

# INVESTIGATING THE ROTOMOULDING PROCESS

Product design Special Project

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Of Design In Industrial Design

Industrial Design Centre  
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# APPROVAL SHEET:

Industrial Design Project II titled

## **INVESTIGATING THE ROTOMOULDING PROCESS**

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**Master of Design in Industrial Design**

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## ABSTRACT :

Rotational molding is a virtually pressure and shear force free process for producing hollow plastic articles by heating, melting, sintering of powders in biaxially rotating molds and subsequently cooling it for solidification.

Rotomoulding has various advantages over other plastic manufacturing techniques. .Also typical machines used for the purpose of rotomoulding have also been discussed in the project. Various industrial,commercial,consumer and defence applications have been cited along with the innovative materials used for their manufacturing.

At the end a design assignment has been taken up for the manufacture of a car bumper in rotomoulding which used a technique of a 'double wall foam filled' product.

## INTRODUCTION :

Rotational moulding is one of the most versatile plastic manufacturing methods, much enhanced by the range of specialist polyethylene and polypropylene materials available. Rotational Moulding has the creativity, the productivity, the quality, the simplicity, the professional standards that is required in product design and production.

Simple in concept, rotational moulding is considered by those in the industry to be as much an art as a science in view of the importance of human judgement in the quality of the finished product.

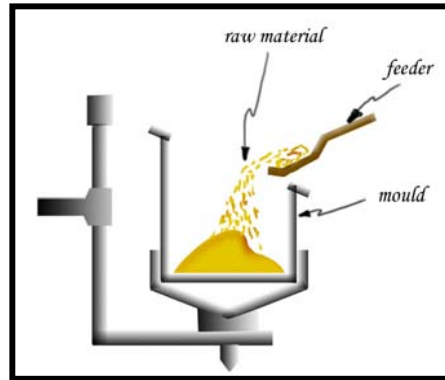
## THE ROTOMOULDING PROCESS:

Plastic resins are loaded into a mould that is heated as it is rotated slowly on both the vertical and the horizontal axis. This simultaneous heating and rotation distributes the material on the inner surfaces of the mould and fuses it. Several moulds may be loaded on a given machine at the same time.<sup>1</sup>

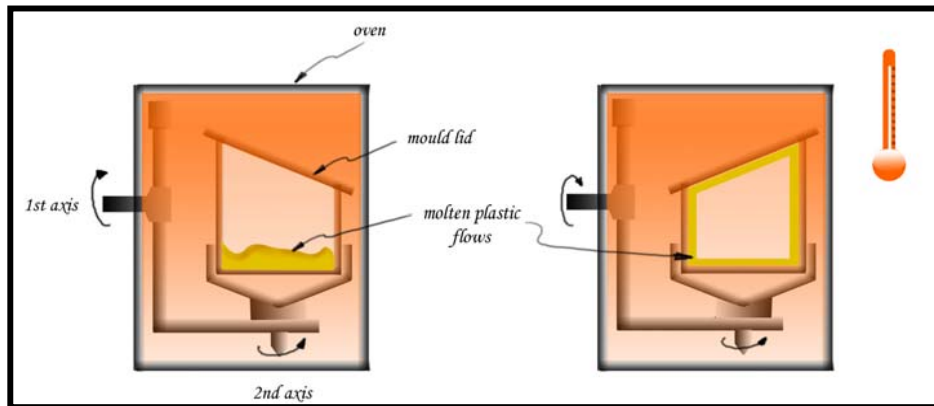
Rotomoulding is a four-phase process, which comprises loading, heating, cooling, and unloading the mould.

In the first stage the pre-measured plastic resin is loaded into the mould. The charged moulds are then closed and moved into the oven, where they slowly rotate on two axes. As the heat penetrates the moulds, the melting resin adheres to the mould's inner surface until it is thoroughly fused, evenly coating the entire surface. When cool enough the product is released from the mould, and the process starts again for the next product. Different rotating patterns achieve variations in such things as wall thickness as required.

# THE ROTOMOULDING PROCESS:



**Fig.1**



**Fig.2**

A mould tool is produced from sheet steel or cast aluminium to the shape and dimensions of the finished product, plus a shrinkage allowance. The actual moulding process is as follows <sup>2</sup>:

## 1. LOADING THE RAW MATERIAL:

The mould tool is mounted on the arm. Weights are added to balance the mould (not shown) so that it can be spun smoothly during the heating and cooling phases.

