

# The Polymer Processing Research Centre



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# ARMSA Seminar

# Evaluating and Competing with other processes

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# Introduction

- **Is rotomoulding the best process or viable?**
- **What are the unique selling points for rotomoulding?**
- **Unique rotomoulding design attributes e.g. kiss-offs**
- **How can I make an injection moulded part rotomouldable?**
- **Typical cost comparison with blow / injection / twin sheet thermoforming**

# The Rotational Moulding Process

- **Rotational Moulding, also known as rotocasting or rotomoulding**

**Can be defined as:**

- **A low pressure, high temperature, moulding process that uses heat and biaxial rotation to produce hollow, one - piece plastic parts.**
- **The basic principle dates back to 1855, the process did not gain recognition until the 1950's possibly due to the belief that it was a slow process and restricted to a small number of polymers.**

# The Rotational Moulding Process

Over the past number of years,

- innovative improvements in process control
  - the development of improved performance plastic powders
- have resulted in a very significant increase in the use of the process
- Currently the advantages in terms of the economic production of often complex, stress - free articles, have made rotational moulding a very competitive alternative for the manufacture of hollow plastic products to:
    - Blow Moulding
    - Injection Moulding

# The Rotational Moulding Process

- **Used to produce small and large hollow articles with uniform wall thickness, which cannot be produced economically by any other processing method.**
- **The process is relatively modern and new products and materials are constantly being researched and developed.**
- **Such products include bulk containers, oil tanks and canoes etc.**

# Cycle Times

- **Cycle times are relatively long compared to other plastic fabrication processes**
- **Typical cycle times varying from 3 to 60 minutes**
- **More suitable for the manufacture of large parts because they are generally produced in low to medium volumes**
- **In comparison with other processes the required levels of instrumentation and process monitoring are minimal**

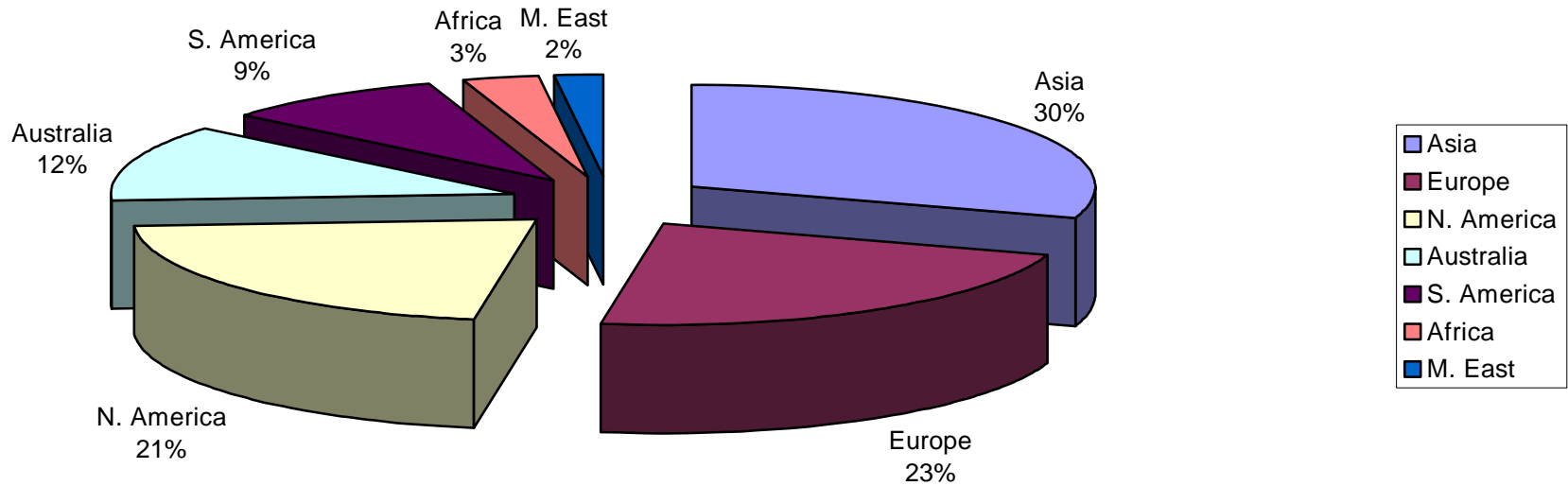
# History

- **The earliest commercial applications of the concept of rotational moulding used vinyl plastisols to coat the inside surface of a hollow metal mould**
- **The use of these thick, viscous liquids led originally to the term 'slush moulding' being used for the process**
- **Typical products included play balls and toy dolls**
- **This process using PVC is still in widespread use today**

