollow bodies of the type in question are made by preparing a pre-molded object by injection molding, i.e. with the resin in its thermoplastic condition. At this point, the apparatus is opened and the pre-molded object, including its core, is inserted into a second hollow mold suitable for blowing. In this mold, the hollow body is given its final shape by the introduction of gas. This process is widely used, particularly for the preparation of bottles and other relatively small hollow bodies.

The object of the present invention is to prepare hollow bodies of large size, for example double-paned windows, hollow glass bricks, double-walled lighting fixtures of large area, and double-walled skylights, from thermoplastic resins in one step and in a single mold using an injection molding procedure. In this way, the new procedure differs from the injection-blowing technique mentioned above, which latter involves at least two processing steps.

The new method is characterized by the following features, illustrated by reference to the preparation of a hollow "glass brick" of polymethylmethacrylate. The molding material, which has been rendered plastic in the injection cylinder of an automatic injection molding machine, is injected at a temperature of 260° C. into the mold cavity of the apparatus through an injection nozzle. In known fashion, the injection aperture of the mold is suitably located in the middle of the mold surface surrounding the aperture. In general, the total amount of the forming material which is to form the hollow body is injected with one stroke. Immediately after the injection process, or even superimposed on this process, gas is introduced into the mold through the injection aperture under such a pressure that the mold-filling process takes place completely. Air, carbon dioxide, or nitrogen, for example, can be employed as the pressurized gas. In the mold, the desired hollow body is formed and, because of the thermoplasticity of the resin, is held in its final form by gas pressure.

After cooling of the finished hollow body below the softening point of the resin, but before opening the mold, a pressure equalization with the ambient atmosphere is carried out. The pressure within the cooled shaped body can be equalized with ambient pressure simply by separating the mold and the injection nozzle, causing the resin to break around the thin neck of resin surrounding the injection aperture.

Alternatively, an amount of molten forming material sufficient to close the gas entry opening in the shaped body can be injected under pressure into the injection aperture after a sufficient amount of compressed gas has been introduced. In this case, equalization of the pressure in the closed hollow body is effected after cooling by boring into or piercing a wall of the body. It is recommended that this opening be made in the plane along

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which the mold will be separated, since an opening in this location is in general not visible on later use of the hollow body, for example as a double paned window.

A better understanding of the invention will be had by referring to the accompanying drawings, in which

FIG. 1 is a front elevation, partly in section, of an apparatus, including a mold and an injection nozzle, for carrying out the process of the present invention; and

FIGS. 2 and 3 are front elevations, partly in section, showing two successive stages in carrying out the method of the present invention employing a mold embodiment having male and female portions.

FIG. 1 shows a mold comprising upper mold portion 10 and lower mold portion 11, both suitably of metal, defining mold cavity 12 therebetween. Mold cavity 12 has a form corresponding to that of the hollow resin body to be produced according to the invention.

Injection nozzle 13, also suitably of metal and attached at one end to outlet 14 of an injection molding machine, is mated with lower mold portion 11 at its other end through injection aperture 15 (better seen in FIGS. 2 and 3 which omit injection nozzle 13). Injection nozzle 13 has therein core portion 16 provided in its interior portions with compressed gas channel 17 in communication through gas inlet tube 18 with a source of compressed gas. Located within channel 17 in core portion 16 of injection nozzle 13 is pressure-activated valve 19. Valve 19 is slidably movable within channel 17 under the action of compressed gas alternately introduced through gas lines 20 and 21 through three-way valves 22 and 23.

At the beginning of the process of the present invention, molten thermoplastic resin 24 is introduced into mold cavity 12 from outlet 14 of an injection molding machine through injection nozzle 13. During the resin injection stage, pressure-activated valve 19 is in a position (not shown in FIG. 1) which blocks gas inlet tube 18. This is achieved by introducing compressed gas through line 21 and valve 23 while permitting gas to escape from the interior of core portion 16 through line 20 and valve 22. After mold cavity 12 is partially filled with resin, gas line 20 is pressurized through valve 22 while gas is bled from the interior of core portion 16 through line 21 and valve 23. This causes valve 19 to assume the position shown in FIG. 1. Gas inlet tube 18 is thus opened, permitting compressed gas to flow therethrough into compressed gas channel 17, in turn in communication with mold cavity 12 through injection aperture 15. In consequence, resin bubble 25 is formed within mold cavity 12. Compressed gas continues to flow through inlet tube 18 causing resin bubble 25 to expand in the direction shown by the arrows until the exterior walls of the bubble are pressed completely against the inner wall of mold cavity 12 defined by upper and lower mold portions 10 and 11. Valve 19 is then again actuated by appropriate manipulation of valves 22 and 23 to introduce gas through line 21 and remove it from line 20, thereby moving valve 19 in compressed gas channel 17 into a position which again blocks the entry of compressed gas through inlet tube 18. As soon as the hollow shaped body thus formed within mold cavity 12 has cooled below the softening temperature of the thermoplastic resin, joined upper and lower mold portions 10 and 11 are separated as a combination from injection nozzle 13 by means 26, for example hydraulic moving means. This movement breaks the thin neck of resin surrounding the walls of injection aperture 15 and the pressurized gas contained

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within cavity 27 of the hollow shaped body formed within the mold portion escapes to the ambient atmosphere through the opening produced thereby. Upper and lower mold portions 10 and 11 are then separated and the shaped resin body is removed from the separated mold portions.

FIGS. 2 and 3 show two successive stages of carrying out the method of the present invention employing a different mold embodiment comprising female mold portion 30, suitably of metal, having therein shaped depression 31 into which matching male mold portion 32, also suitably of metal, is fitted. Male mold portion 32 and female mold portion 30 are brought into sealing relationship by peripheral sealing gasket 33. Female mold portion 30 contains therein injection aperture 15 which, as for the mold embodiment shown in FIG. 1, is brought into a mating relationship with an injection nozzle such as nozzle 13 shown in FIG. 1. (For purposes of clarity, the injection nozzle has been omitted from FIGS. 2 and 3.)

At the beginning of the resin injection process shown in FIG. 2, thermoplastic resin 24 is introduced into a cavity defined between female mold portion 30 and male mold portion 32. Then, proceeding as described earlier herein with reference to FIG. 1, compressed gas is introduced through an injection nozzle into the molten thermoplastic resin while, simultaneously, male mold portion 32 is moved upwardly by means 34, for example hydraulically operated moving means, connected thereto. In this manner, the resin mass 24 of FIG. 2 is formed into a hollow shaped body (shown as 35 in FIG. 3).

Just as in the process described with reference to FIG. 1, after the resin comprising hollow shaped body 35 has cooled beneath its softening temperature, joined mold portions 30, 32 are separated in combination from the injection nozzle so that pressurized gas contained within cavity 36 of the resultant shaped body can escape and equalization with ambient pressure occurs. On removal of male mold portion 32 completely from shaped depression 31 defined within female mold portion 30, shaped resin body 35 can be removed from the mold.

