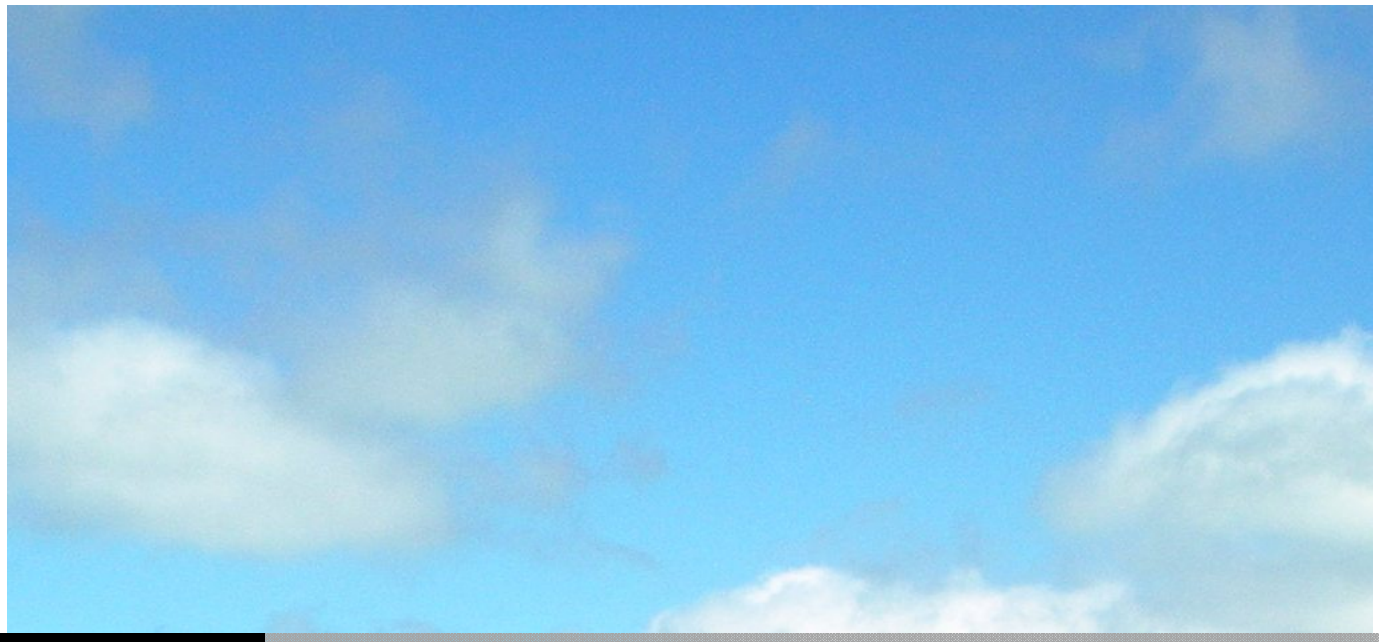
DAIHO INDUSTRIAL CO., LTD.



PULP INJECTION MOLDING

Pulp Injection Molding Explanatory Material

Introduction

With the motto of "leaving an irreplaceable global environment to future generations", the Daiho Group has been committed to activities based on the concept of eco-friendly manufacturing by acquiring ISO14001 for all its domestic and overseas offices, etc. In addition to research on energy saving and resource saving, the Daiho Group is also carrying out research on Pulp Injection Molding(PIM) which uses pulp and starch as raw materials. This pamphlet introduces the technology, by providing details of the processes involved, etc.

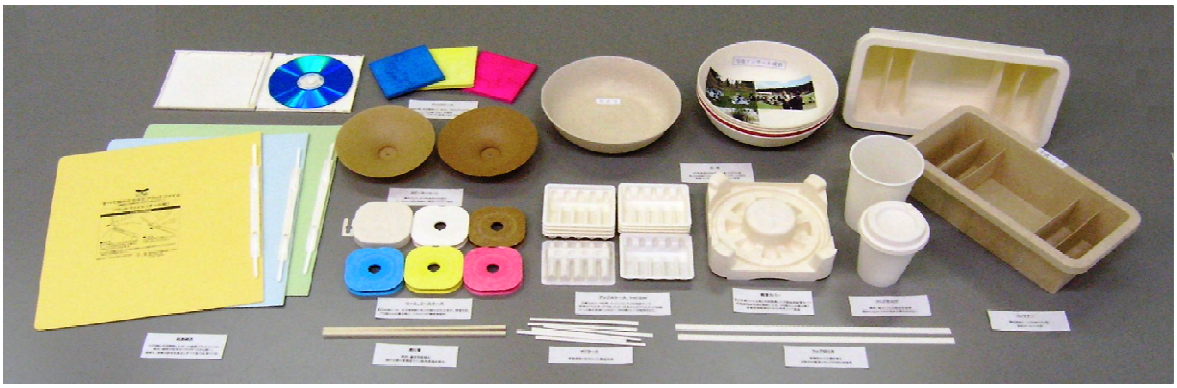
Revised August 2010

Content

Background

1995	Started research on PIM
1998	Acquired first patent on PIM
2000	Acquired trademark for PIM, improved existing method, and started mass production
2002	Started special production plant
2005	Started join research with Yokoi Laboratory of University of Tokyo and Nissei Plastic to enhance productivity
2006	Set up PIM consortium in University of Tokyo Production Technologies Research Foundation
2007	Enhanced productivity by more than 60%
2008	Started Phase 2 consortium of runnerless molding
Present	