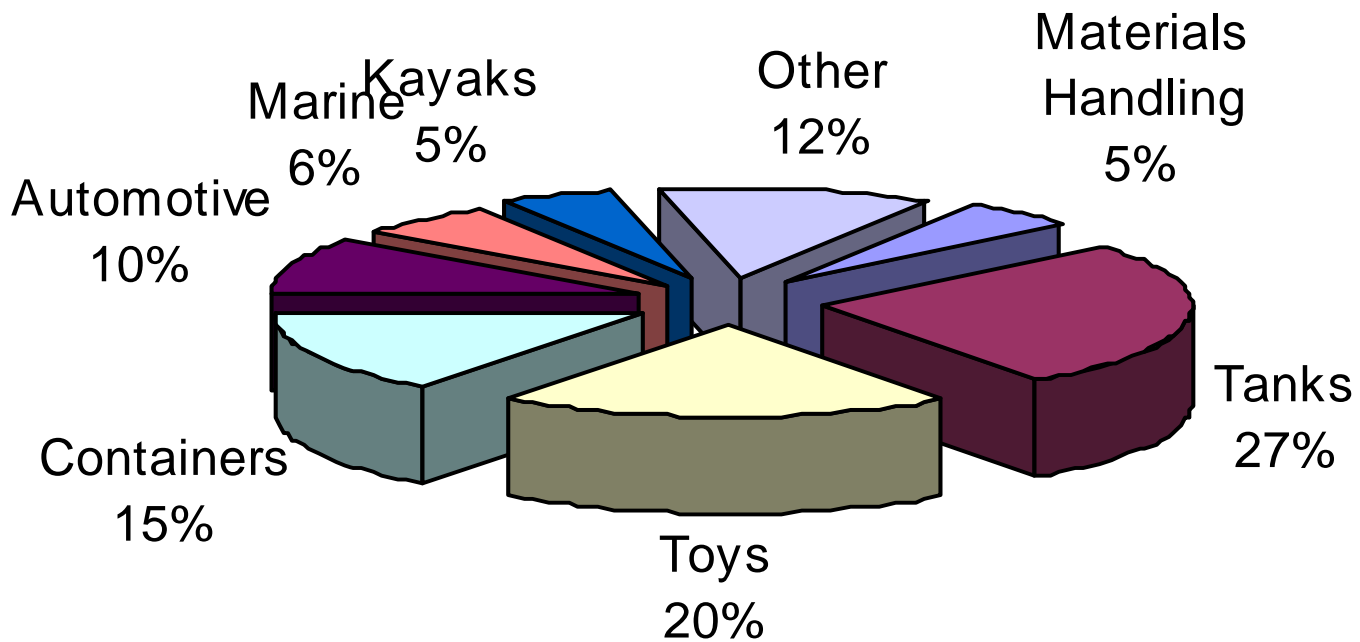
# History

- **Late 1950's the use of the rotational moulding process expanded due to the introduction of powdered polyethylene grades specifically developed for the process**
- **Polyethylene still accounts for over 90% of the total tonnage of plastics used in rotational moulding due to:**
  - **powder flow**
  - **melt flow**
  - **thermal stability**

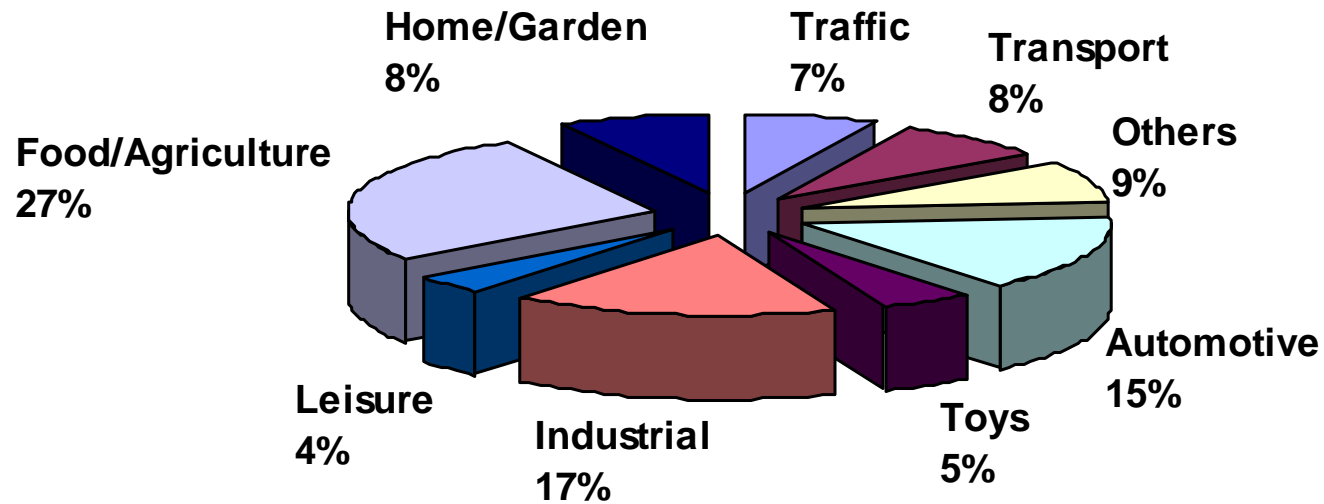
# Rotomoulders around the World



# Products – NAFTA



# Products – EU



# Advantages of Rotational Moulding

- **The moulds are simple and relatively cheap (disadvantage?)**
- **This is as a result of rotational moulding being a low-pressure process and therefore it is unnecessary to manufacture the moulds from expensive metal alloys, as in the injection moulding process**
- **The products manufactured using the rotational moulding process will be hollow, seamless and virtually stress free**
- **The wall thickness of parts produced by rotational moulding are more uniform in comparison to products from other processes**

# Advantages of Rotational Moulding

- **Products with undercuts and intricate contours can be relatively easily moulded**
- **It is also possible to produce double wall mouldings**
- **Relatively little waste is produced since the required weight of the part is placed inside the mould**
- **It is also common place for a number of moulds to be moulded at the same time**
- **These moulds can be of different sizes and shapes**

# Disadvantages of Rotational Moulding

- **One of the main disadvantages associated with rotational moulding is that materials suitable for the rotational moulding process are more limited than for other processes**
- **The raw material costs are generally higher since polymer materials are generally supplied in pellet form and hence grinding is required to produce a fine free-flowing powder**
- **This additional grinding operation may add a further 25% to the material cost, which adds a significant increase in overall cost of the product**

# Disadvantages of Rotational Moulding

- **The process is often not suitable for large production runs of small parts, since the long cycle times associated with the process would make it viably uneconomical**
- **The process is relatively labour intensive as a result of the manual loading and demoulding operations**
- **Products with bosses or solid ribs cannot be easily moulded, due to poor cavity filling by the powder during rotation and heating**
- **Such design features may lead to difficulties during the demoulding operation**

# Disadvantages of Rotational Moulding

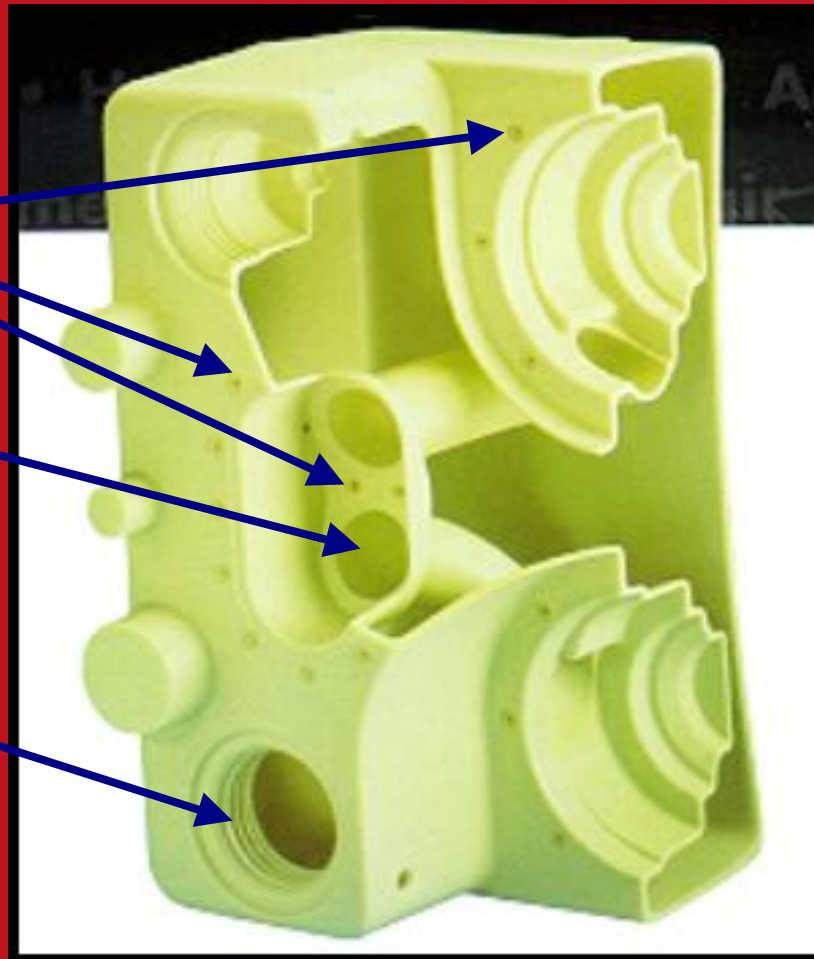
- **The cycle times are much longer than those of other processes**
- **Both the plastic and mould must be heated from room temperature to a high temperature e.g. 200°C and then subsequently cooled to room temperature during each cycle**