In addition to the method embodiment specifically described with reference to FIGS. 2 and 3, numerous other embodiments for carrying out the process of the invention are possible. Thus, for example, at the beginning of the resin injection process, the cavity present in mold 30, 32 can be only partially filled with resin. Male mold portion 32 can be moved upwardly even during the injection of resin, although it is more advantageous to effect this movement simultaneously with the injection of compressed gas or even to permit the movement of male mold portion 32 within female mold 30 to be effected solely by means of the forces exerted on male mold portion 32 by the compressed gas introduced into the cavity therebeneath.

In many cases, it is not desired that the shaped body formed according to the process of the invention have an opening therein at the locus of the injection aperture 15 in lower mold portion 11 of FIG. 1 or female mold portion 30 of FIGS. 2 and 3. In this case, the gas entry opening in the final shaped body can be sealed with a resin plug such as resin plug 37 particularly shown in FIG. 3. To form such a resin plug, an amount of molten resin sufficient to form the plug is introduced through the injection nozzle after the injection of compressed gas into the resin body is completed. In this case, the gas within the hollow shaped body (cf. cavity 27 of FIG. 1

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or cavity 36 of FIG. 3) remains at superatmospheric pressure. After cooling of the thermoplastic resin beneath its softening point, but before the resultant hollow shaped body can be removed from the mold, the gas pressure therein must be equalized with the ambient pressure to avoid a possible explosion of the hollow body on removal from the mold. As shown in FIGS. 2 and 3, to equalize interior pressure with ambient pressure, an aperture can be drilled within hollow shaped body 35 by drill 38 rotated and propelled forward by means 39. The pressurized gas within the hollow shaped body can thus escape into the atmosphere through the opening so produced. If a sufficiently tough resin body is employed for formation of the hollow shaped body, the body can be pierced with a sharp instrument (not shown), in a manner analogous to that shown in FIGS. 2 and 3, instead of employing drill 26. Suitably, the piercing instrument is formed as a cannula having an interior passage therein so that the pressurized gas can escape directly to the atmosphere through the interior passage.

The boring technique and the analogous piercing technique described immediately above with reference to the mold of FIGS. 2 and 3 can, of course, also be adapted to the mold shown in FIG. 1 by appropriate modification thereof.

As synthetic resins which can be employed according to the foregoing process, polystyrene, polyethylene, polyvinyl chloride, and acetobutyrate can be given as examples, in addition to the polymethylmethacrylate already mentioned.

Hollow bodies having a relatively small separation of the parallel walls thereof from one another, for example of 5 millimeters, can be prepared in any of the above-described manners without effort. However, in the preparation of bodies such as the aforementioned glass bricks, whose principal surfaces may be spaced about 50 mm from one another, it is preferable to use expandable molds like the mold shown in FIGS. 2 and 3.

The hollow bodies prepared according to the process of the present invention have an exterior surface which corresponds to the quality of the surface of the mold cavity in the apparatus. If the required temperature for whichever resin is being used is maintained and other injection requirements are met, the inner surface of the hollow body is shiny. Even in the processing of opalescent materials, the quality of the inner and outer surfaces of the shaped body formed therefrom meets all requirements.

It should also be mentioned that the new process can be carried out on commercially-available machines to the extent that these can be modified in a simple manner to permit the controlled introduction of gas under pressure. In evaluating the new process, it should not remain unmentioned that the process permits the preparation of closed hollow bodies whose interior portions are completely dust-free. In the preparation of hollow bodies by the joining of two halves, freedom from dust can only be achieved with a comparatively great effort.

What is claimed is:

1. A method for making a hollow shaped body from a thermoplastic resin by injection molding, which method comprises injecting an amount of molten resin sufficient for the preparation of the hollow shaped body from an injection nozzle into a mold through an injection aperture in said mold, injecting gas under pressure through said injection nozzle and aperture to expand and distribute the molten resin over the interior surfaces

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of the mold, whereby said hollow shaped body is formed within said mold with a gas entry opening in said hollow shaped body, cooling the hollow shaped resin body so formed to a temperature beneath the softening point of the resin, separating said mold and said injection nozzle after said resin has cooled beneath its softening point, whereby the interior of said hollow shaped body is opened to the atmosphere through said injection aperture and gas-entry opening to equalize the pressure within said body with ambient pressure, and then opening said mold to remove said hollow shaped body.

2. A method as in claim 1 wherein said mold defines therein a mold cavity of fixed volume having the form of the hollow shaped body to be formed therein, and wherein the molten resin injected into said mold initially only partially fills said mold cavity.

3. A method as in claim 1 wherein said mold comprises a female mold portion and a male mold portion movable within said female mold portion to define therein a mold cavity of variable volume, wherein the molten resin injected into said mold initially fills said mold cavity, and wherein the volume of said mold cavity is increased on injection thereinto of gas under pressure.

4. A method for making a hollow shaped body from a thermoplastic resin by injection molding, which method comprises injecting an amount of molten resin sufficient for the preparation of the hollow shaped body from an injection nozzle into a mold through an injection aperture in said mold, injecting gas under pressure through said injection nozzle and aperture to expand and distribute the molten resin over the interior surfaces

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of the mold, whereby said hollow shaped body is formed within said mold with a gas entry opening in said hollow shaped body, injecting an amount of resin sufficient to close said gas-entry opening in said hollow shaped body through said injection nozzle into said injection aperture, cooling the hollow shaped resin body so formed to a temperature beneath the softening point of the resin, opening the interior of the hollow shaped body to equalize the pressure therein with ambient pressure, and then opening said mold to remove said hollow shaped body.

5. A method as in claim 4 wherein the interior of the hollow shaped body is opened to the ambient atmosphere after cooling of the resin by boring an aperture in said body.

6. A method as in claim 4 wherein said hollow shaped body is opened to the ambient atmosphere after cooling of the resin by piercing said body.

7. A method as in claim 4 wherein said mold defines therein a mold cavity of fixed volume having the form of the hollow shaped body to be formed therein, and wherein the molten resin injected into said mold initially only partially fills said mold cavity.

8. A method as in claim 4 wherein said mold comprises a female mold portion and a male mold portion movable within said female mold portion to define therein a mold cavity of variable volume, wherein the molten resin injected into said mold initially fills said mold cavity, and wherein the volume of said mold cavity is increased on injection thereinto of gas under pressure.