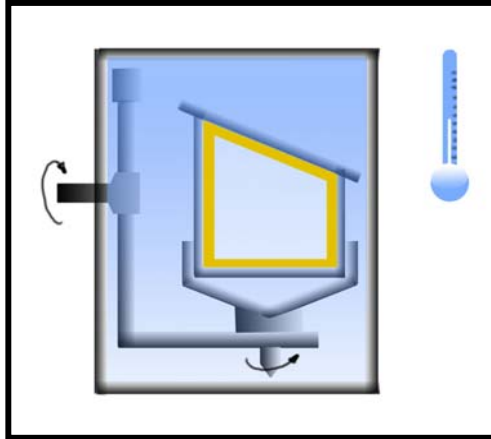
Once balanced, a carefully predetermined weight of raw material (resin powder) is loaded into the mould, which is then closed as shown in Fig.1.

## 2. HEATING:

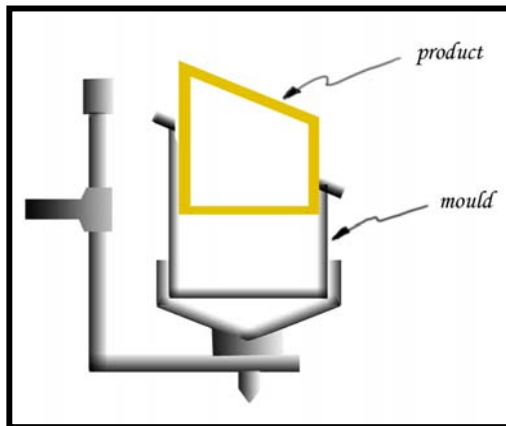
The mould is spun slowly around two axes while being heated inside a large oven. The slow rate of spin means that the powder tends to sit in a pool at the lowest point of the mould. As the powder begins to melt it adheres to the hot walls of the mould, coating it as it passes through the pool of powder.

This is accompanied by an intermediate process called as 'Sintering'. Still being spun around two axes, the mould is air-cooled to allow the part to form sufficiently to enable it to withstand the more aggressive cooling of the next phase without warping as shown in Fig.2..

# THE ROTOMOULDING PROCESS:



**Fig.3**



**Fig.4**

### 3. **COOLING:**

Still being spun, the mould is sprayed with water to provide rapid cooling as shown in Fig.3. This also encourages a slight shrinkage of the part, making it easier to remove from the mould. Once cool, the spinning stops and the product is now ready to be removed from the mould.

### 4.. **UNLOADING THE PRODUCT:**

The still-warm part is removed from the mould as shown in Fig.4. A jig may be inserted to minimise shrinkage, if necessary. Another mould can be loaded onto the arm if required, or the existing one reused.

The rotational speed, heating and cooling times are all controlled throughout the process.

Rotationally moulded products may be simple or complex in shape and include features such as strengthening ribs, inserts of brass or steel, moulded threads, holes, textured and engraved surfaces.

The process provides a extremely uniform wall thickness even at corners and sharp angles. In comparison, blow moulding tends to stretch the molten plastic and the finished product has inherent stress and thus, locations where failure may occur in service.

## PROS AND CONS:

### ADVANTAGES:

1. Rotomoulding results in seamless parts with uniform wall thickness and more material in corners, to absorb shocks and stresses where they occur most.
2. The material isn't stressed during production (as in thermoforming or pressure forming) hence the finished part is stronger.
3. The moulds need not be engineered to withstand the high pressures as in case of injection moulding.
4. The mould has no internal core to manufacture hence the tooling costs are lower – and minor changes can be easily made to existing moulds as compared to injection and blow moulding<sup>3</sup>.
5. Superb flexibility and precision.
6. Material wastage is low as compared to other manufacturing process.
7. Complex contours, metal inserts, flanges, and moulded-in threads can be designed into the walls.
8. The color can never crack or chip off, because it is moulded-in and hence no painting is required.
9. Products are tough, long lasting, and corrosion-proof. They have excellent load bearing capabilities.
10. Ability to produce multi-wall mouldings, which can be left hollow or foam filled.

## PROS AND CONS:

11. Economical for short production runs,as well as high volume output.
12. Vast variety of sizes and shapes varying from 1kg to several tonnes.Eg a tiny medical bulb to a 16-foot kayak.

### **DISADVANTAGES:**

1. Slow cycle time hence leading to high price per piece <sup>4</sup>.
2. Narrow range of raw materials.
3. Some geometric features such as ribs used for strengthening in products,are difficult to mould.