# Products - Tanks

Threaded Inserts

Integral channels

Moulded in threads



# Vented Roof Tile - Domestic



Note: 'kiss-off' features

# Comparison with other Processes

Factor	Blow Molding	Thermoforming	Rotational Molding
Plastics available	limited	broad	limited
Feedstock	pellets	sheet	Powder/liquid
Mould materials	steel/aluminium	aluminium	steel/aluminium
Mould pressure	<1 MPa	<0.3 MPa	<0.1 MPa
Mould cost	high	moderate	moderate
Wall thickness uniformity	Tends to be non-uniform	Tends to be non-uniform	Uniformity possible
Inserts	feasible	no	yes
Residual stress	moderate	high	low
Part detailing	very good	good, with pressure	adequate
In-mould graphics	yes	possible	yes
Cycle time	fast	fast	slow
Labour intensive	no	moderate	yes

# Rotomoulding Seminar

## Assessing mouldability: Influences over the process

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# Factors to Consider

- Shrinkage / Warpage / Tolerances / Jigging
- Surface quality – graphics / colour effects
- External mould design features – clamps / venting / movable inserts / air movers
- Moulded-in inserts / threads / radii
- Wall thickness – variation / shot weight
- Colour blending method
- Mould release

# Rotomoulding Seminar

## Colour + Mould Release

# Pigmentation in Rotational Moulding

- **Coloured mouldings can be produced with the addition of pigments**
- **Pigments are very fine solid particles of organic or inorganic material**
- **Pigment concentration should be kept minimal**

**There are three common pigmentation methods used in rotational moulding:**

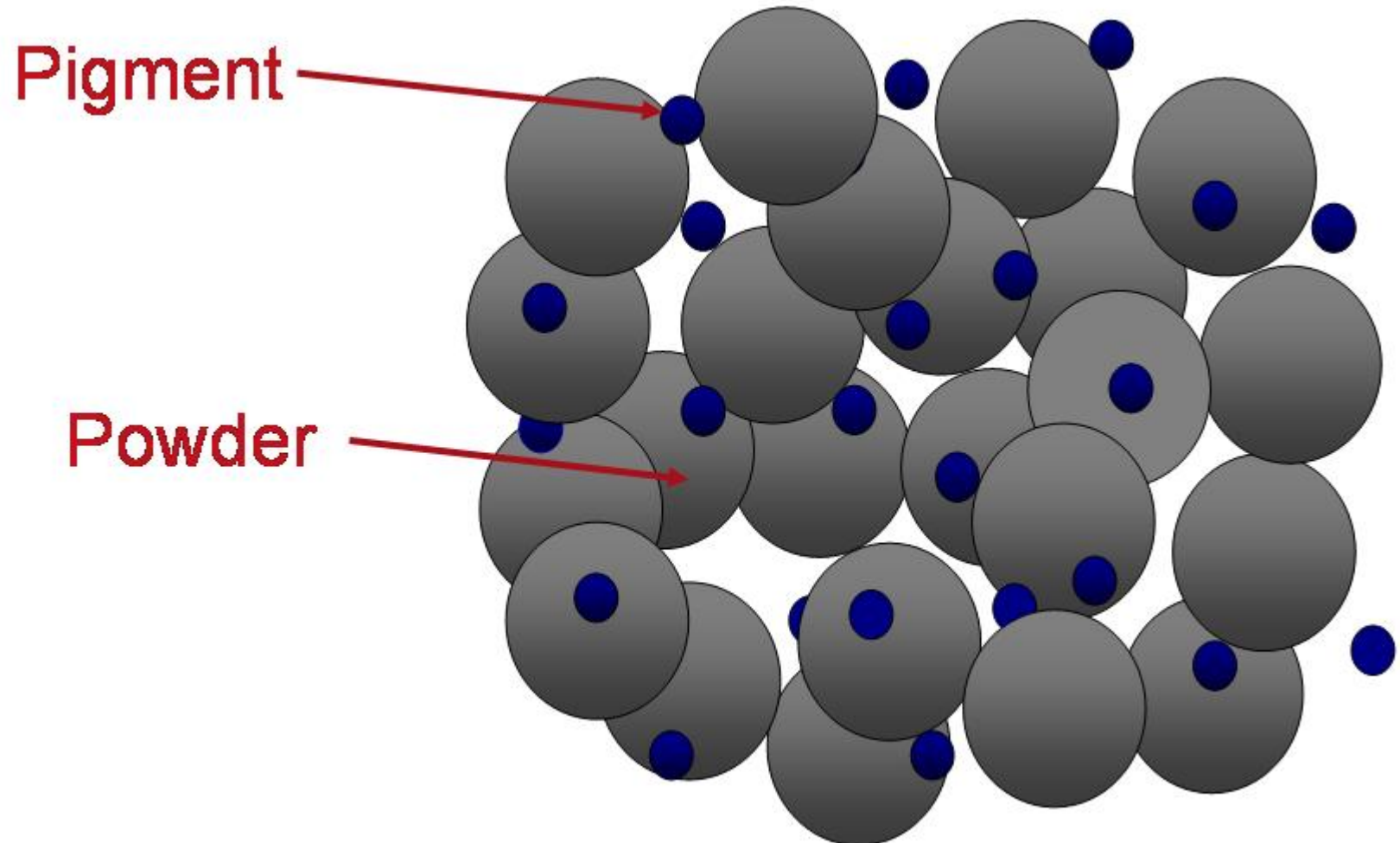
- (1) Tumble blending**
- (2) Turbo-blending**
- (3) Melt compounding**