* * * * *

ภาคผนวก ข

คุณสมบัติเทอร์โมพลาสติกในงานวิจัย

ตาราง ข.1 แสดงคุณสมบัติของเทอร์โมพลาสติก

**HMC POLYMERS
COMPANY LIMITED**

Moplen HP500N

General Purpose Polypropylene Homopolymer Resin

Features :

* Good stiffness
* Good heat - age life
* Low odor and taste transfer
* Excellent resistance to environmental
  stress - cracking

Typical Applications :

* Food containers
* Housewares
* Toys
* Closures
* Hospital and institutional wares
* Multifilament fiber

Resin properties (a)	Moplen HP500N	ASTM METHOD(b)
Melt flow rate, dg/min.	12	D 1238
Density, g/cm³	0.90	D 792B
Tensile strength at yield, MPa	34	D 638
Elongation at yield, %	10	D 638
Flexural modulus, MPa	1480	D 790A
Notched izod impact strength at 23°C, J/m	25	D 256A
Deflection temperature, at 455 kPa, °C	97	D 648

(a) Values shown are averages and are not to be considered as specifications
(b) ASTM test methods are the latest under Society's current procedures. All molded specimens are prepared by injection

FDA Statement
Moplen HP500N meets FDA requirements in the Code of Federal Regulations in 21 CFR 177.1520 for all food
contact. All ingredients in Moplen HP500N meets the chemical registration requirements of TSCA (U.S.) and
DSL (Canada)

Note: Due to the fact that different regulations in each country, set different details of compliance, users of
Moplen HP500N are recommended to undertake their own investigation of the requirements and comply with
each regulation set form, for instance in applicable local FDA requirements. Ultimately, the users must make
their own determination that their use of Moplen HP500NS is safe, lawful and technically suitable in their
intended applications.

Moplen is a trademark of Basell
HMC Polymers is certified according to ISO 9001 and 14001   Issued 28-Apr-05
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information or the safety, and suitability of our products, either alone or in combination with other products. Users are advised
to make their own tests to determine the safety, and suitability of each such product or product combination for their purposes.
Unless otherwise agreed in writing, we sell the products without warranty, and buyers and users assume all responsibility and
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                              polyethylene and advanced polyolefins companies

ภาคผนวก ข

สภาวะต่างๆในการทดลอง

ตาราง ข.1 แสดงสภาวะต่างๆ ในการตั้งค่าเครื่องฉีด

Program	Parameters	Values	Program	Parameters	Values
1	Clamping Force (bar)	30	9	Ejector forward speed 1 (mm/sec)	15
	Mold close (mm)	16.1		Ejector forward stroke 1 (mm)	50
	Mold safety stroke (mm)	40		Ejector forward pressure (bar)	20
2	Nozzle touching point (mm)	38.8		Ejector forward speed 2 (mm/sec)	15
3	Max injection speed (mm/sec)	100		Ejector forward stroke 2 (mm)	100
	Max injection pressure (bar)	140		Ejector shuttle stroke (mm)	100
	Metering stroke (mm)	75		Melt temperature zone 0 ($^\circ$C)	230
	Injection speed 1 (mm/sec)	30		Melt temperature zone 1 ($^\circ$C)	230
	Injection stroke 1 (mm)	0		Melt temperature zone 2 ($^\circ$C)	230
	Injection speed 2 (mm/sec)	0		Melt temperature zone 3 ($^\circ$C)	230
	Injection stroke 2 (mm)	0		Melt cushion (mm)	230
	Injection speed 3 (mm/sec)	0			
	Injection stroke 3 (mm)	0	**Monomodule**		
	Injection speed 4 (mm/sec)	0	Program	Parameters	Values
	Injection stroke 4 (mm)	0		Delay time (sec)	
	Injection speed 5 (mm/sec)	0		Gas pressure (bar)	
4	Follow-up pressure stroke-dependent	1		Gas hold time (sec)	
	Follow-up pressure stroke (mm)	5			
	Follow-up pressure time-dependent	0			
	Follow-up pressure time (sec)	20			
5	Follow-up pressure 1 (mm/sec)	0			
	Follow-up pressure 1 time (sec)	0			
	Follow-up pressure 2 (mm/sec)	0			
	Follow-up pressure 2 time (sec)	0			
	Cooling time (sec)	80			
6	Metering delay (sec)	18			
	Back pressure 1 (bar)	5			
	Back pressure stroke 1 (mm)	5			
	Back pressure 2 (bar)	5			
	Back pressure stroke 2 (mm)	5			

ตาราง ข.1 (ต่อ) แสดงสภาวะต่างๆ ในการตั้งค่าเครื่องฉีด

Program	Parameters	Values
	Metering speed 1 (mm/sec)	60
	Metering stroke 1 (mm)	10
	Metering speed 2 (mm/sec)	60
	Metering stroke 2 (mm)	75
7	Nozzle back delay (sec)	20
	Nozzle back speed (mm/sec)	30
	Nozzle back pressure (bar)	40
	Nozzle back stroke (mm)	240

ตาราง ข.2 แสดงสภาวะของการขึ้นรูปชิ้นงานสำหรับการทดลอง

Range of varying parameters

		MFI of materials	12		
Melt temperature (°C)	200	215	230	245	260
Shot size (mm)	60	65	70	75	80
Delay time (sec)	1	3	5	7	9
Gas time (sec)	1	3	5	7	9
Gas hold time (sec)	0	15	30	50	70
Gas pressure (bar)	50	100	150	200	
Mold temperature (°C)	35	45	55	65	75

Reference Condition for Injection Molding

Number of test	Melt temperature (°C)	MFI of materials	Shot size (mm)	Delay time (sec)	Gas time (sec)	Gas hold time (sec)	Gas pressure (bar)	Mold temperature (°C)	Cooling time
1	200	12	65	3	3	15	100	35	80
2	215	12	65	3	3	15	100	35	80
3	245	12	65	3	3	15	100	35	80
4	260	12	65	3	3	15	100	35	80
5	230	12	60	3	3	15	100	35	80
6	230	12	65	3	3	15	100	35	80
7	230	12	70	3	3	15	100	35	80
8	230	12	75	3	3	15	100	35	80
9	230	12	80	3	3	15	100	35	80
10	230	12	65	1	3	15	100	35	80
11	230	12	65	5	3	15	100	35	80
12	230	12	65	7	3	15	100	35	80
13	230	12	65	9	3	15	100	35	80
14	230	12	65	3	1	15	100	35	80
15	230	12	65	3	5	15	100	35	80
16	230	12	65	3	7	15	100	35	80
17	230	12	65	3	9	15	100	35	80

ตาราง ข.2 (ต่อ) แสดงสภาวะของการขึ้นรูปชิ้นงานสำหรับการทดลอง

Number of test	Melt temperature (°C)	MFI of materials	Shot size (mm)	Delay time (sec)	Gas time (sec)	Gas hold time (sec)	Gas pressure (bar)	Mold temperature (°C)	Cooling time
18	230	12	65	3	3	0	100	35	80
19	230	12	65	3	3	0	150	35	80
20	230	12	65	3	3	30	100	35	80
21	230	12	65	3	3	30	150	35	80
22	230	12	65	3	3	50	100	35	80
23	230	12	65	3	3	50	150	35	80
24	230	12	65	3	3	70	100	35	100
25	230	12	65	3	3	70	150	35	100
26	230	12	65	3	3	15	50	35	80
27	230	12	65	3	3	15	150	35	80
28	230	12	65	3	3	15	200	35	80
29	230	12	65	3	3	15	100	45	80
30	230	12	65	3	3	15	100	55	80
31	230	12	65	3	3	15	100	65	80
32	230	12	65	3	3	15	100	75	80