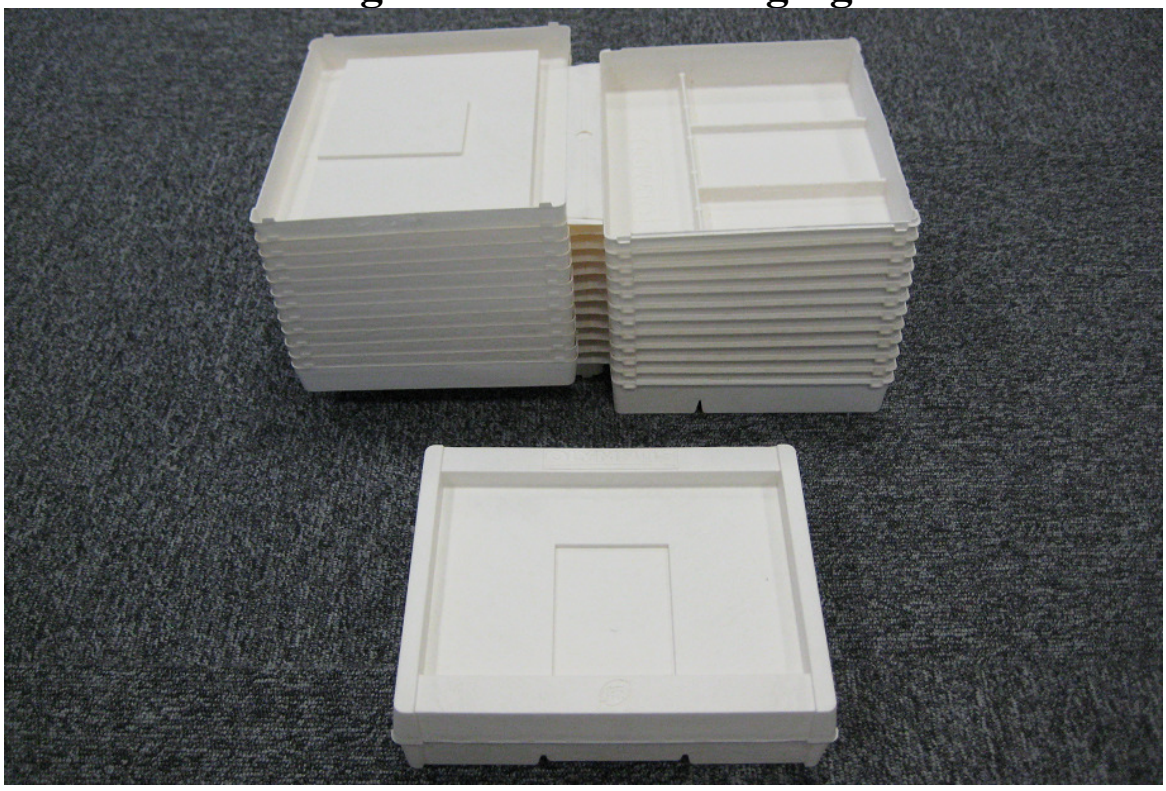
Introduction of Products



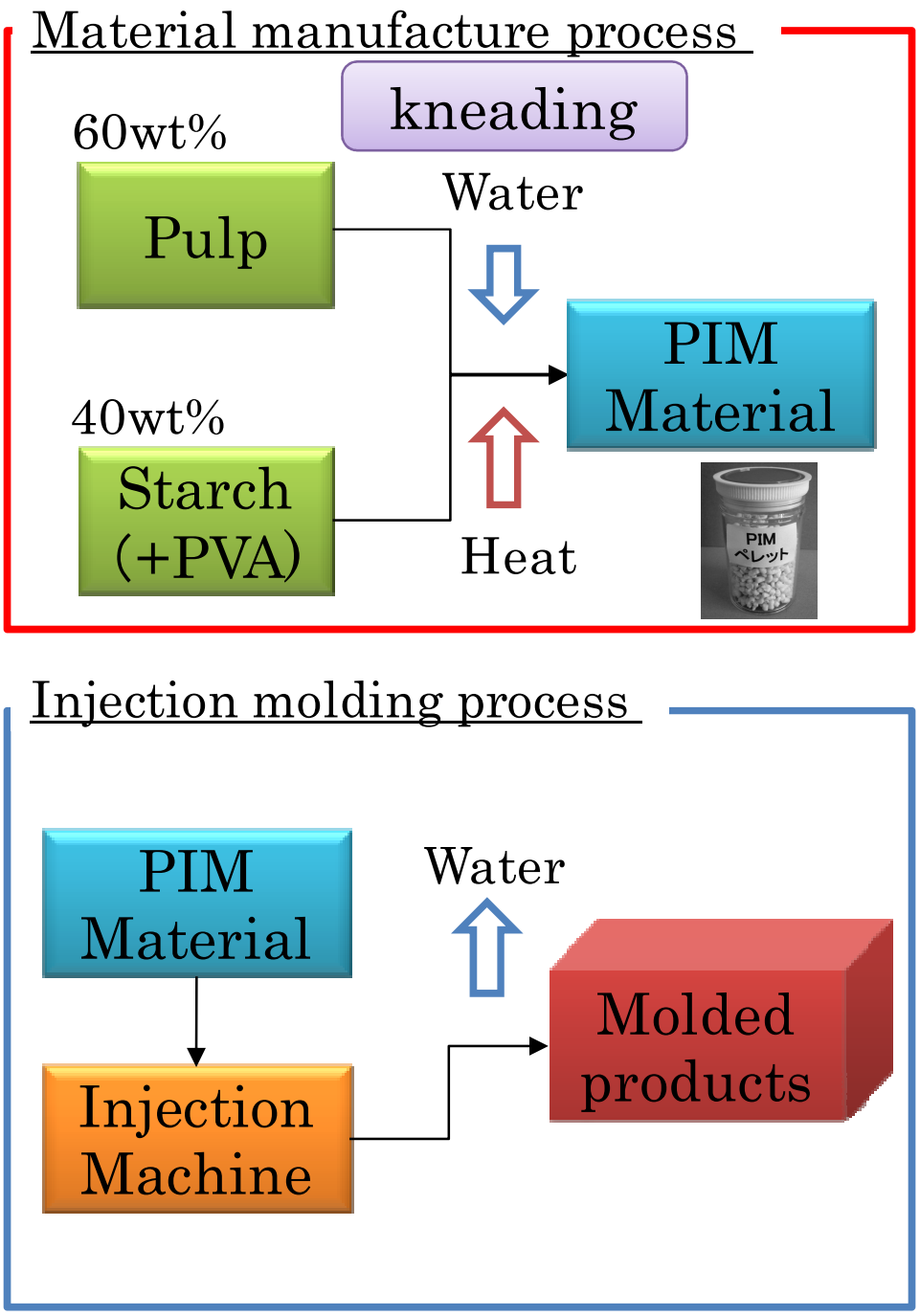
- File binding accessories
- CD case
- Speaker cone
- Reel case
- Ampule case
- Lap cutter
- Chopsticks
- Plate
- Paper core cover
- Cup and cup lid
- Container/planter

Disk Storage Cases (10 sheets)

Digital Camera Packaging Cases

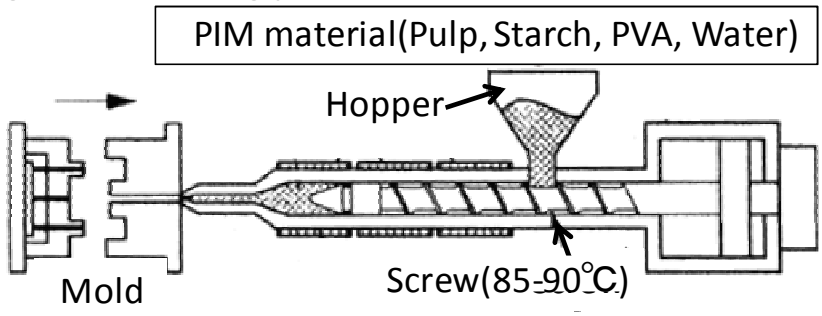


Outline of PIM Process

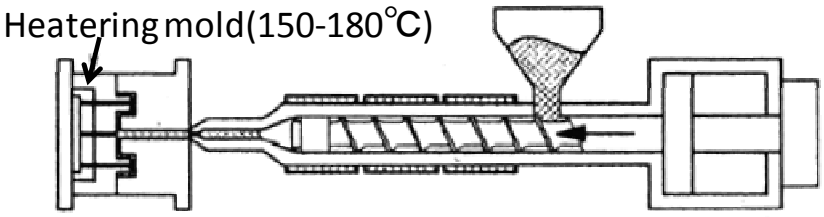


Injection Molding Process

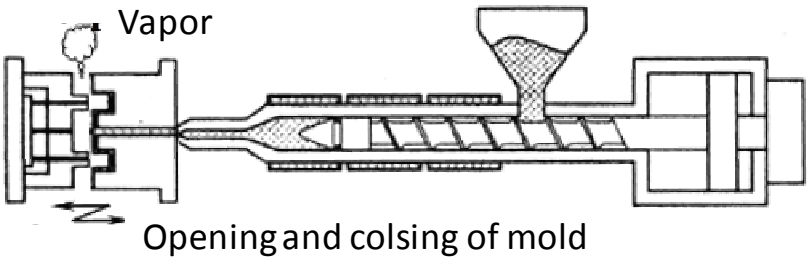
(1)Reciprocating and metering process



(2)Injection process



(3)Heating and drying process



PIM Injection Molding Machine

110T PIM Machine

Made by Nissei Plastic Industrial

Machine Specifications(110T)