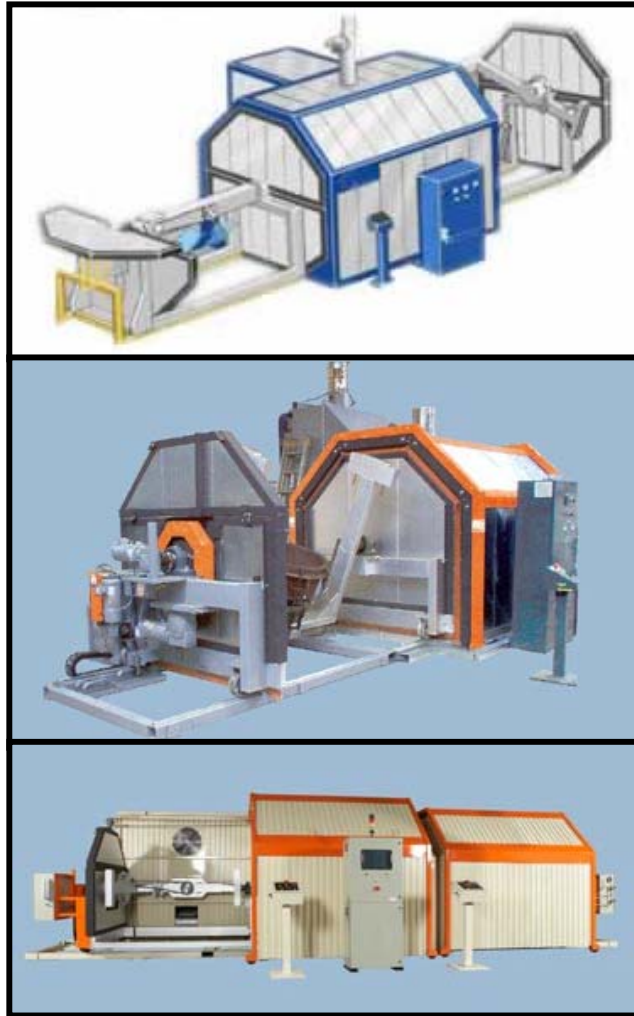
# COMPARISON:

Fig.5 shows the comparison of Rotomoulding with other plastic manufacturing processes.

MANUFACTURING PROCESS	OPERATING PRESSURE	TOOLING COST	PIECE PRICES	PIECE SIZES	LABOUR COST	LEAD TIMES	PRODUCTION RATE	CYCLE TIMES	RAW MATERIALS
<b>THERMOFORMING</b>	<i>atmospheric</i>	<i>low</i>	<i>vary depending on machinery</i>	<i>extremely large</i>	<i>high</i>	<i>6 to 8 weeks</i>	<i>high</i>	<i>from 1 min.</i>	<i>PVC(rigid and flexible), Polystyrene, Polypropylene, Polycarbonate, ABS, Polyester compounds</i>
<b>EXTRUSION</b>	<i>high</i>	<i>low</i>	<i>medium</i>	<i>medium</i>	<i>medium</i>	<i>3 to 5 weeks</i>	<i>high</i>	<i>n/a</i>	<i>BOPP(Biaxially oriented PP), CPP(Cast PP), LDPE, HDPE, PET, PC, Nylon, EVA(Ethylene Vinyl Acetate)</i>
<b>BLOW MOULDING</b>	<i>high</i>	<i>moderately expensive</i>	<i>higher than IM, less than RM</i>	<i>moderate</i>	<i>low</i>	<i>4 to 8 weeks</i>	<i>low</i>	<i>3 to 10 min.</i>	<i>ABS, Nylon, PC PPO(Poly Phenylene Oxide), ASA(Acrylate Styrene Acrylonitrile), PC-PBT(Poly Butylene terphthalate), PSO (Polysulphone)</i>
<b>INJECTION MOULDING</b>	<i>high</i>	<i>generally the highest</i>	<i>lowest available</i>	<i>very large</i>	<i>low</i>	<i>8 to 12 weeks</i>	<i>high</i>	<i>10 to 100 seconds</i>	<i>ABS, Nylon, PC, Polyethylenes, Polypropylenes, Polystyrenes, PVC</i>
<b>ROTATIONAL MOULDING</b>	<i>atmospheric</i>	<i>very low</i>	<i>high</i>	<i>small to large</i>	<i>low</i>	<i>3 to 5 weeks</i>	<i>moderate</i>	<i>40 to 45 min.</i>	<i>Rapid Roto 3604, Linear Medium Density PE, Borocene, LLDPE, PP, PVC Plastisols, LDPE, HDPE, PP, EVA, Nylon</i>
<b>FIBRE REINFORCED PLASTIC (FRP)</b>	<i>atmospheric</i>	<i>low</i>	<i>higher than plastic products</i>	<i>small to large</i>	<i>high</i>	<i>2 to 6 weeks</i>	<i>high</i>	<i>15 to 20 min.</i>	<i>—</i>