ภาคผนวก ค

ข้อมูลที่ได้จากการทดลอง

ตาราง ค.1 แสดงค่าปริมาตรของแก๊สที่ได้จากการทดลอง

Condition	No.	Volume	Average	Min	Max	Condition	No.	Volume	Average	Min	Max
1	1	47.6	34.2	32.7	35.7	6	1	28.9	28.9	28.5	29.4
	2	47.7					2	29.6			
	3	27.4					3	28.5			
	4	27.7					4	29.3			
	5	27.6					5	28.9			
	6	27.4					6	28.3			
2	1	17.4	18.6	16.8	20.5	7	1	30.0	30.2	30.0	30.5
	2	19.2					2	30.6			
	3	16.8					3	30.6			
	4	17.0					4	30.1			
	5	19.9					5	30.1			
	6	21.4					6	30.1			
3	1	9.3	9.5	8.2	10.9	8	1	22.2	21.4	20.6	22.2
	2	8.9					2	19.8			
	3	11.8					3	21.6			
	4	9.3					4	21.9			
	5	8.3					5	21.6			
	6	9.0					6	21.2			
4	1					9	1	32.5	32.9	32.5	33.4
	2						2	33.6			
	3						3	33.2			
	4						4	33.0			
	5						5	33.1			
	6						6	32.4			
5	1	32.1	32.4	32.2	32.6	10	1	28.9	28.9	28.6	29.2
	2	32.5					2	29.3			
	3	32.4					3	28.5			
	4	32.7					4	28.6			
	5	32.3					5	29.0			
	6	32.4					6	29.2			

ตาราง ค.1 (ต่อ) แสดงค่าปริมาตรของแก๊สที่ได้จากการทดลอง

Condition	No.	Volume	Average	Min	Max	Condition	No.	Volume	Average	Min	Max
11	1	33.2	32.6	32.1	33.2	16	1	33.1	33.0	32.6	33.4
	2	32.8					2	33.1			
	3	32.7					3	33.0			
	4	32.4					4	33.4			
	5	31.7					5	32.9			
	6	33.1					6	32.2			
12	1	30.1	30.1	29.8	30.4	17	1	32.6	32.6	32.1	33.0
	2	29.7					2	32.1			
	3	29.9					3	33.2			
	4	30.1					4	32.6			
	5	30.4					5	32.1			
	6	30.4					6	33.0			
13	1	28.9	37.8	37.4	38.2	18	1	34.1	32.6	32.1	33.0
	2	28.5					2	33.6			
	3	28.4					3	33.6			
	4	29.5					4	33.8			
	5	28.5					5	33.5			
	6	29.1					6	34.0			
14	1	27.0	26.2	25.2	27.1	19	1	32.3	35.3	33.8	36.8
	2	25.0					2	36.0			
	3	25.4					3	35.7			
	4	25.9					4	36.2			
	5	27.4					5	35.6			
	6	26.2					6	36.1			
15	1	21.7	21.9	20.3	23.5	20	1	31.0	30.5	30.1	30.8
	2	21.8					2	30.5			
	3	22.2					3	29.8			
	4	20.1					4	30.5			
	5	24.8					5	30.7			
	6	20.9					6	30.4			

ตาราง ค.1 (ต่อ) แสดงค่าปริมาตรของแก๊สที่ได้จากการทดลอง

Condition	No.	Volume	Average	Min	Max	Condition	No.	Volume	Average	Min	Max
21	1	33.3	35.8	35.5	36.1	26	1	33.3	31.9	31.1	32.6
	2	30.3					2	31.4			
	3	30.6					3	31.6			
	4	31.1					4	31.7			
	5	30.9					5	31.5			
	6	31.0					6	31.7			
22	1	37.1	37.5	36.9	38.2	27	1	31.8	32.0	31.6	32.4
	2	37.0					2	32.0			
	3	37.2					3	31.8			
	4	37.7					4	32.7			
	5	37.4					5	31.8			
	6	38.8					6	-45.0			
23	1	11.4	5.9	4.9	7.0	28	1	30.5	30.9	30.1	31.7
	2	5.6					2	30.3			
	3	7.8					3	30.6			
	4	5.4					4	30.7			
	5	5.4					5	30.5			
	6	5.5					6	32.5			
24	1	0.0	31.9	31.5	32.4	29	1	27.1	27.2	26.8	27.5
	2	31.2					2	26.6			
	3	32.3					3	29.6			
	4	32.3					4	27.4			
	5	31.9					5	27.1			
	6	32.0					6	27.6			
25	1	32.2	32.4	32.2	32.6	30	1	30.6	30.0	29.6	30.4
	2	32.5					2	30.0			
	3	32.4					3	30.0			
	4	32.4					4	29.7			
	5	32.6					5	30.3			
	6	32.3					6	29.4			

ตาราง ค.1 (ต่อ) แสดงค่าปริมาตรของแก๊สที่ได้จากการทดลอง

Condition	No.	Volume	Average	Min	Max
31	1	32.4	32.5	32.0	32.9
	2	31.9			
	3	33.2			
	4	32.2			
	5	32.6			
	6	32.4			
32	1	31.2	31.8	31.4	32.2
	2	32.2			
	3	31.5			
	4	31.8			
	5	32.1			
	6	32.0			

ตาราง ค.2 แสดงค่าความหนาตกค้าง (RWT) ที่ได้จากการทดลอง

Cond.	Sect.	Up	Left	Down	Right	Cond.	Sect.	Up	Left	Down	Right
1	1	2.9	6.5	5.9	5.6	7	1	2.9	5.4	5.5	4.9
	2	3.5	6.5	3.8	3.4		2	3.7	6.4	3.8	3.5
	3	3.4	5.1	3.3	3.8		3	3.5	5.3	3.4	3.9
	4	5.2	10.7	7.0	7.0		4	5.2	9.1	5.9	4.6
	5	10.4	16.0	10.7	16.4		5	11.1	15.9	11.6	16.2
2	1	3.4	5.8	5.2	5.5	8	1	3.0	5.3	4.9	4.8
	2	3.5	6.6	3.6	3.5		2	3.5	6.9	3.8	3.5
	3	2.9	6.4	3.0	4.6		3	3.4	5.6	3.3	3.9
	4	9.6	16.1	9.7	16.1		4	7.2	14.2	5.5	12.4
	5	10.1	16.0	9.8	16.3		5	8.8	15.7	7.7	16.0
3	1	3.9	11.3	7.5	10.8	9	1	2.9	6.3	6.3	5.5
	2	3.3	6.6	3.9	4.1		2	3.7	6.4	3.9	3.6
	3	6.7	10.8	4.4	11.9		3	3.1	3.8	3.3	3.9
	4	9.8	15.7	10.2	15.9		4	5.0	8.6	4.7	4.2
	5	10.3	16.0	10.2	16.3		5	12.0	16.0	12.2	16.0
4	1					10	1	2.9	5.2	4.7	4.9
	2						2	3.7	6.3	4.0	3.6
	3						3	3.5	5.4	3.5	4.0
	4						4	4.7	9.1	6.0	4.4
	5						5	10.5	15.9	11.1	16.2
5	1	3.9	6.6	6.5	5.1	11	1	3.1	6.5	5.6	5.0
	2	4.1	6.6	4.1	3.7		2	3.6	6.3	4.0	3.8
	3	3.7	5.5	2.2	4.1		3	3.5	5.3	3.4	3.8
	4	3.7	6.7	3.4	3.1		4	5.1	9.6	5.7	4.3
	5	11.0	15.9	11.4	16.1		5	11.1	16.0	11.4	16.1
6	1	3.0	5.4	5.4	4.8	12	1	2.8	5.7	4.6	5.3
	2	3.7	6.4	3.9	3.4		2	3.7	7.2	3.9	3.4
	3	3.4	5.3	3.4	3.9		3	3.7	8.2	3.3	5.0
	4	5.0	9.5	6.2	4.7		4	5.2	11.5	7.6	10.3
	5	10.6	15.9	11.0	16.3		5	10.0	15.8	10.4	16.2