Specification item		9E			12E (Standard)			18E		
Screw diameter (mm)		AA	A	B	AA	A	B	AA	A	B
		26	28	32	28	32	36	32	36	40
Injection capacity (cm^3)		59	69	90	77	101	127	117	148	182
Plasticization capacity [PS] (kg/h)		19	28	40	28	40	54	40	54	75
Max. injection pressure (MPa [kgf/cm^2])		265	243	186	265	223	176	265	218	176
		[2700]	[2480]	[1900]	[2700]	[2280]	[1800]	[2700]	[2220]	[1800]
Injection rate (cm^3/s)	Standard	159	185	241	166	217	275	161	204	251
	High velocity							201	255	314
	High load	127	148	193	135	177	224	161	204	251
Injection velocity (mm/s)	Standard	300			270			200		
	High velocity							250		
	High load	240			220			200		
Screw velocity (rpm)		0 ~ 300			0 ~ 300			0 ~ 300		
Hopper capacity [Optional] (L)		25			25			25		
Clamping force (kN [tf])		**1080 [110]**			**1080 [110]**			**1080 [110]**		
Clamping stroke (mm)		350			350			350		
Mold thickness [min. - max.] (mm)		220 ~ 410			220 ~ 410			220 ~ 410		
Max. daylight opening (mm)		760			760			760		
Tie bar clearance [H x V] (mm)		460 x 460			460 x 460			460 x 460		
Die plate dimensions [H x V] (mm)		647 x 647			647 x 647			647 x 647		
Min. mold dimensions [H x V] (mm)		325 x 325			325 x 325			325 x 325		
Locating ring diameter (mm)		100			100			100		
Ejector stroke (mm)		85			85			85		
Heater band capacity (kW)		7.22	8.36	9.26	7.98	9.13		8.88	10.57	
Machine dimensions [L x W x H] (m)		4.45 x 1.19 x 1.80	4.49 x 1.19 x 1.80	4.53 x 1.19 x 1.80	4.48 x 1.19 x 1.80	4.57 x 1.19 x 1.80		4.48 x 1.19 x 1.80	4.57 x 1.19 x 1.80	
Floor dimensions [L x W] (m)		4.12 x 0.78			4.12 x 0.78			4.12 x 0.78		
Machine weight (t)		4.8			4.8			5		

Evaluation of Properties

- Advantages/disadvantages of PIM products
- Records of biodegradation experiments
- Comparison of mechanical characteristics
- Environment impact factors of PIM
- LCA comparison of PIM materials
- LCA comparison of packaging container
- Results of hygiene analysis and combustion measurement
- Heat-resistance tests
- Water suction characteristics

Advantages/Disadvantages of PIM Molded Products

Advantages

- No adherence of dusts
- Can be disposed with general waste(can be recycled as paper)
- No toxic substances produced when burnt
- Light specific weight（about 0.85）
- Biodegradable performance (degradation in soil in about six months)
- High heat-resistance About 200˚C
- No change even in -20˚C environment
- Dimensional accuracy is same as general resin
- Products can be recycled as raw materials

Disadvantages

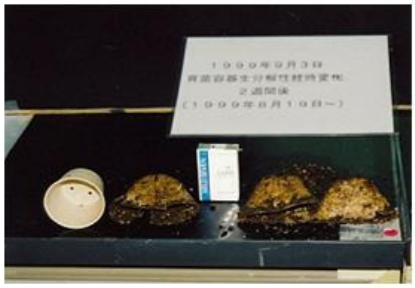
- Weak in high temperature high humidity (moisture absorption deformation ±0.5%）
- Welded portions lack strength
- Risks of animal and insect damage

Biodegradation Experiment Data

Addition of water twice/day for three months (8:00 and 17:00 daily)

Pulp material (Purge valve)

After one week



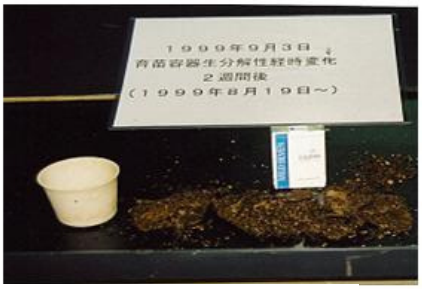
After two weeks

After one month

After three months

Pulp material (Recycled material)