# Tumble Blending

- Dry blending or tumble blending involves some preliminary mixing outside the mould
- Followed by natural tumbling action within the mould during rotational moulding
- Results in an fairly even dispersion of pigment
- Can cause 'plateout' on the mould



# Tumble Blending



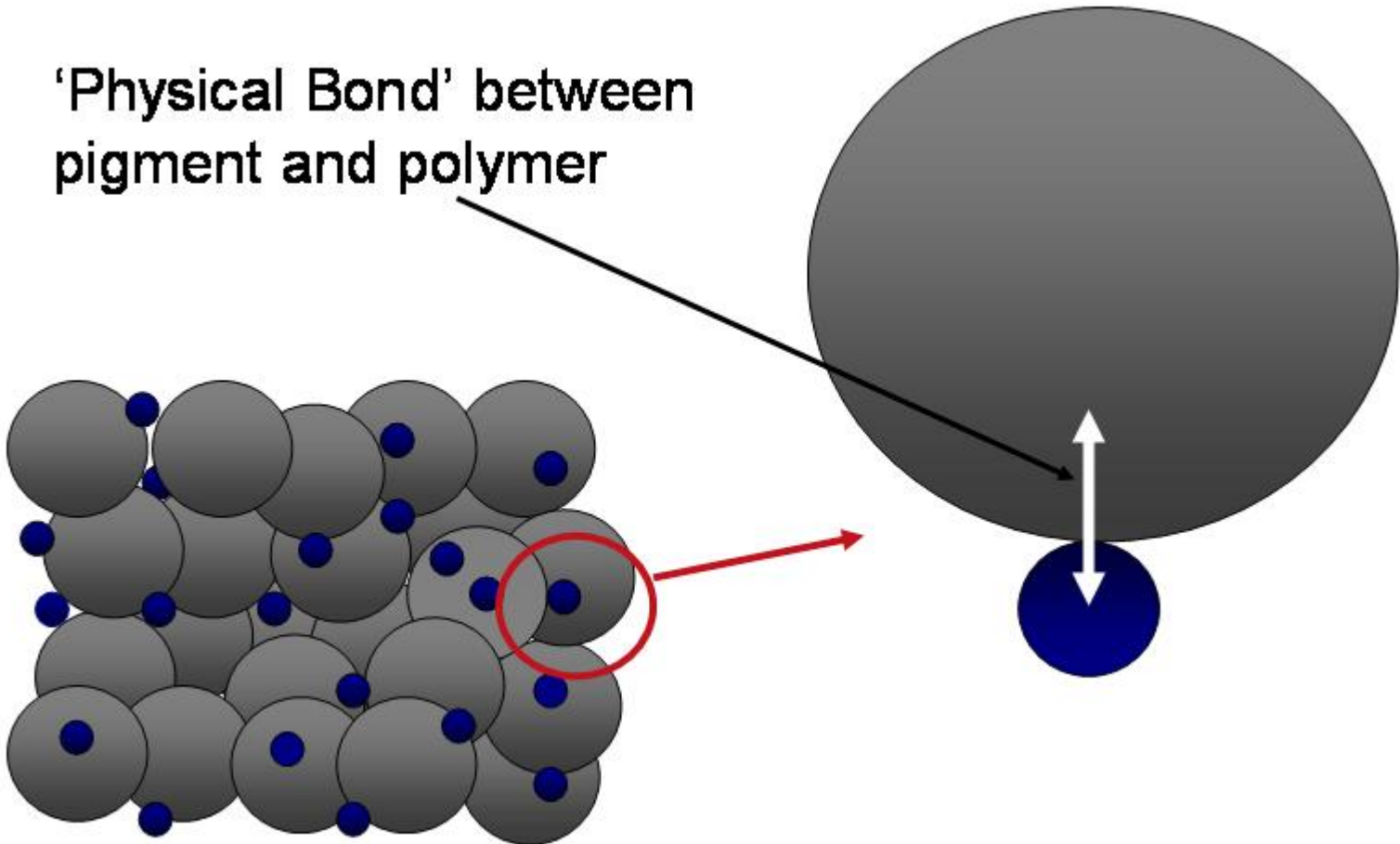
# High Speed Blending

- Improvement over the tumble blending
- Pigment is combined with powder using a paddle type device
- Paddle rotates at very high speeds resulting in a increase in temperature
- Polymer becomes tacky and pigment sticks to it



# High Speed Blending

'Physical Bond' between pigment and polymer



# High Speed Blending

## Advantages

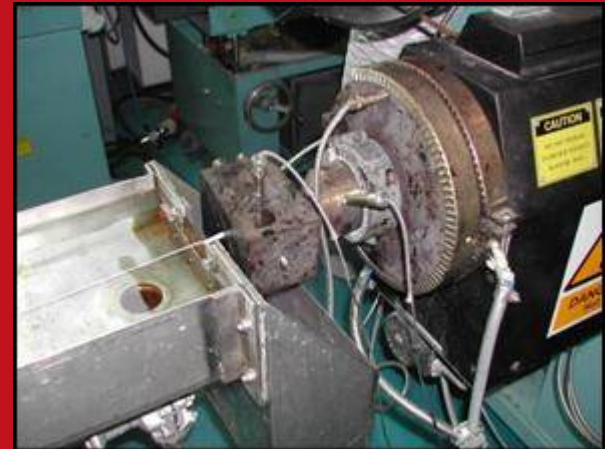
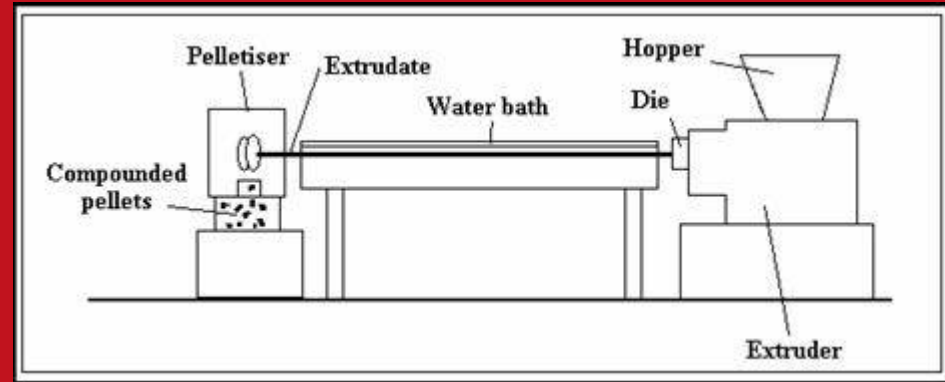
- **Cost savings through the ability to pigment bulk quantities of natural material**
- **Equipment costs are lower than Melt Compounding**