ตาราง ค.2 (ต่อ) แสดงค่าความหนาดกค้าง (RWT) ที่ได้จากการทดลอง

Cond.	Sect.	Up	Left	Down	Right	Cond.	Sect.	Up	Left	Down	Right
13	1	2.5	5.5	4.9	5.0	19	1	2.6	3.6	3.5	3.4
	2	3.5	6.6	3.6	3.3		2	2.9	4.8	3.1	2.8
	3	3.3	5.2	3.2	3.7		3	2.7	3.8	2.7	3.1
	4	6.1	9.4	6.8	3.2		4	3.5	5.7	3.4	2.9
	5	11.3	16.0	11.7	16.2		5	12.5	16.2	12.6	16.2
14	1	2.9	5.7	4.7	5.7	20	1	3.0	5.4	4.3	5.1
	2	3.7	6.5	3.8	3.6		2	3.8	6.6	4.0	3.5
	3	3.6	5.5	3.4	3.9		3	3.6	6.0	3.4	4.0
	4	5.7	11.0	6.4	8.9		4	4.9	9.8	5.4	8.1
	5	9.9	15.9	9.9	16.2		5	11.0	15.7	11.8	15.9
15	1	3.0	5.5	4.6	5.7	21	1	3.5	4.3	3.4	4.3
	2	3.6	6.7	3.7	3.5		2	3.8	7.7	4.0	2.9
	3	3.8	5.7	3.2	3.9		3	3.5	5.7	3.3	3.6
	4	7.1	13.7	5.1	11.6		4	4.8	10.1	4.8	5.4
	5	9.3	15.9	8.8	15.8		5	10.8	16.0	11.3	16.2
16	1	2.3	4.5	4.0	4.4	22	1	3.0	5.4	4.0	5.2
	2	2.8	4.4	2.9	2.8		2	3.8	6.7	3.8	3.5
	3	2.7	3.7	2.8	3.0		3	3.4	5.4	3.1	3.8
	4	5.5	8.1	4.9	4.9		4	3.7	6.7	3.1	2.9
	5	12.4	16.1	12.5	16.1		5	3.9	7.8	3.3	2.8
17	1	2.2	4.4	3.7	3.9	23	1	4.1	10.7	8.9	11.1
	2	2.8	4.7	2.9	2.7		2	4.7	13.3	9.4	13.5
	3	2.5	3.7	2.5	2.8		3	6.0	10.9	5.7	10.0
	4	3.4	6.4	3.3	3.0		4	10.6	15.9	11.3	16.3
	5	12.3	16.2	12.4	16.1		5	10.8	15.8	11.1	15.7
18	1	2.3	4.6	3.7	4.3	24	1	4.1	5.4	4.2	5.1
	2	3.0	4.7	3.1	2.9		2	4.4	6.8	4.3	3.9
	3	2.8	4.1	2.9	3.0		3	4.0	5.8	3.7	4.7
	4	4.4	7.4	3.9	3.5		4	3.8	6.6	3.3	3.2
	5	12.4	16.1	12.6	16.2		5	7.9	11.7	8.6	8.0

ตาราง ค.2 (ต่อ) แสดงค่าความหนาตกค้าง (RWT) ที่ได้จากการทดลอง

Cond.	Sect.	Up	Left	Down	Right	Cond.	Sect.	Up	Left	Down	Right
25	1	4.3	5.5	4.3	5.1	29	1	2.9	5.7	4.3	5.3
	2	4.6	6.9	4.4	4.2		2	3.6	6.5	3.9	3.5
	3	4.2	6.0	4.0	4.6		3	3.6	5.3	3.3	3.8
	4	3.7	6.3	3.3	3.2		4	5.6	11.6	7.2	6.6
	5	6.6	10.9	8.4	5.9		5	10.1	16.0	10.6	16.1
26	1	3.0	5.6	4.1	4.9	30	1	3.0	5.8	4.5	5.2
	2	3.7	6.4	3.8	3.5		2	3.7	6.3	3.9	3.6
	3	3.4	5.4	3.3	3.9		3	3.6	5.4	3.3	3.9
	4	4.9	7.9	4.6	4.0		4	5.3	8.3	5.5	4.3
	5	12.0	16.4	12.2	14.1		5	11.9	15.3	12.0	15.7
27	1	2.9	6.5	5.2	5.3	31	1	2.4	6.2	4.8	4.0
	2	3.6	6.5	3.9	3.3		2	2.9	7.1	2.9	2.7
	3	2.9	4.0	2.6	3.2		3	2.7	3.5	2.6	2.9
	4	5.1	9.0	4.6	4.0		4	4.8	8.7	4.4	3.3
	5	12.0	15.8	12.3	15.9		5	12.0	16.4	12.3	14.6
28	1	2.9	5.5	4.2	5.2	32	1	2.8	5.6	4.2	5.0
	2	3.7	6.4	3.9	3.5		2	3.7	6.4	3.8	3.5
	3	3.6	5.3	3.3	3.9		3	3.5	5.5	3.3	4.1
	4	5.1	8.3	5.2	4.2		4	4.9	8.0	4.5	3.9
	5	11.6	15.7	12.1	15.9		5	12.0	17.0	12.3	12.5