After one week



After two weeks

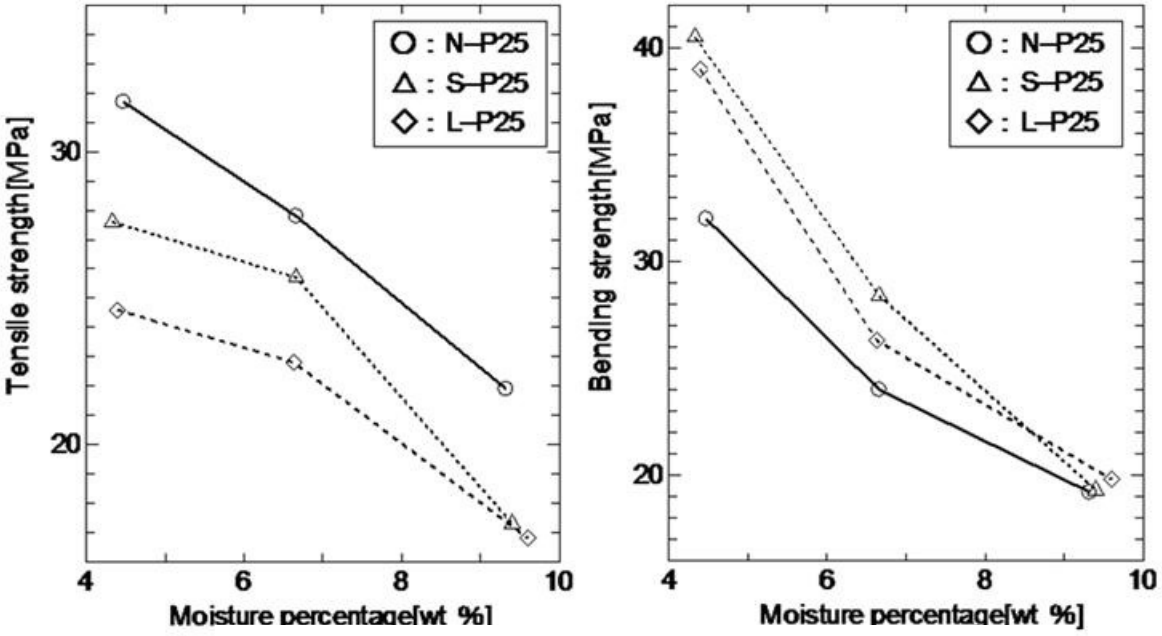
After one month

After three months

Comparison of Mechanical

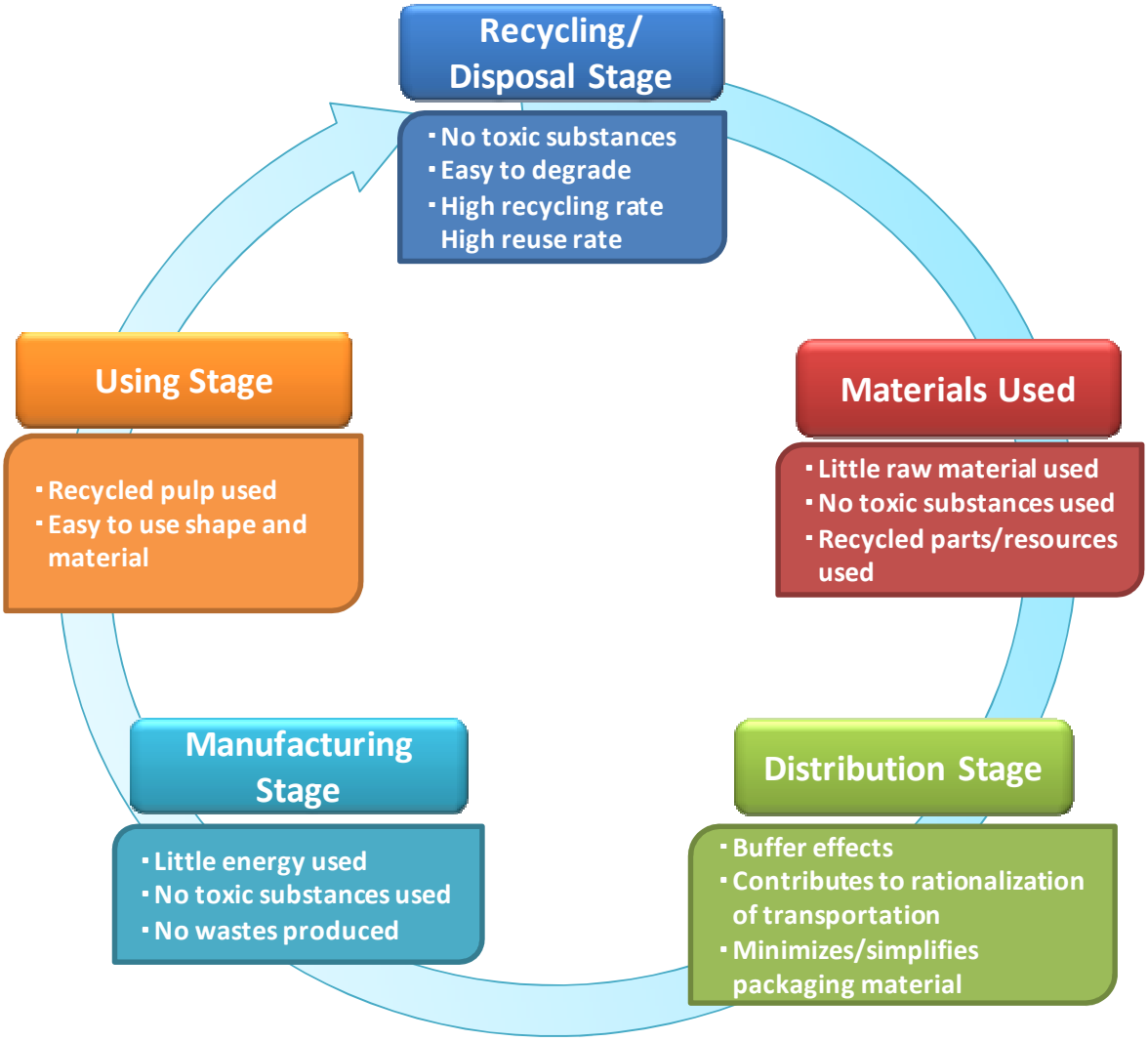
Characteristics

	PIM material		General resin		Polylactate
	Virgin	Used newspaper	PS	PP	
Specific weight	0.85	0.78	1.05	0.9	1.25
Tensile Strength (MPa)	29	19	28	19	69
Elongation (%)	8.5	4.8	40	80	4
Bending strength (MPa)	24.5	35	47	33	100
Bending elasticity (MPa)	2,900	3,600	2,500	1,200	3,800
Impact Strength ($kg \cdot J/m^2$)	11.5	5.6	6	6.6	2.1



Average fiber length ; N-P25>S-P25>L-P25

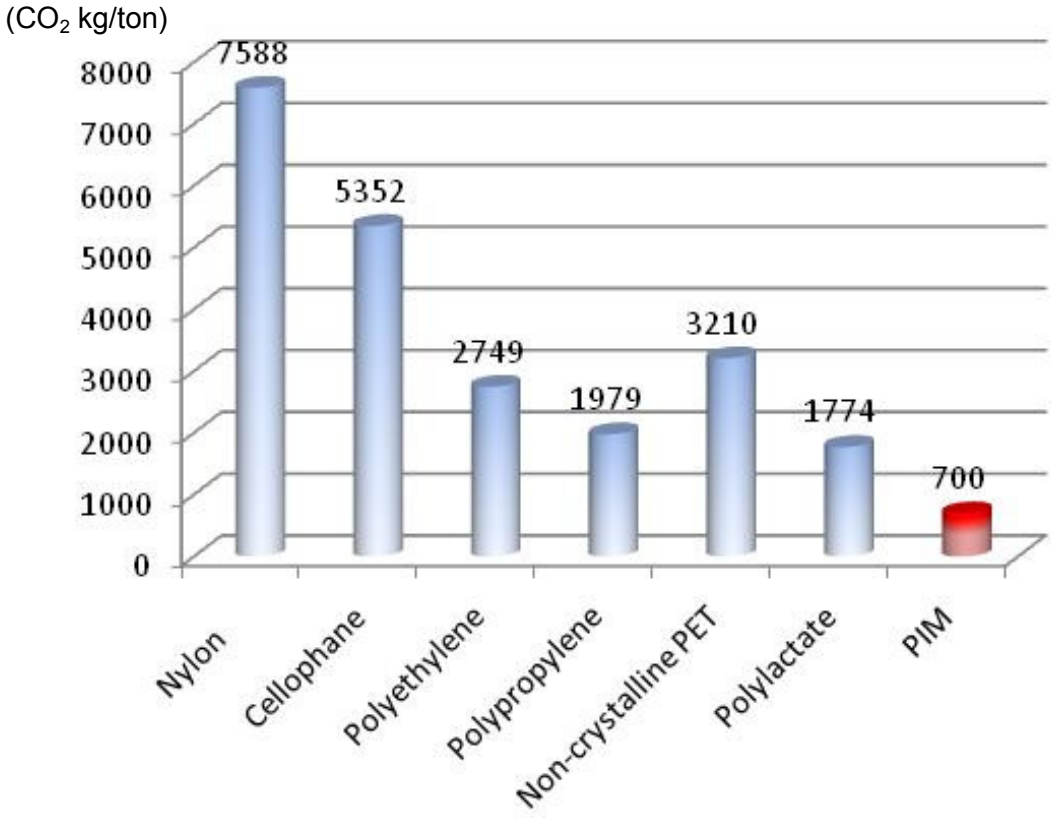
Environment Impact Factors of PIM



LCA Comparison of PIM Materials

Amount of CO_2 generated

(During manufacturing process from raw materials to pellets)