## Disadvantages

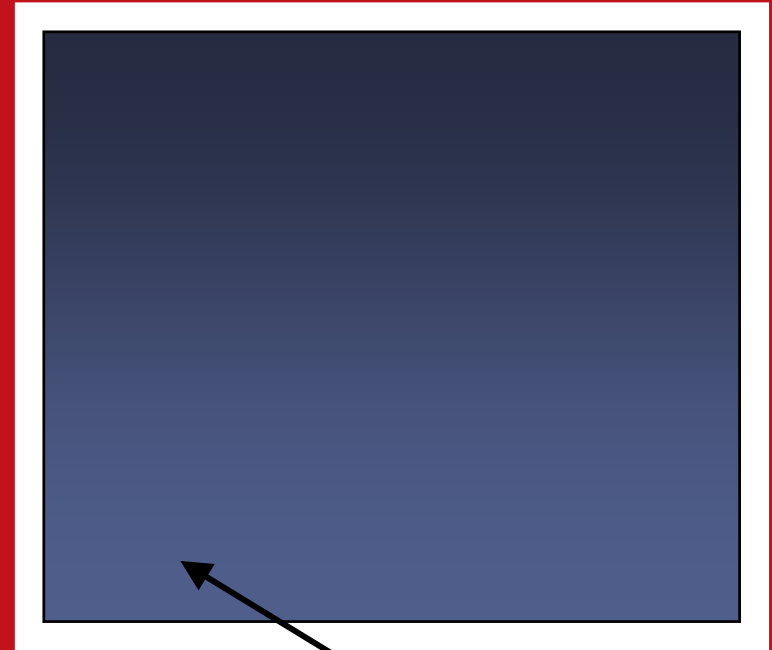
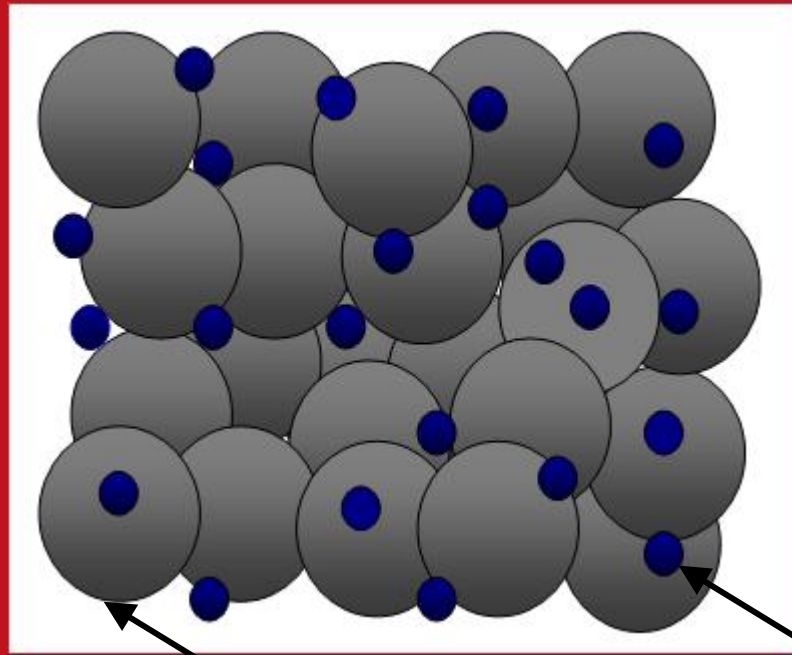
- **Pigment is not homogenised**
- **Very sensitive to amount of pigment used**
- **End product properties are decreased**

# Melt Compounding

- Melt compounding enables excellent mixing of the pigment throughout the polymer matrix,
- this results in the pigment being homogeneously distributed within the polymer, not in the interface between particles



# Melt Compounding



Powder Particle

Pigment

Homogenised Melt

# Melt Compounding

## Advantages

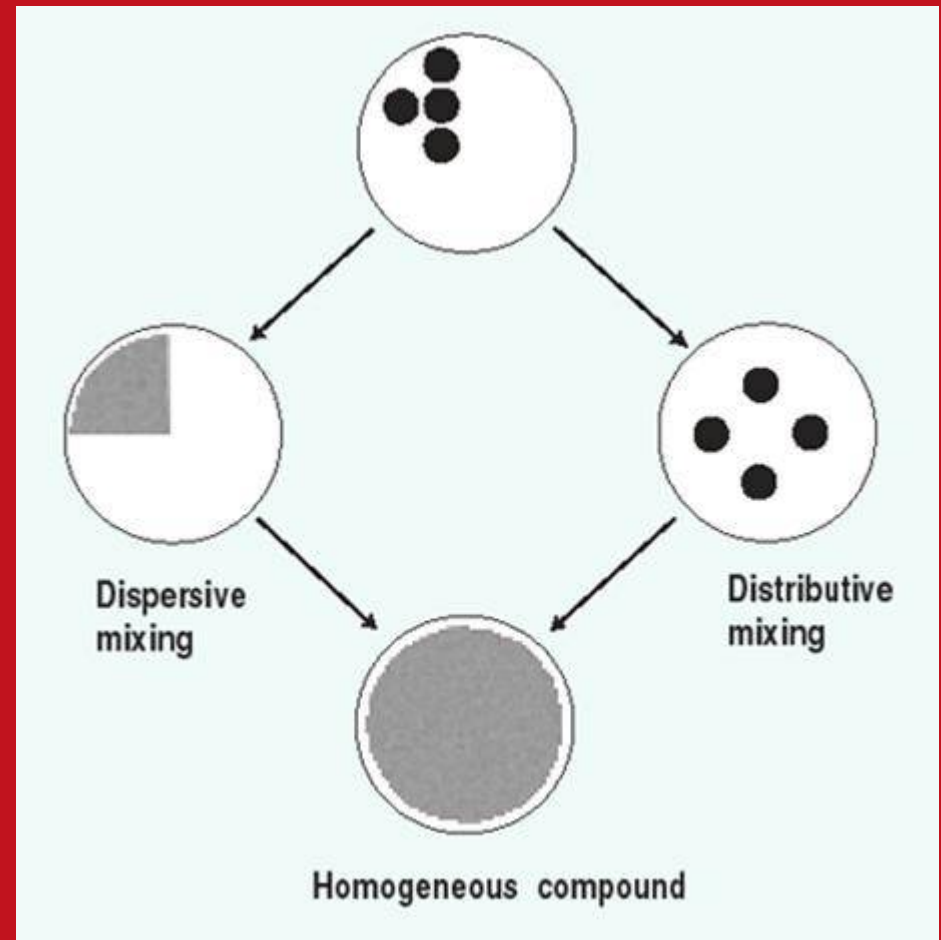
- Properties of moulded part better than any other blending method