ตาราง ค.3 แสดงค่าการยุบตัว (Sink Mark) ที่ได้จากการทดลอง

Cond.	Sect.	Up	Left	Down	Right	Cond.	Sect.	Up	Left	Down	Right
1	1	0.5	0.5	0.4	0.3	7	1	0.3	0.5	-0.3	0.3
	2	0.7	0.4	0.3	0.0		2	0.2	0.5	0.0	0.2
	3	0.9	0.4	-0.1	0.0		3	0.5	0.4	-0.1	0.3
	4	2.6	0.2	1.9	-0.1		4	1.3	0.4	0.6	-0.1
	5	2.5	0.2	2.1	-0.1		5	1.7	0.2	1.3	0.1
2	1	0.9	0.4	1.4	0.2	8	1	1.6	0.6	2.2	0.3
	2	2.1	0.2	1.5	-0.2		2	3.8	0.0	2.4	-0.5
	3	2.7	-0.7	2.5	-0.3		3	3.3	-0.4	2.3	0.0
	4	3.3	0.0	2.7	-0.3		4	5.0	-0.2	4.4	-0.3
	5	2.8	0.1	3.0	-0.1		5	3.9	0.3	4.2	-0.1
3	1	1.6	0.5	2.7	0.5	9	1	0.3	0.3	0.0	0.3
	2	1.9	-0.6	1.7	-0.1		2	0.1	0.3	0.0	0.1
	3	3.5	-0.7	3.3	-0.2		3	0.1	0.3	0.0	0.2
	4	3.0	0.2	2.3	-0.3		4	0.4	0.3	0.2	0.1
	5	2.6	0.1	2.6	-0.1		5	0.9	0.2	0.6	0.2
4	1					10	1	0.5	0.6	0.0	0.5
	2						2	0.9	0.6	0.2	0.3
	3						3	1.0	0.4	0.3	0.4
	4						4	2.0	0.3	1.2	-0.2
	5						5	2.3	0.2	1.7	-0.1
5	1	0.5	0.4	0.0	0.3	11	1	0.3	0.7	-0.1	0.4
	2	0.4	0.5	-0.1	0.0		2	0.7	0.5	0.0	0.2
	3	0.5	0.3	0.5	0.5		3	0.4	0.4	-0.2	0.4
	4	0.5	0.6	0.0	0.1		4	1.3	0.4	0.6	0.0
	5	1.8	0.3	1.5	0.1		5	1.7	0.2	1.4	0.0
6	1	0.5	0.4	0.0	0.3	12	1	0.4	0.3	-0.1	0.2
	2	0.6	0.5	0.0	0.1		2	0.2	0.4	0.0	0.0
	3	0.8	0.4	-0.2	0.4		3	0.5	0.3	-0.1	0.2
	4	2.0	0.4	1.1	-0.1		4	1.3	0.3	0.7	0.1
	5	2.3	0.2	1.9	-0.1		5	1.4	0.2	1.2	0.1

ตาราง ค.3 แสดงค่าการยุบตัว (Sink Mark) ที่ได้จากการทดลอง

Cond.	Sect.	Up	Left	Down	Right	Cond.	Sect.	Up	Left	Down	Right
13	1	0.5	0.7	-0.2	0.6	19	1	0.3	0.1	0.0	0.0
	2	0.9	0.4	0.2	-0.1		2	0.2	0.1	0.0	0.0
	3	1.1	0.5	-0.3	0.4		3	0.2	0.1	0.1	0.2
	4	2.6	0.4	1.2	-0.3		4	0.2	0.1	0.1	0.0
	5	2.7	0.3	2.4	0.0		5	0.5	0.1	0.2	0.2
14	1	0.5	0.7	0.3	0.4	20	1	0.5	0.3	-0.1	0.1
	2	2.3	0.3	0.8	-0.1		2	0.6	0.5	0.1	-0.4
	3	1.8	-0.1	0.6	0.2		3	0.7	0.4	-0.2	0.2
	4	3.3	0.1	2.6	-0.2		4	1.6	0.4	0.6	-0.1
	5	2.8	0.1	2.8	-0.1		5	2.1	0.3	1.5	0.0
15	1	1.4	0.6	1.0	0.7	21	1	0.2	0.5	-0.2	0.5
	2	2.4	0.1	2.1	-0.1		2	0.7	0.6	0.1	0.1
	3	3.1	-0.7	2.5	0.0		3	0.9	0.5	0.4	0.5
	4	4.6	-0.2	4.1	-0.1		4	2.3	0.6	1.5	0.1
	5	3.3	0.2	3.2	0.1		5	2.6	0.4	2.4	0.2
16	1	0.2	0.2	0.0	0.1	22	1	0.3	0.6	-0.2	0.4
	2	0.1	0.2	0.1	0.1		2	0.1	0.6	0.0	0.1
	3	0.1	0.1	0.0	0.1		3	0.5	0.4	-0.2	0.3
	4	0.2	0.2	0.0	0.0		4	0.2	0.6	0.1	0.1
	5	0.5	0.2	0.5	0.2		5	1.0	0.5	0.3	0.2
17	1	0.3	0.1	0.0	0.1	23	1	1.8	0.3	2.2	0.3
	2	0.2	0.2	0.0	0.0		2	2.7	0.2	2.1	-0.2
	3	0.2	0.1	0.1	0.2		3	3.2	-0.5	3.0	-0.2
	4	0.2	0.1	0.1	0.0		4	2.3	0.3	1.9	-0.2
	5	0.6	0.1	0.5	0.3		5	2.6	0.4	2.4	0.0
18	1	0.3	0.1	0.0	0.2	24	1	0.1	0.5	-0.2	0.3
	2	0.2	0.2	0.0	-0.1		2	0.1	0.5	-0.1	0.2
	3	0.3	0.1	0.1	0.0		3	0.0	0.3	-0.3	0.4
	4	0.2	0.1	0.0	0.1		4	0.0	0.5	-0.1	0.1
	5	0.5	0.2	0.4	0.1		5	0.9	0.4	0.6	0.3

ตาราง ค.3 แสดงค่าการยุบตัว (Sink Mark) ที่ได้จากการทดลอง

Cond.	Sect.	Up	Left	Down	Right	Cond.	Sect.	Up	Left	Down	Right
25	1	0.1	0.4	-0.2	0.3	29	1	0.3	0.8	-0.1	0.7
	2	0.1	0.4	-0.2	0.1		2	1.3	0.3	1.0	-0.1
	3	0.0	0.2	-0.3	0.3		3	1.5	0.8	1.1	0.2
	4	0.1	0.5	-0.1	0.1		4	2.8	0.1	1.8	-0.1
	5	0.9	0.3	0.6	0.4		5	2.6	0.2	2.2	0.1
26	1	0.2	0.5	-0.1	0.4	30	1	0.2	0.6	-0.3	0.5
	2	0.1	0.5	-0.1	0.1		2	-0.1	0.7	-0.2	0.1
	3	0.1	0.4	-0.2	0.2		3	0.8	0.1	0.3	0.5
	4	0.4	0.4	0.1	0.1		4	2.2	0.7	1.8	0.1
	5	0.9	0.3	0.6	0.3		5	2.5	0.8	2.2	0.3
27	1	0.2	0.4	-0.1	0.3	31	1	0.2	0.3	-0.1	0.2
	2	0.1	0.5	-0.1	0.2		2	0.1	0.4	-0.1	0.1
	3	0.1	0.3	-0.1	0.2		3	0.0	0.3	-0.1	0.2
	4	0.4	0.5	0.0	0.0		4	0.3	0.4	0.1	0.1
	5	0.9	0.4	0.6	0.3		5	0.8	0.2	0.5	0.3
28	1	0.2	0.6	-0.2	0.4	32	1	0.2	0.4	-0.1	0.3
	2	0.1	0.5	-0.1	0.1		2	0.1	0.4	-0.1	0.1
	3	1.1	0.5	0.6	0.4		3	0.1	0.4	-0.2	-0.3
	4	2.0	0.5	1.8	0.1		4	0.4	0.4	0.1	0.2
	5	2.3	0.4	2.2	0.2		5	0.7	0.3	0.7	0.4