**Fig.5**

## THE MACHINES:



**Fig.6**

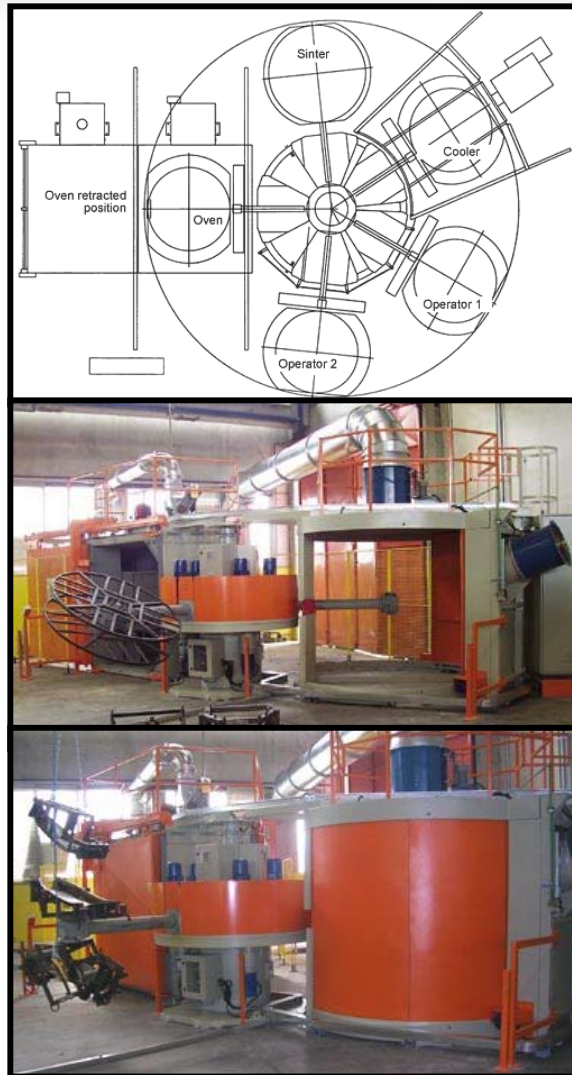
### **SHUTTLE MACHINES: SRM LINE :**

The shuttles are linear installations featuring a central oven and 1 or 2 carriages which are entered into the oven for cooking and then removed to a cooling station for cooling and extraction of the moulded parts as shown in Fig.6 <sup>4</sup>.

These installations require only limited operating space while providing increased loading capacity from the mould-holding arms which are supported at the two ends. The same arm can perform consecutive cycles while the other arm has stopped production in order to interchange a straight/square arm or because production tests have been performed <sup>5</sup>.

These machines are truly unique in which the compartmentalization of the oven is not obtained using doors, but with fixed panels assembled onto the carriages, optimizing the sealing of the oven and reducing cycle times.

## THE MACHINES:

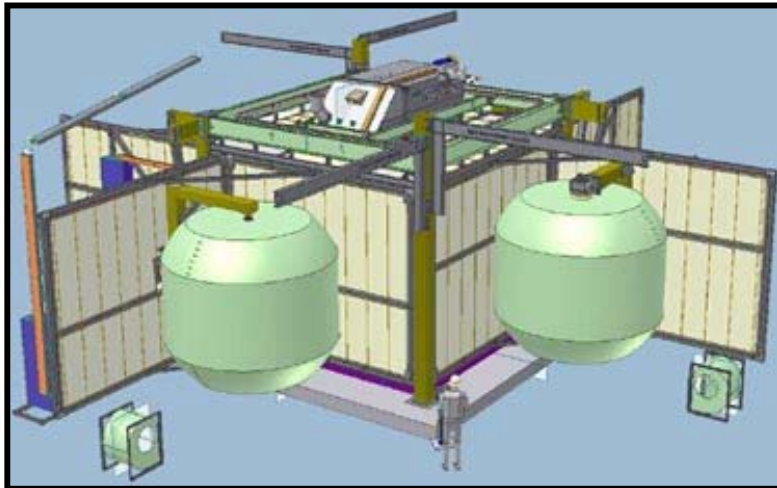


**Fig.7**

### CARROUSEL:

A plant with a central turret: maximum reliability and simplicity in use. An ideal machine for high volume production of articles, even of different sizes with similar working cycles as shown in Fig.7. Sturdy construction a minimum maintenance are its principal features. It can be equipped on request with 3 or 4 arms that change station simultaneously, so alternating in the different phases. Many cycle customizing possibilities (double loading/unloading station, pre-cooling etc.)<sup>5</sup>.