## Disadvantages

- Powder more expensive to produce due to equipment costs
- Moulder needs to keep good control over stocks of the required colours

# High Speed Blending Vs Melt Compounding

- High Speed Blending enables good distributive mixing
- Melt compounding enables excellent distributive and dispersive mixing



# Tumble Mixing / Dry Blending

- **Simple, low shear, low cost technique**
- **Pigment remains in large agglomerates situated in the interface between the polyethylene particles**
- **Performed inside the mould before it is heated**
- **Colour tends to be weak and speckled**
- **Smaller particles of the pigment adhere to the mould**

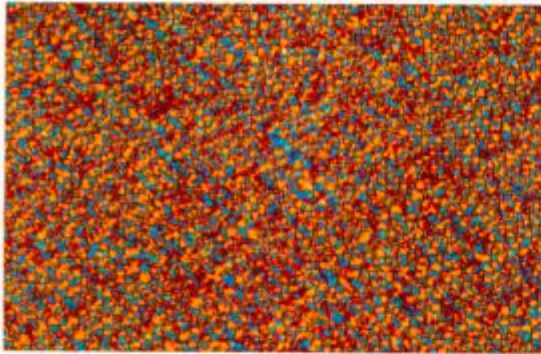
# Turbo - Blending

- Turbo blending involves the physical bringing together of pigment and polyethylene particles by mixing them together using a high- speed mixer
- Pigment is dispersed evenly throughout the polyethylene particles at high speed and at an elevated temperature
- Colour intensity is improved over tumble blending

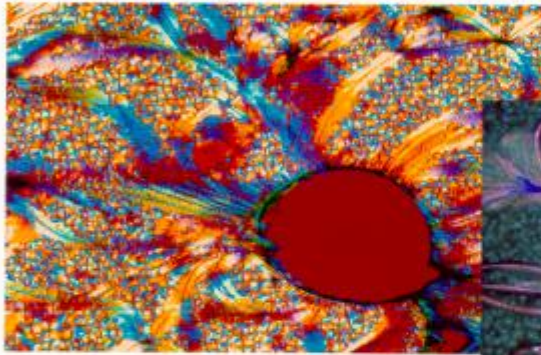
# Melt Compounding

- **Material that has already been turbo blended is then fed to an extruder where the pigment and polymer are melted together**
- **This results in the pigment being homogeneously distributed within the polymer, not in the interface between particles**
- **Colour is even and well distributed**
- **Expensive in comparison to the previous two methods**

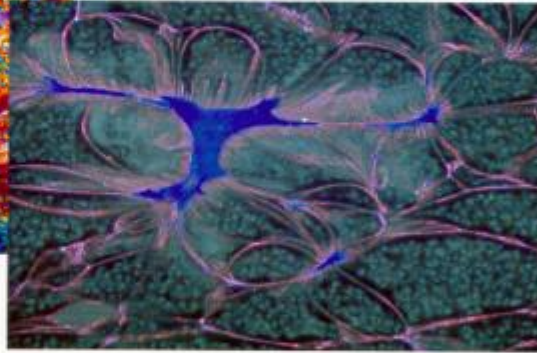
## Effects of Turbo – Blending and compounding



Virgin ME8169



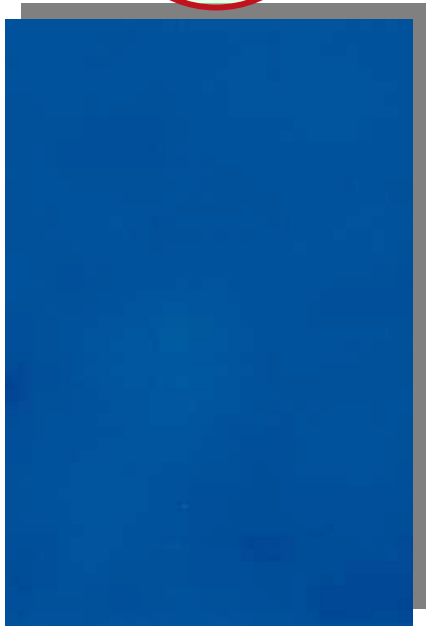
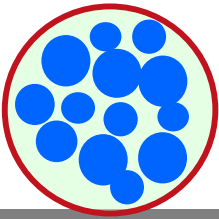
ME8169 + 0,5% Mersey Blue  
(Turbo Blending)



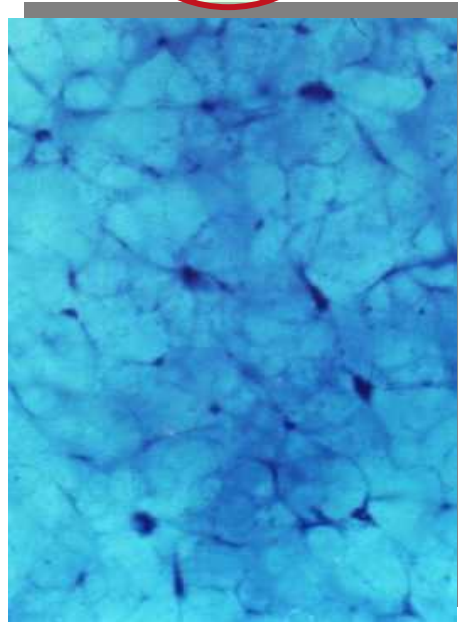
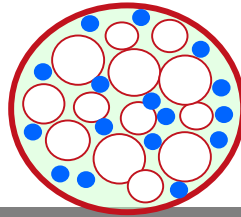
ME8169 + 0,5% Mersey Blue  
(Compounding)

**Note the very fine structure created by compounding. Also, the Turbo Blending results in the pigment nucleating special structures at the particle boundaries.**