ตาราง ค.4 แสดงค่าการโก่งตัว (Warpage) ที่ได้จากการทดลอง

Condition	No.	Volume	Average	Min	Max	Condition	No.	Volume	Average	Min	Max
1	1	2.630	2.000	1.775	2.225	6	1	2.048	1.951	1.735	2.167
	2	2.622					2	2.043			
	3	2.626					3	2.126			
	4	2.220					4	1.720			
	5	2.214					5	1.637			
	6	2.212					6	2.131			
2	1	3.866	3.329	2.730	3.928	7	1	1.644	1.643	1.584	1.702
	2	2.977					2				
	3	2.314					3	1.643			
	4	3.874					4	1.727			
	5	3.556					5	1.643			
	6	3.384					6	1.560			
3	1	1.728	1.830	1.289	2.372	8	1	0.231	0.290	0.127	0.453
	2	2.151					2	0.475			
	3	2.152					3	0.323			
	4	1.483					4	0.155			
	5	0.989					5	0.474			
	6	2.479					6	0.083			
4	1					9	1	1.878	1.715	1.490	1.940
	2						2	1.800			
	3						3	1.470			
	4						4	1.878			
	5						5	1.877			
	6						6	1.387			
5	1	1.641	1.515	1.329	1.701	10	1	1.149	1.119	0.934	1.304
	2	1.557					2	1.474			
	3	1.552					3	0.983			
	4	1.552					4	0.979			
	5	1.146					5	1.065			
	6	1.642					6	1.066			

ตาราง ค.4 (ต่อ) แสดงค่าการโก่งตัว (Warpage) ที่ได้จากการทดลอง

Condition	No.	Volume	Average	Min	Max	Condition	No.	Volume	Average	Min	Max
11	1	1.537	1.362	1.155	1.570	16	1	2.525	2.332	2.136	2.527
	2	1.231					2	2.128			
	3	1.557					3	2.372			
	4	1.148					4	2.458			
	5	1.146					5	2.458			
	6	1.555					6	2.051			
12	1	2.935	2.806	2.400	3.212	17	1	2.615	2.426	2.198	2.655
	2	3.291					2	2.369			
	3	2.056					3	2.537			
	4	2.799					4	2.125			
	5	2.878					5	2.697			
	6	2.874					6	2.214			
13	1	1.966	1.867	1.679	2.056	18	1	2.212	2.624	2.415	2.834
	2	2.128					2	2.712			
	3	1.874					3	2.618			
	4	1.557					4	2.703			
	5	1.875					5	2.791			
	6	1.803					6	2.709			
14	1	2.129	2.397	2.184	2.610	19	1	2.786	2.643	2.341	2.945
	2	2.768					2	2.796			
	3	2.373					3	2.218			
	4	2.284					4	3.071			
	5	2.452					5	2.453			
	6	2.373					6	2.536			
15	1	2.524	2.129	1.851	2.408	20	1	1.547	1.412	1.311	1.513
	2	2.193					2	1.299			
	3	1.952					3	1.456			
	4						4	1.412			
	5	2.187					5	1.467			
	6	1.791					6	1.289			

ตาราง ค.4 (ต่อ) แสดงค่าการโก่งตัว (Warpage) ที่ได้จากการทดลอง

Condition	No.	Volume	Average	Min	Max	Condition	No.	Volume	Average	Min	Max
21	1	2.865	3.006	2.757	3.255	26	1	1.387	1.449	1.243	1.656
	2	3.195					2	1.709			
	3	3.290					3	1.214			
	4	2.794					4	1.697			
	5	3.193					5	1.299			
	6	2.699					6	1.391			
22	1	1.884	2.119	1.892	2.347	27	1	0.979	1.211	0.983	1.439
	2	2.368					2	1.393			
	3	1.968					3	1.224			
	4	2.302					4	0.900			
	5	2.302					5	1.476			
	6	1.891					6	1.292			
23	1	0.727	1.087	0.689	1.485	28	1	1.387	1.180	0.969	1.390
	2	1.237					2	1.384			
	3	0.548					3	1.132			
	4	1.315					4	1.300			
	5	1.065					5	0.896			
	6	1.631					6	0.979			
24	1	0.894	0.462	0.078	0.846	29	1	1.536	1.315	1.056	1.574
	2	0.000					2	1.635			
	3	0.083					3	1.140			
	4	0.408					4	1.462			
	5	0.489					5	1.057			
	6	0.897					6	1.060			
25	1	0.655	0.435	0.259	0.612	30	1	1.546	1.341	1.109	1.572
	2	0.167					2	1.049			
	3	0.491					3	1.140			
	4	0.322					4	1.217			
	5	0.405					5	1.546			
	6	0.573					6	1.545			

ตาราง ค.4 (ต่อ)   แสดงค่าการโก่งตัว (Warpage) ที่ได้จากการทดลอง

Condition	No.	Volume	Average	Min	Max
31	1	1.469	1.776	1.460	2.093
	2	2.186			
	3	1.468			
	4	1.553			
	5	1.958			
	6	2.022			
32	1	1.788	1.792	1.615	1.969
	2	2.031			
	3	1.879			
	4	1.781			
	5	1.787			
	6	1.489			

ภาคผนวก ศ

ภาพตัดขวางที่ตำแหน่งต่างๆ ของชิ้นงานที่สภาวะเปลี่ยนแปลงไป

ต้นฉบับ หน้าขาดหาย

ภาคผนวก ฆ

วิธีการใช้โปรแกรมการวัดค่าต่างๆ

ฆ.1) <u>การวัดค่าการโก่งตัวของชิ้นงาน (Warpage)</u>

มีขั้นตอนต่างๆ ดังต่อไปนี้

1.) นำชิ้นงานมาตัดส่วนที่เป็นช่องลำเลียง (Runner) พลาสติกหลอมออก

2.) จากนั้นนำชิ้นงานไปสแกน (Scan) แสดงดังรูป ฆ.1
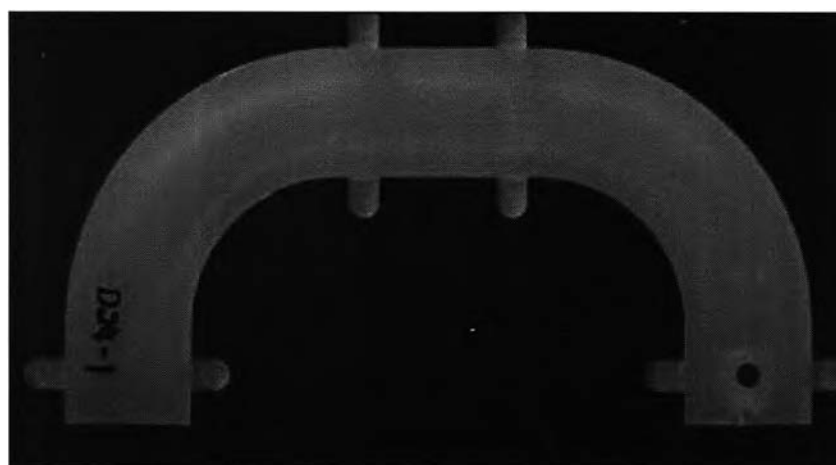
รูป ฆ.1 แสดงภาพจากการสแกนชิ้นงาน