## THE MACHINES:



**Fig.8**

### **ROCK & ROLL:**

Rotomachinery Group's Rock & Roll machinery is the ideal solution for high productivity moulding capability for large and very large parts as shown in Fig.8. The installation combines the advantages of an in line 3-stations machine (one cooking and two separate cooling) with an oscillating oven composed of 3 to 5 independent cooking zones. The special feature on this system are the two independent mould-holding carriages which alternate during the cooking and cooling phases, thus making it a completely automatic operating cycle <sup>5</sup>.

## THE MACHINES:



**Fig.9**

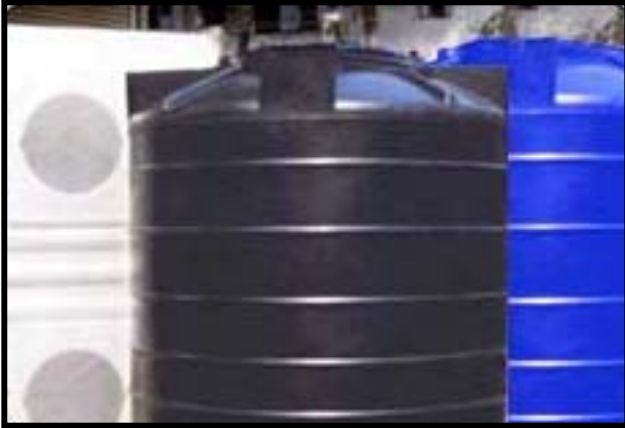
### **900 BOX :**

A small sized plant for rotational moulding used for the production of small items in large quantities (balls for games, and sports, dolls, toys, cones and road safety articles, fenders and buoy for boats, air mattress pumps, technical articles for cars, hygienic-sanitary ware and infant care) as shown in Fig.9.

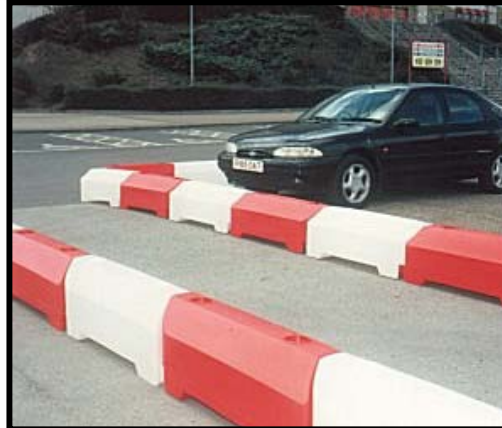
High degree of simplicity and reliability in use. Also there is a possibility of adjusting the secondary rotation independently of the primary to obtain perfectly uniform distribution of materials for quality production <sup>5</sup>.

## APPLICATIONS:

### INDUSTRIAL & COMMERCIAL APPLICATIONS:



Specialty tanks and containers for fuel, water, and chemical processing



Highway barriers and road markers



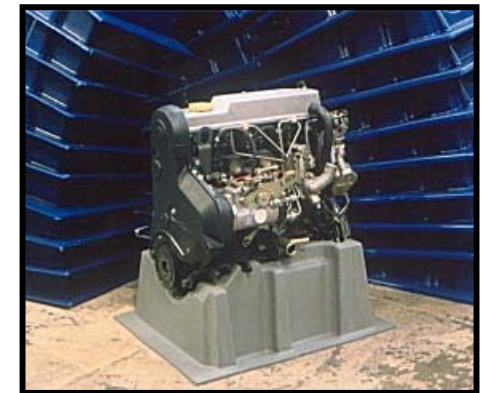
Car Dashboards



Drainage systems



Industrial pellets



Engine Racks

## APPLICATIONS:

### CONSUMER PRODUCTS APPLICATIONS :



Rocking toys for kids



Rotomoulded chair



Double walled flasks



Litter box



Double walled foam filled  
product

## APPLICATIONS:

### DEFENCE APPLICATIONS :

Rotomoulded containers are used all over the world in extreme climatic conditions, including active combat, for such varied uses as transit of hot food, missile storage, rifle cases, foot lockers, engineering spares, 19 inch electronics racking and ammunition storage as shown in Fig.10 <sup>6</sup>.



**Fig.10** Ammunition storage

### **BASF Has Developed its First Polyamide for Rotomoulding Technology <sup>7</sup>**

**Date: March 15,2005**

**BASF** has developed its first polyamide for the rotomoulding technology. This un-reinforced polyamide 6 (PA6) is sold under the brand name **Capron BR30HS**. The plastic's first serial production application is in the automotive sector and additional projects are on the drawing board.