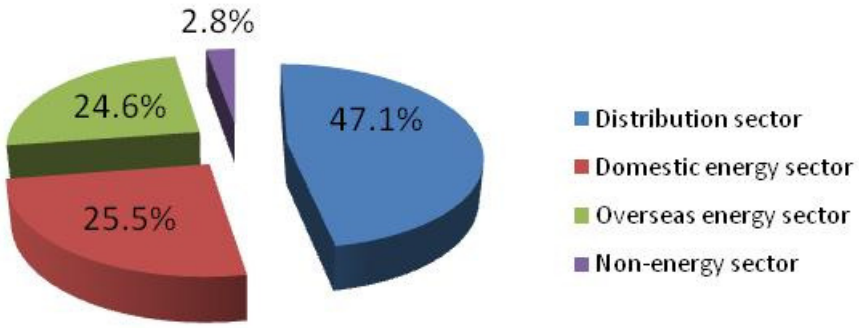


- **E. T.H. Vink et al.,Cargill Dow Polymer Degradation and Stability(2003).**
- **The figures for polylactate are that when the Nature Works 140000t plant is fully operating.**
- **Material data of pulp etc. was calculated by totaling the data disclosed by the Japan Paper Association using the raw material mixing rates, and adding the value calculated based on the data disclosed by the Environmental Agency to the energy used for manufacturing PIM material (Kneading, extrusion, pelletization).**

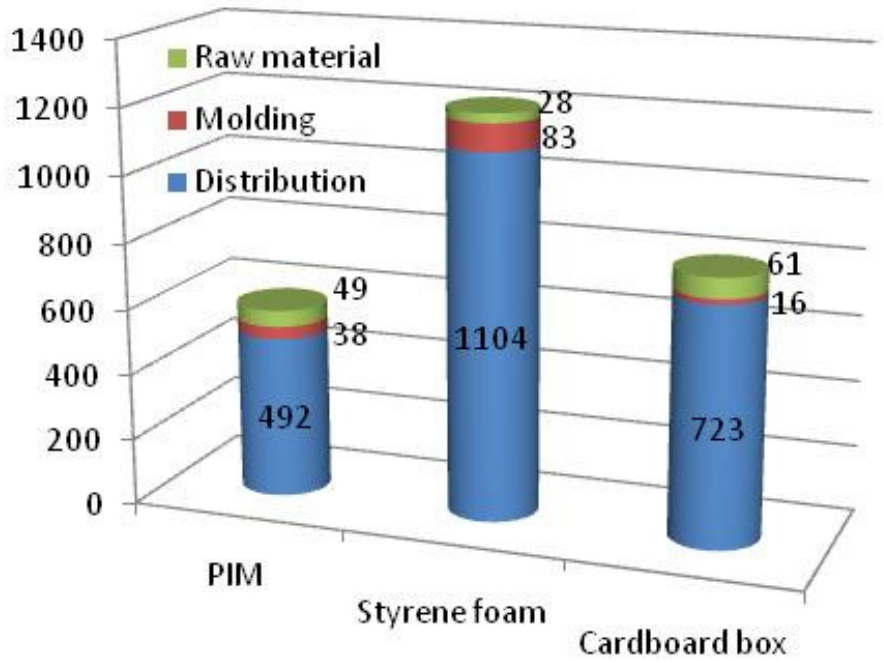
Data prepared by Daiho Industrial Co., Ltd.

LCA Comparison of Packaging Container

In the case of digital camera manufacturer O;
210, 563 tons-CO2 in 2006



As 70% of digital cameras are shipped by air, the distribution sector's percentage for CO2 emissions is high.



Results of Hygiene Analysis and Combustion Measurement Analysis

Analysis Results of Hygiene Tests (heavy metals, others)

Analysis test items	Results	Detection limit	Note	Method
Lead	Undetected	5 ppm		Atomic absorption photometry
Cadmium	Undetected	0.5ppm		Atomic absorption photometry
PCB	Undetected	0.1 ppm		Gas chromotograph
Elution tests			1	
Heavy metals (as Pb) (Solvent:4V/V% acetic acid)	Undetected	1μg/ml		Sodium sulfide colorimetric sensor
Phenols (as phenol) (Solvent:water)	Undetected	0.5μg/ml		4-aminoantipyrine absorption photometry
Formaldehyde (Solvent:water)	Undetected	0.5μg/ml		Aminoantipyrine absorption photometry
Florescent substances	Undetected		2	

Note 1: Elution conditions: 2ml of solvent was used per surface area of 1 cm2, and immersed elution was carried for 30 minutes at 60˚C

Note 2: Test methods for devices or container packaging using florescent substances conform to 1971 Environment Corrosion Article 244, 2004 Corrosion Safety Regulations No. 0107001 and Corrosion Safety Supervision Article No. 0107001).