3.) เปิดโปรแกรมการวัดค่าและเปิดภาพจากการสแกน

4.) ทำการสร้างแกนอ้างอิงของชิ้นงาน จากทางด้านทิศทางการไหลเข้าของพลาสติกหลอมและแก๊ส แสดงดังรูป ฆ.2

รูป ฆ.2 แสดงการสร้างเส้นอ้างอิง

5.) วัดค่าการโก่งงอของชิ้นงานจากทางด้านปลายของชิ้นงานอีกทางด้านหนึ่ง

รูป ฆ.3 แสดงตำแหน่งการวัดการโก่งตัวของชิ้นงาน

ฆ.2) <u>การวัดค่าความหนาตกค้างของชิ้นงาน (RWT) และการยุบตัวของชิ้นงาน (Sink Mark)</u>

มีขั้นตอนต่างๆ ดังต่อไปนี้

1.) ภายหลังตัดชิ้นงานตามตำแหน่งต่างๆ ที่ต้องการ

2.) ทำการสแกน (Scan) ภาพตัดขวางของชิ้นงานที่ตำแหน่งนั้นๆ

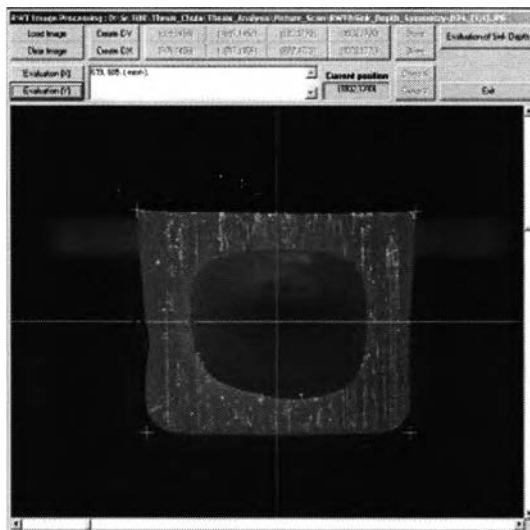3.) เปิดโปรแกรมการวัดค่าและภาพจากการสแกน (Scan) แสดงดังรูป ฆ.4
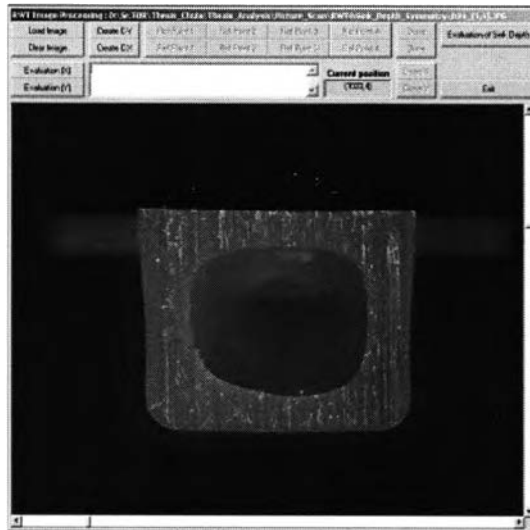
รูป ฆ.4 แสดงภาพสแกนจากการตัดชิ้นงาน

4.) เริ่มทำการสร้างเส้นอ้างอิง โดยเส้นอ้างอิงนี้จะเป็นเส้นแบ่งครึ่งของชิ้นงานทั้งแกน X และแกน Y แสดงดังรูป ฆ.5
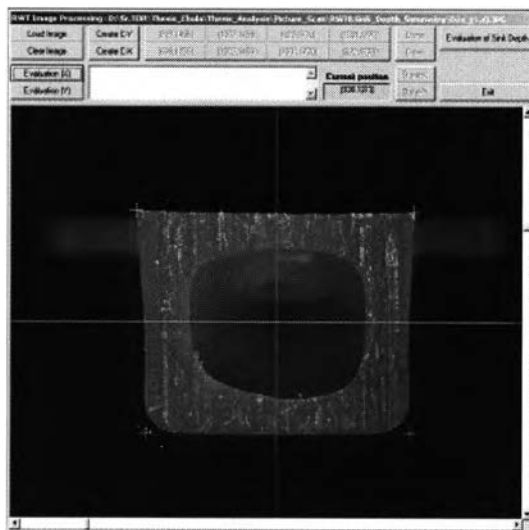
รูป ฆ.5 แสดงเส้นอ้างอิงในการวัดค่า

5.) วัดค่าความหนาตกค้างของชิ้นงาน (RWT) ที่ตำแหน่งต่างๆ บนเส้นอ้างอิง แสดงดังรูป ฆ.6

รูป ม.6 แสดงตำแหน่งการวัดค่าความหนาตกค้างและการยุบตัว

6.) จากค่าตำแหน่งของจุดอ้างอิงชิ้นงานและจุดวัดค่าความหนาของชิ้นงานต่างๆ สามารถนำมาคำนวณ
ค่าการหดตัวของชิ้นงาน (Sink Mark) และค่าความหนาตกค้างของชิ้นงาน (RWT) ในแต่ละด้านของชิ้นงาน

ม.3) <u>การแปลงหน่วย</u>

เนื่องจากหน่วยในการวัดขนาดที่ได้จากคอมพิวเตอร์จะเป็นหน่วยพิกเซล (Pixel) ซึ่งต้องทำการแปลง
หน่วยเป็นมิลลิเมตร (mm.) โดยสามารถทำได้ดังนี้

1.) ทำการสแกน (Scan) ไม้บรรทัดเหล็กที่มีขนาดที่แน่นอน
2.) ทำการเปรียบเทียบหน่วยโดยการวัดขนาดของไม้บรรทัดที่ 10 มิลลิเมตร ว่าเท่ากับกี่พิกเซล (Pixel)

ประวัติผู้เขียนวิทยานิพนธ์

นาย ต่อ ฉวานนท์ เกิดเมื่อวันที่ 27 เมษายน พ.ศ. 2518 จังหวัด กรุงเทพมหานคร สำเร็จการศึกษา
ปริญญาวิศวกรรมศาสตรบัณฑิต ภาควิชาวิศวกรรมเคมี คณะวิศวกรรมศาสตร์ มหาวิทยาลัยเทคโนโลยีพระจอม
เกล้าธนบุรี ในปีการศึกษา 2540 และเข้าศึกษาต่อในหลักสูตรวิศวกรรมศาสตรมหาบัณฑิต ที่จุฬาลงกรณ์
มหาวิทยาลัยเมื่อ พ.ศ. 2545

ปัจจุบันทำงานในหน่วยงานวิจัยและพัฒนา ชิ้นส่วนยานยนต์ที่เป็นพลาสติก บริษัท ไทยซัมมิทโอโต
พาร์ท อินดัสตรี จำกัด