The new Capron in powder form can be employed wherever there is a need to produce a small series of liquid containers used in motor vehicles. This includes **tanks for hydraulic oil or diesel fuel as well as coolant equalizing reservoirs**. Other possible components are air supply conduits and covers for trucks, construction machinery, forklifts and tractors. Metal inserts such as sleeves or screw threads can be readily integrated into the parts. The inner surface of components made of the new Capron is very smooth, which is a prerequisite for liquid-carrying vessels. The plastic is available in uncoloured form and in black.

Capron ideally complements the Ultramid® portfolio for customers from the automotive industry, the electric & electronics industry as well as all other sectors of industry such as furniture, packaging, sports and recreation.

## RAW MATERIAL INNOVATIONS:

### BASF Has Developed its First Polyamide for Rotomoulding Technology

Date: March 15,2005

Parts in the engine block and in engine lubrication, e.g. camshaft timing gears, chain guides, toothed belt covers, air intake modules, engine covers, oil sumps, oil filter housings, valve bonnet and cylinder head covers as shown in Fig.11..

Its excellent electrical insulation properties, advantageous sliding friction characteristics and outstanding mechanical strength make **Ultramid** a material which is employed in almost all fields of power engineering and mechanical and chemical engineering..



Fig.11

## **BORECENE:**

**Date: 2002**

Borecene is a third generation linear medium density polyethylene designed for rotomoulding, developed by Borealis<sup>8</sup>.

The property balance imparted through the novel metallocene catalyst system creates a combination of processing and product performance benefits for the moulder and the end user.

### Borecene key strengths

- Improved mechanical properties
- Improved flow properties
- Less resin complexity
- Light weighting potential
- Better surface finish
- Less wall bubbles
- Better colour consistency

### Advantages

- Higher impact strength and ESCR (Environmental Stress Cracking Resistance)
- Improved process efficiency
- Simplified material handling
- Significant material savings
- Good looking products
- Optimal moulding performance
- Brighter colours

## RAW MATERIAL INNOVATIONS:

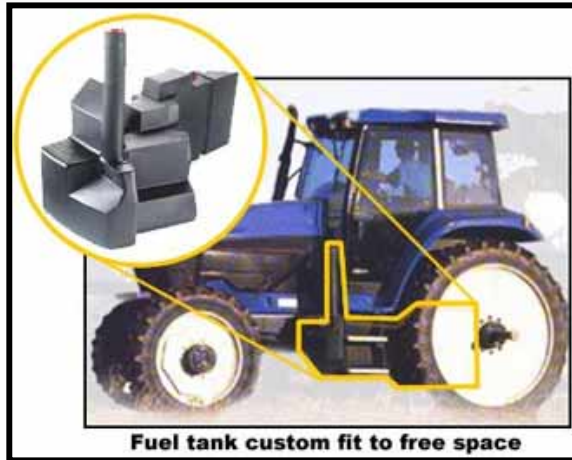


Fig.12



Fig.13

### BORECENE:

Date: 2002

The main application for this new grade will be diesel fuel tanks, where its barrier performance is superior to standard linear and cross linked resins as shown in Fig.12.

The application for this new grade also includes its use in the field of exterior styling for automotive industries as shown in Fig.13.

## RAW MATERIAL INNOVATIONS:



**Fig.14**

### **BORSTAR :**

**Date: 2002**

Borstar bimodal PE grades are the preferred materials used by many film producers for the production of high quality film products as shown in Fig.14 <sup>8</sup>.

Mechanical film properties like toughness, stiffness and easy opening, down-gauging, homogeneous appearance, improved processing and high production regularity are the key elements for this new Borstar grade.

### RAPID ROTO 3604: ROTATIONAL MOLDING POWDER

Rapid Roto 3604 is a linear medium density polyethylene specifically designed for rotational applications as shown in Fig.15. Rapid Roto 3604 has good flow, toughness, impact resistance and environmental stress crack resistance (ESCR) <sup>9</sup>.

#### SPECIAL GRADES:

Rapid Roto 3604 can be incorporated with additional properties to suit individual requirements.

- **Anti-Static:** Special formulations provide protection against dust pick-up and static generation. Find application in the food industry where hygiene is extremely essential.
- **UV Stabilised:** Special formulations are available for protection against harsh sunlight/ UV Light Find application in the outdoor articles in countries like India, Saudi Arabia, etc.
- **Custom Colours:** Powders can be manufactured in the other grades of L.D.P.E./ L.L.D.P.E./ H.D.P.E. and in different colors & fineness to suit individual requirements.



Fig.15

## INNOVATIVE APPLICATIONS:



**Fig.16**

### **MANUFACTURING OF 'KAYAKS':**

Celliers Kruger has designed, built and is now exporting hundreds of plastic kayaks for "playboating" (freestyle stunts) and downriver tripping, effectively becoming the newest arrival in SA's innovative boat-building industry as shown in Fig.16 <sup>10</sup>.