Source; Japan Food Research Laboratories

Results of Combustion Measurement Analysis

・Test samples

PIM（N-P25）

・Test items and methods

Combustion test conforms to FMVSS302

Test sample：300mm×100mm×1mm

Test room conditions：24˚C，59%RH

Number of tests：n=5

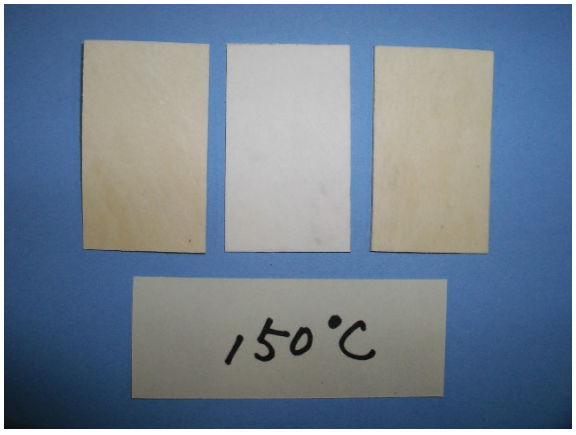
・Test results

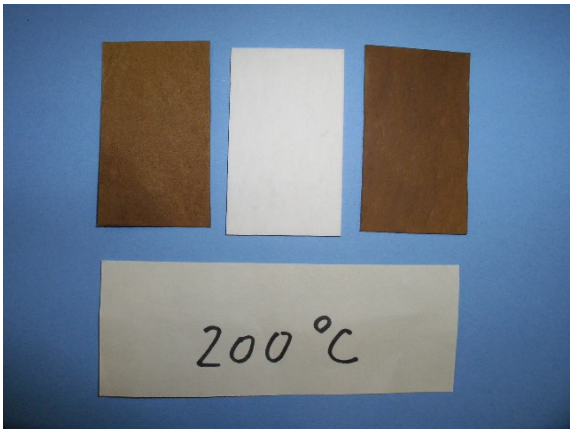
Combustion speed：39mm/min

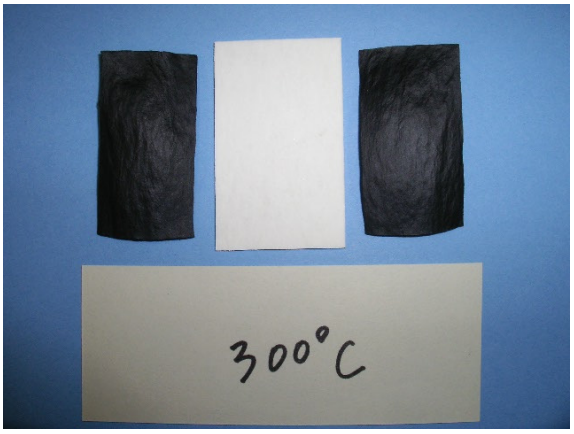
Source; DIA Analytical Service Center Co., Ltd.

Heat-Resistance Tests

Date of measurement : 07/07/26
Heating conditions :
Temperatures 150˚C, 200˚C, 250˚C, 300˚C
Heating time : 60min
Sample size : 3cm×5cm, cut out from normal sheet of thickness 1mm





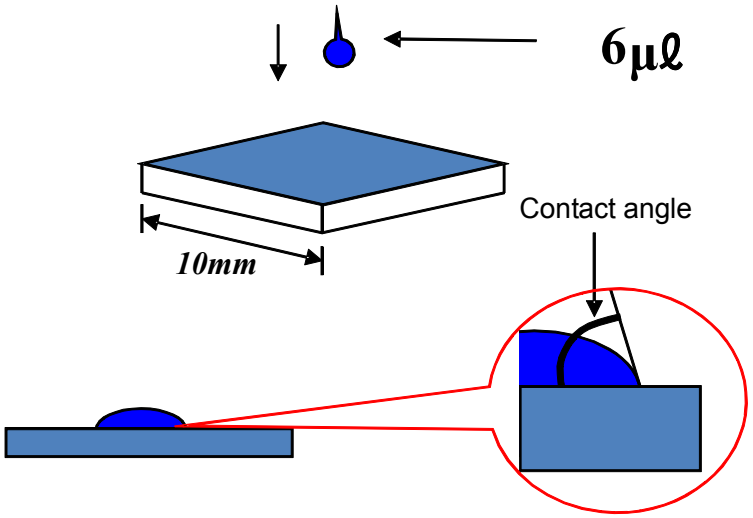


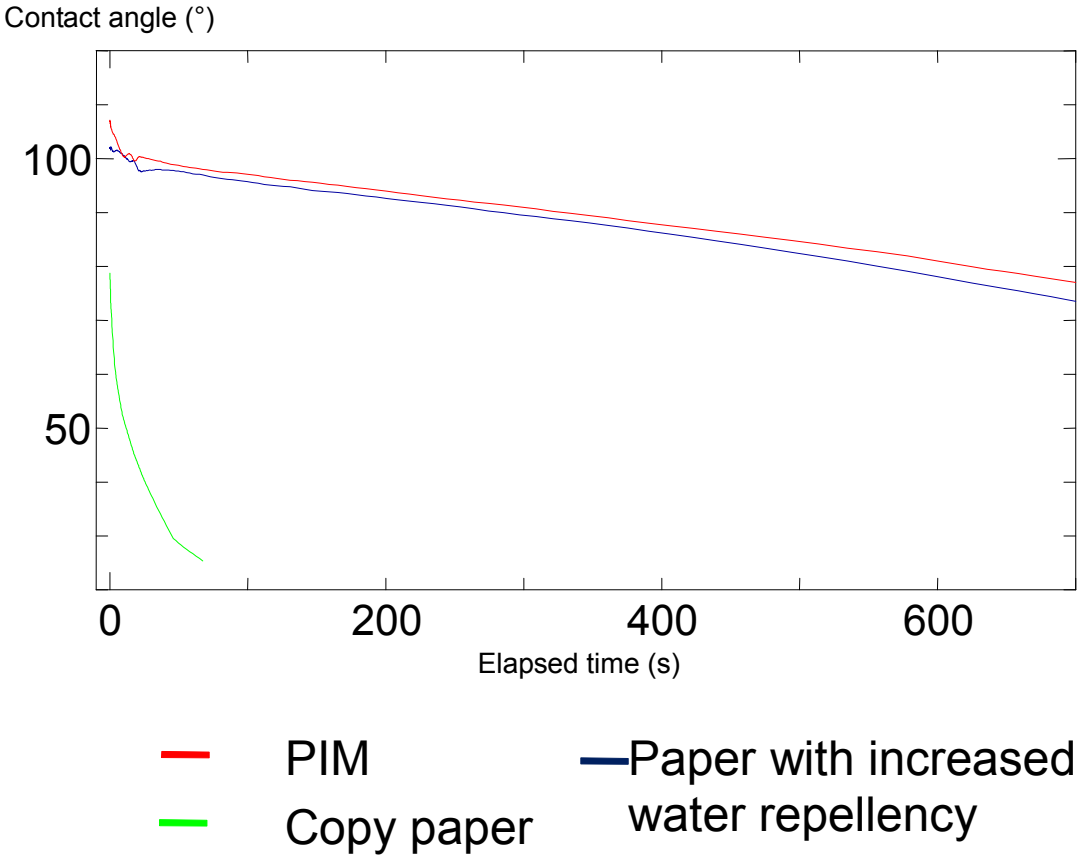
Changes in weight

	Before processing	150℃	200℃	250℃	300℃
Weight decrease rate	0.0%	3.6%	5.9%	31.3%	65.5%

No change in color or weight when heated at 120˚C.

Water Absorption Characteristics



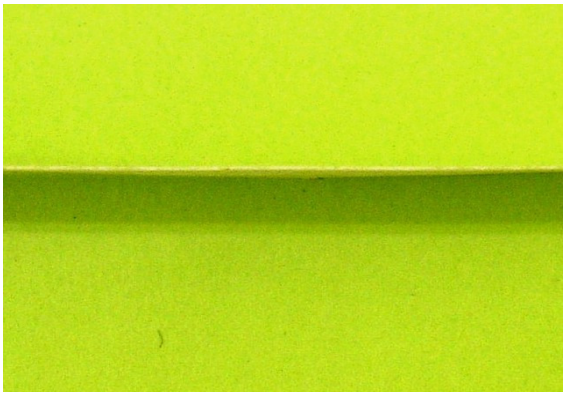


Examples of PIM Technology

- Thin-wall molding
- Undercut
- Insert molding
- Multi-rib structure/hinge shape
- Microshape
- Foaming agent for PIM extrusion molding
- Printing sample
- Addition of other cellulose materials