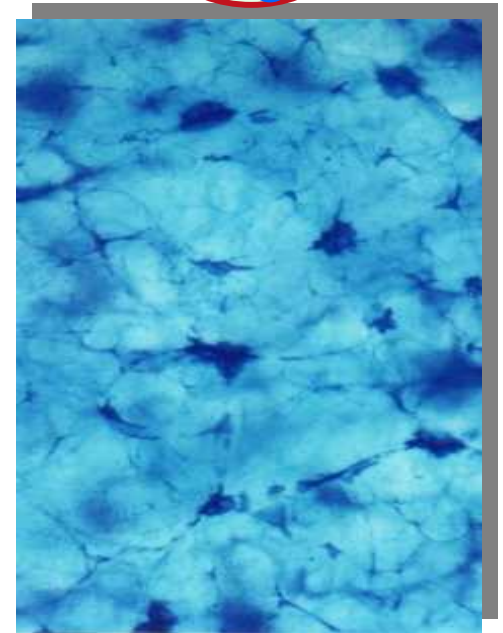
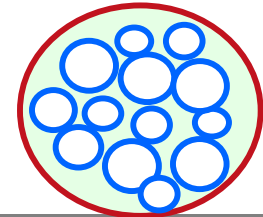
# Comparison of Colouring Method