**Material used: Recyclable Polyethylene**

## INNOVATIVE APPLICATIONS:

### HARVESTING 'RAIN WATER':

Waterwall is a modular rainwater storage system for urban Australia as shown in Fig.17 <sup>11</sup>. Holding approx. 1200 litres of water; and having only two thirds the depth of the average slim line tank.

AND interconnected Waterwall modules can be used as a fence or a dividing wall in the garden –

**STORE WATER IN YOUR FENCE!**



Fig.17

## DESIGN ASSIGNMENT 1:

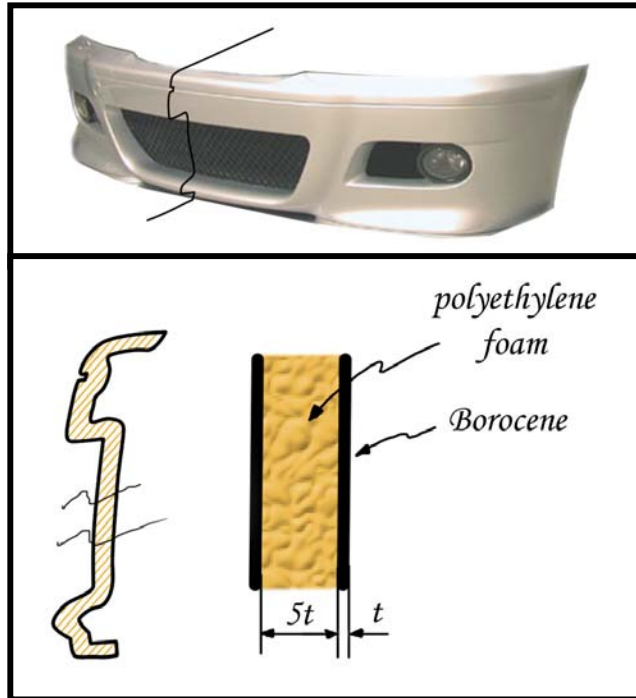


Fig.18. BMW FRONT BUMPER

For material to flow and form properly, it is recommended that the distance between the parallel walls be a minimum of 5 times the nominal wall thickness of the part <sup>13</sup>.

### DESIGN OF A CAR BUMPER (BMW):

Presently, the car bumpers are made from FRP (Fiber Reinforced Plastics) or SMC (Sheet molded compounds) as shown in Fig.18.

Due to the advances in the field of Rotomoulding it is quite possible to make the same bumper with rotomoulding process. The material best suited for the above application could be Borecene.

Borecene is selected due to its following properties,

1. Higher impact strength and ESCR (Environmental Stress Cracking Resistance)
2. Improved mechanical properties.
3. Improved flow properties.
4. Better surface finish.

Bumpers protect the vehicle they surround from damage in low-speed impacts is another matter.

Bumper systems usually include a reinforcement bar plus energy-absorbing material, such as polypropylene foam. Better bumpers often have hydraulic shock absorbers instead of, or in addition to, the foam <sup>12</sup>.

## DESIGN ASSIGNMENT 2:



**Fig.19 A SMALL REFRIGERATOR**

### **DESIGN OF A SMALL REFRIGERATOR:**

This assignment basically deals with the design of 'A Small Refrigerator' for applications in places such as 5-star Hotels, small restaurants and for applications where food has to be stored in small quantities.

Since the size of the refrigerator is very small it becomes very easy to place it at any height level.

Polypropylene is selected as the basic raw material for this purpose mainly due to the following reasons:

1. PP is a Food grade plastic .hence the food can be stored safely.
2. Light in weight, and resistant to staining.
3. Has a low moisture absorption rate.
4. Can be easily fabricated.

Fig.19 shows the sketches of the fridge along with the kind of application it will be used for.

## DESIGN ASSIGNMENT 2:

### DESIGN OF A SMALL REFRIGERATOR:

Fig.20 and Fig.21 below shows the manufacturing details of the two parts, the outer body and the inside sliding rack respectively.

Both the parts are made of polypropylene by the means of rotomoulding. They are manufactured in such a way that a part of the body gets filled entirely by the plastic whereas the remaining part acquires a 'double walled' structure <sup>14</sup>.

This double wall actually helps in filling an insulation material such as polyurethane foam which helps in maintaining the contents of the fridge at the same temperature .