Thin-Wall Molding

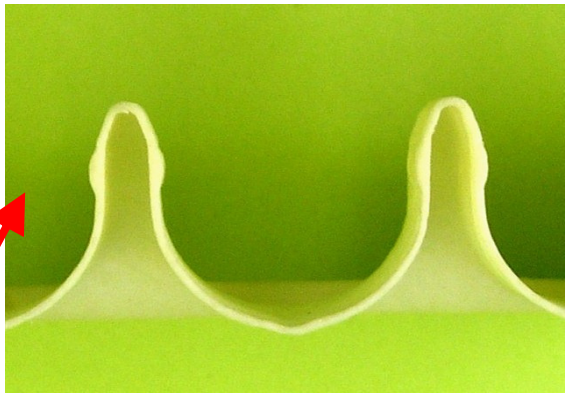
Cup lid



Thickness(0.3mm)

Undercut

Ampoule case



Undercut

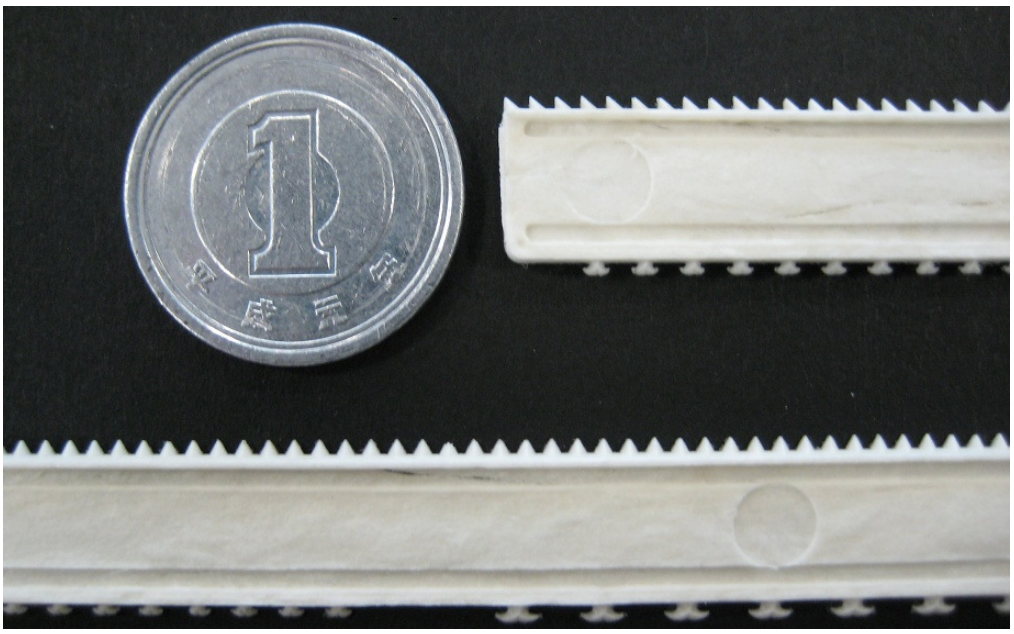
Cross-section of enlargement

Insert Molding

Water absorption paper insert

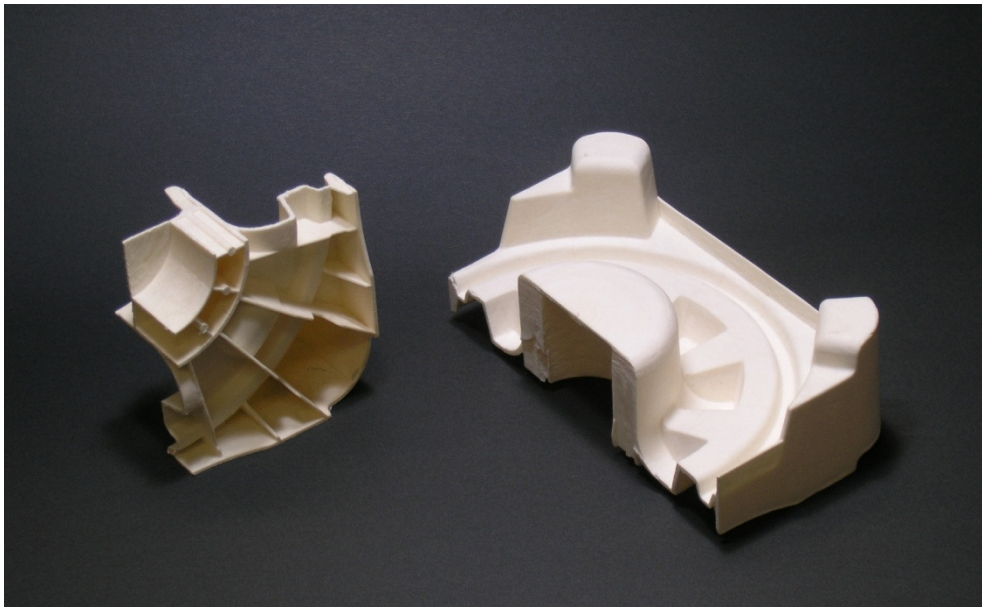
Picture insert

Microshape

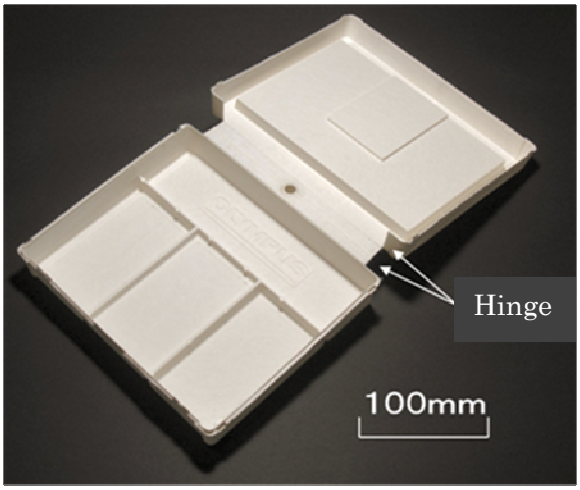


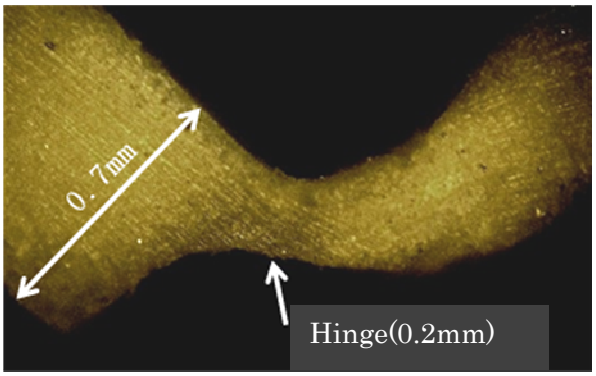
Lap cutting edge

Multi-Rib Structure



Hinge Shape





Foaming Agent for PIM Extrusion Molding

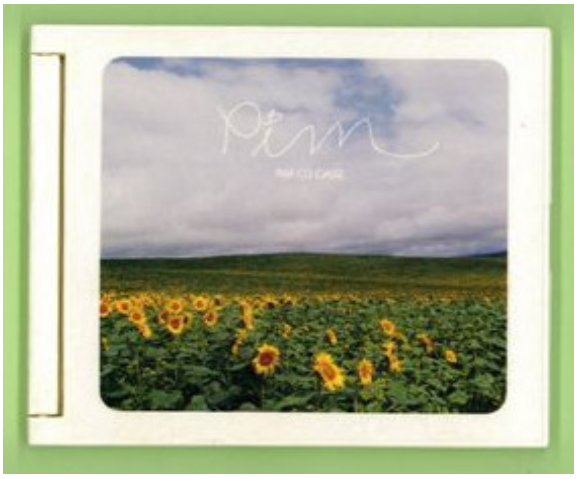
ABS resin only

PIM＋ABS resin

Specific weight can be decreased by nearly30% max.
Advantages such as no need for annealing after molding.