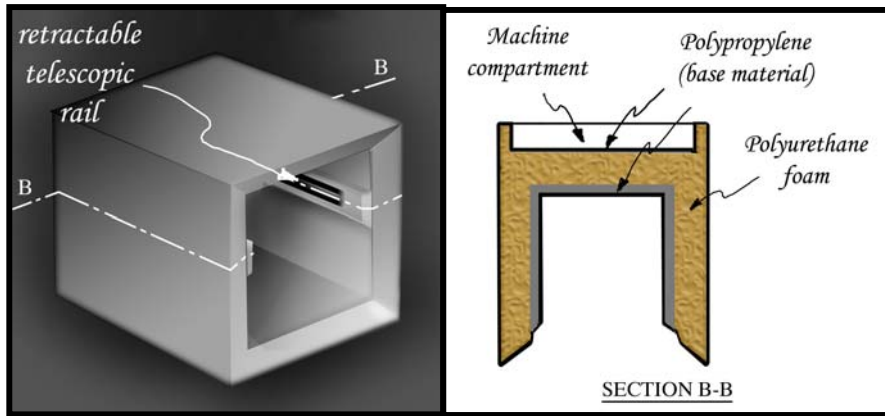


Fig.20 REFRIGERATOR BODY (SECTIONAL VIEW)

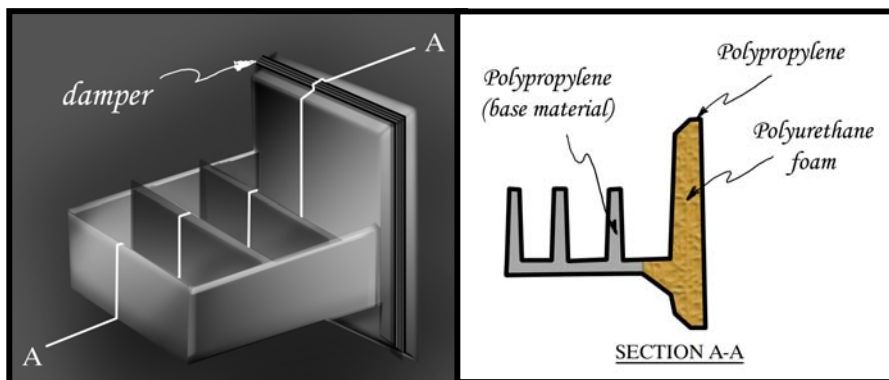


Fig.21 SLIDING DOOR (SECTIONAL VIEW)

## CONFERENCE VISIT (SARD):



### Third Annual Conference of ARM International's South Asia Region Division (SARD)

February 1-3, 2007

Hilton Towers, Mumbai, India

Day 1:

Seminars were into serious working mode after the **Programme Chairman Ravi Mehra** had introduced first **Dr. Nick Henwood, Rotomotive Ltd.** who was conducting the Materials Masterclass Seminar and then **Mike Paloian, Integrated Design Systems** who was conducting the Design Seminar.

While Feedback forms returned at the end of the day ranked the Seminars highly for their utility and knowledge gained, it was the great satisfaction expressed by the presenters on the level of participation and interaction of the attendees that established new standards of success for these Seminars.

The other important activity of Day 1 was the VI Meeting of SARD-OC '06. It turned out to be an important exercise in reviewing the progress made by SARD in 2006 in different realms of activity. This was necessary groundwork to prepare for activities in the year ahead.



## CONFERENCE VISIT (SARD):



A pleasant evening of cocktails brought the day's events in the conference hotel to a close.

**R.P.Shukla, Mplast**, hosted a dinner for conference attendees in the very ethnic ambience of Khyber, a popular banquet venue in Mumbai, to conclude Day 1. Another prompt start on time with registrations was how **Day 2 (Feb 2)** began. Conference branding and Sponsorship recognition stood out at both the Registration Desk and the dais of the conference hall.

**Programme Chairman Ravi Mehra** launched conference proceedings with his opening remarks on the conference theme and purpose that was followed by self introduction of attendees. This exercise was repeated later for the late arrivals who soon filled up the entire seating capacity of the ballroom. The Keynote Address by **Promens hf CEO & President Ragnhildur Geirsdottir** set the tone and theme for the conference as the Technical Conference presentations followed. The presenters took the stage after appropriate introductions by Ravi Mehra.

## CONFERENCE VISIT (SARD):



### Day 2:

On resumption after lunch a few minutes of the General Session was used for important SARD tasks like presentation of the Annual Division Report, announcement of new SARD-OC members, and formal introduction of the new **SARD Chairman A. Baheti** and his team. SARD affairs over, the presentations continued with three Company Profiles rounding up the Technical Conference Session. Attendee questions fielded by Speakers at the end of their presentations made the session interactive and lively.

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