Printing Samples

Pad printing

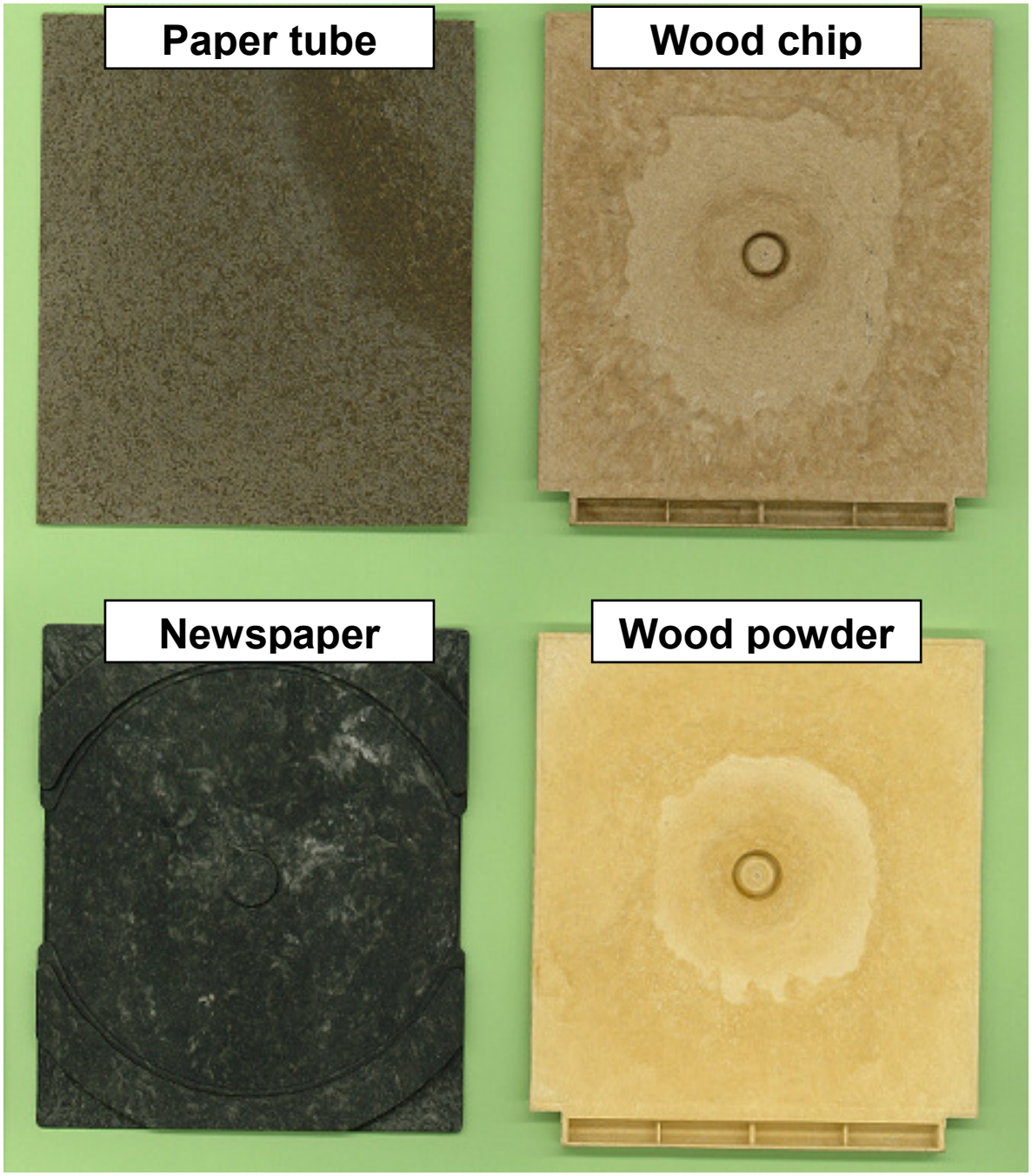


Offset printing

Silk screen printing

Silk screen printing

Addition of Other Celulose Materials



List of PIM Research Papers

Paper No.	Title Page No. Journal carried in
1	Study on Pulp Injection Molding I – Measure of Flow Characteristics Using Bar-flow Mold P139-142 JSPP'05 Sympo.Papers
2	Study on Pulp Injection Molding II – Evaluation of Molded Product Characteristics P143-146 JSPP'05 Sympo.Papers
3	Study on Pulp Injection Molding III – Review of High-cycle Molding P147-148 JSPP'05 Sympo.Papers
4	Study on Pulp Injection Molding IV – Flow Characteristics and High-cycle Molding of Large Molded Products P149-152 JSSP'06 Tech.Papers
5	Study on Pulp Injection Molding V – Evaluation of Characteristics of Molded Products II P151-152 JSSP'06 Tech.Papers
6	Study on Pulp Injection Molding VI – Flow Characteristics and High-cycle Molding of Large Molded Products P95-96 JSPP'06 Sympo.Papers
7	Study on Pulp Injection Molding VII – Evaluation of Internal Voids of Molded Products and Correlation with Molding Conditions- P97-98 JSPP'06 Sympo.Papers
8	Study on Pulp Injection Molding VIII – Optimization of Plasticization Conditions P197-198 JSSP'07 Tech.Papers
9	Experimental Analysis of the In-mold Phenomena in Pulp Injection Molding I P83-84 JSSP'08 Tech.Papers
10	Study on Pulp Injection Molding IX – Effectiveness of Low Compression Screw P85-86 JSSP'08 Tech.Papers
11	Study on Pulp Injection Molding X – Evaluation of Molded Product Using X-ray CT P87-88 JSSP'08 Tech.Papers
12	Evaluation of Pulp Injection Molded Sample I P147-148 JSPP'08 Sympo.Papers
13	Study on Runner-less System in Pulp Injection Molding P149-150 JSPP'08 Sympo.Papers
14	Experimental Analysis of the In-mold Phenomena in Pulp Injection Molding II P150-151 JSPP'08 Sympo.Papers
15	Experimental Analysis of the In-mold Phenomena in Pulp Injection Molding III P367-368 JSPP'09 Tech.Papers
16	Occurrence of Weld-line and Evaluation of Its Characteristics in Pulp Injection Molding P369-370 JSPP'09 Tech.Papers
17	Visualization Analysis of Material Flow inside Simple Rib Cavity in Pulp Injection Molding P253-254 JSPP'09 Sympo.Papers
18	Visualization Analysis of Material Flow around Weld-line Area in Pulp Injection Molded Products P185-186 JSPP'10 Tech.Papers