**Melt Compounded**

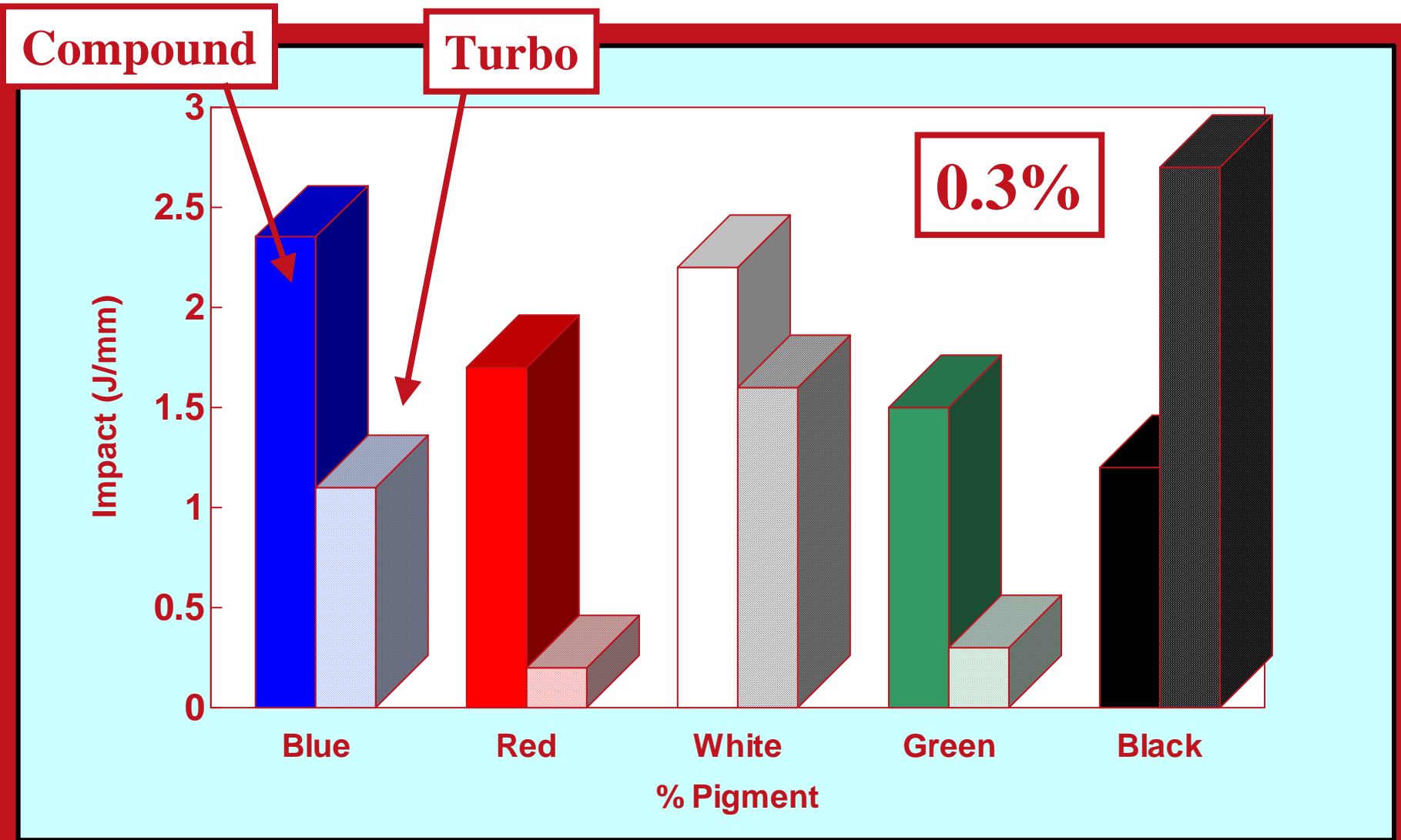


**Dry Blended**

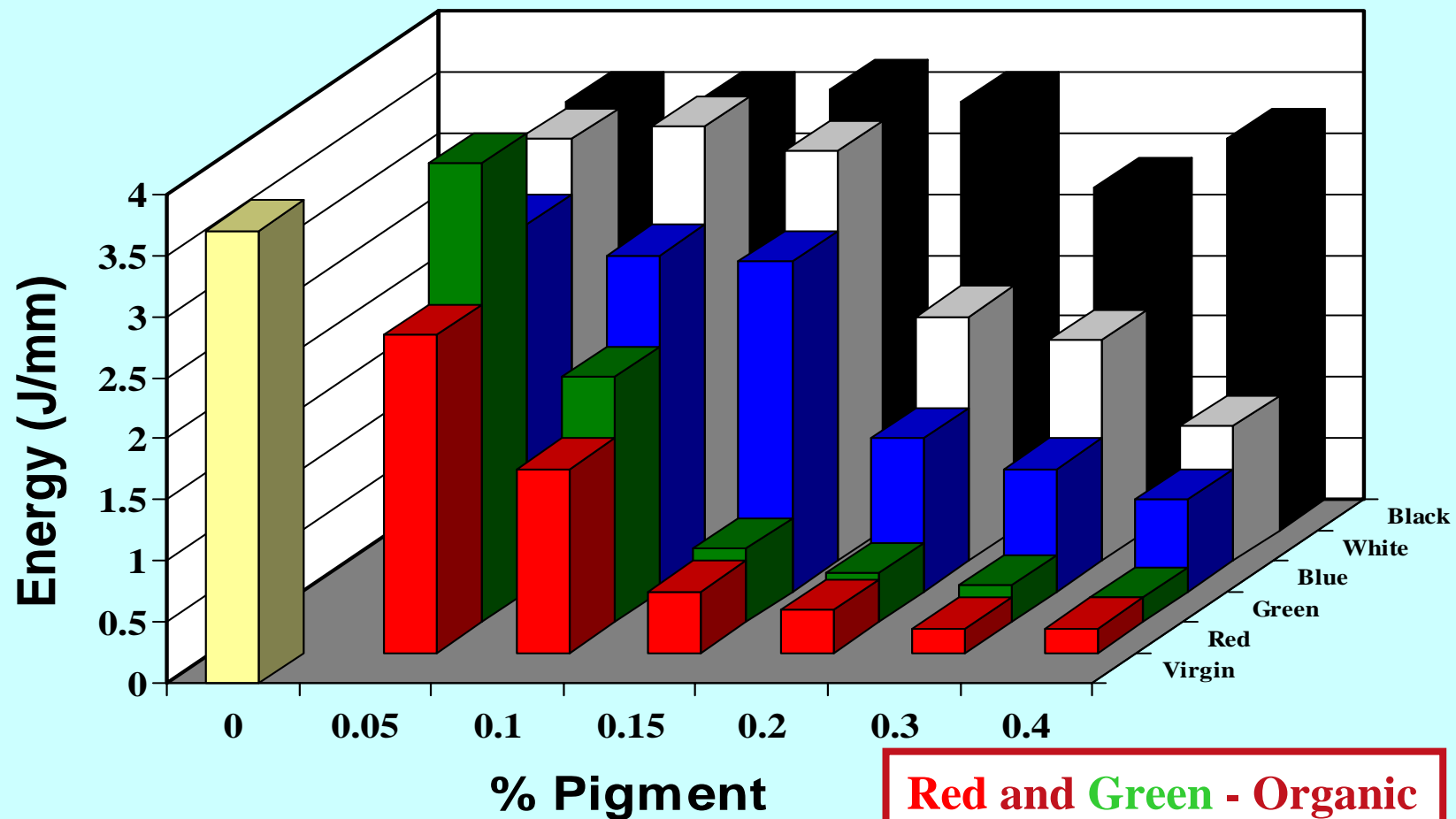


**Liquid Colour**

# Comparison of Compounding and Turbo-blending



# Effect of Pigment Concentration on Impact Strength (Dry Blending)



**Red and Green - Organic**  
**Others - Inorganic**

# Summary

- **The effects of pigmentation are generally detrimental**
- **Compounding is better than dry mixing**
- **The pigment can alter the structure of the moulded part and so affects shrinkage and warpage**
- **The effects of pigments is different in different colours**

# Rotomoulding Seminar

## Quality / Colour / Appearance Finishing

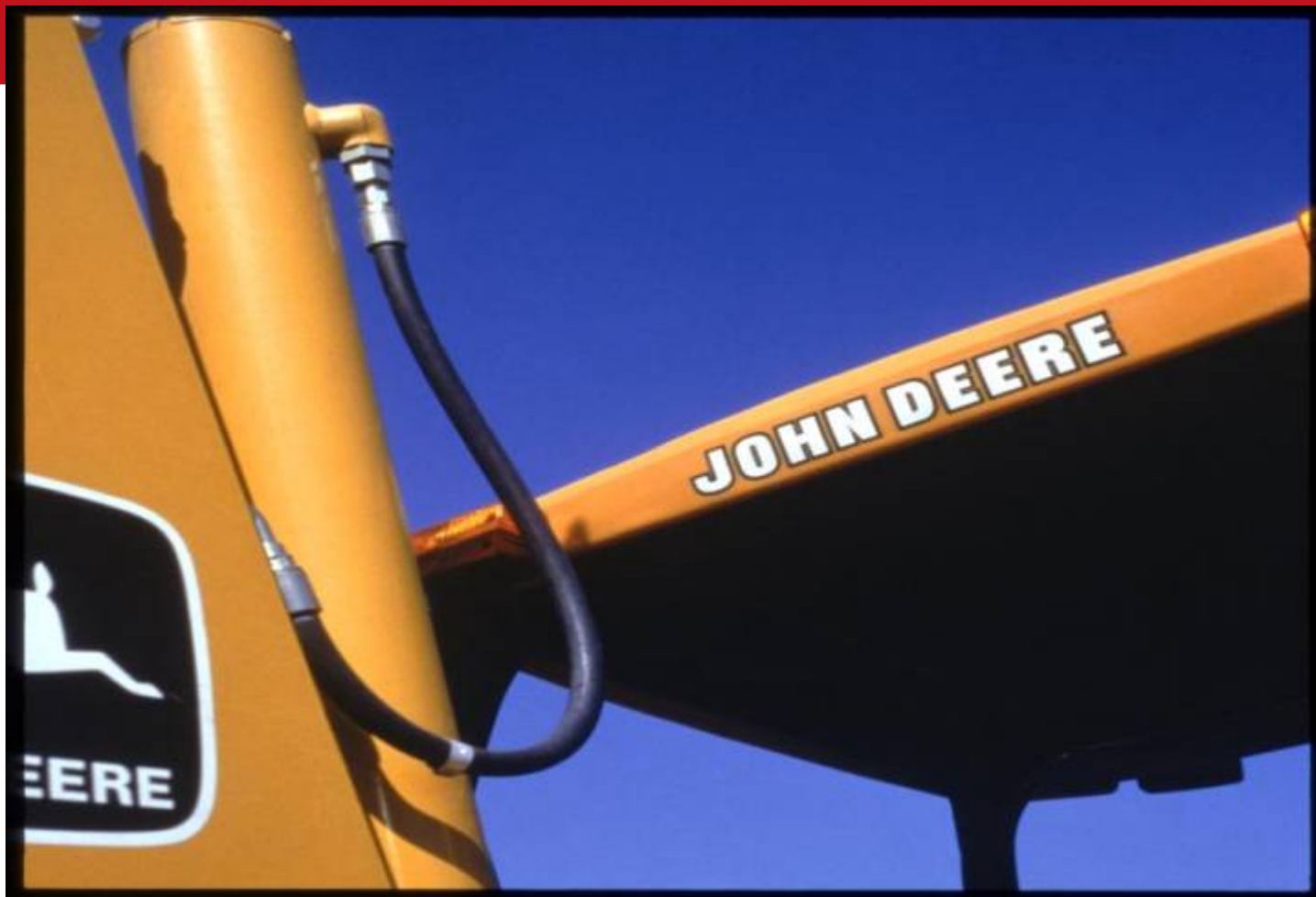
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# Graphics

# Mold-In Graphics



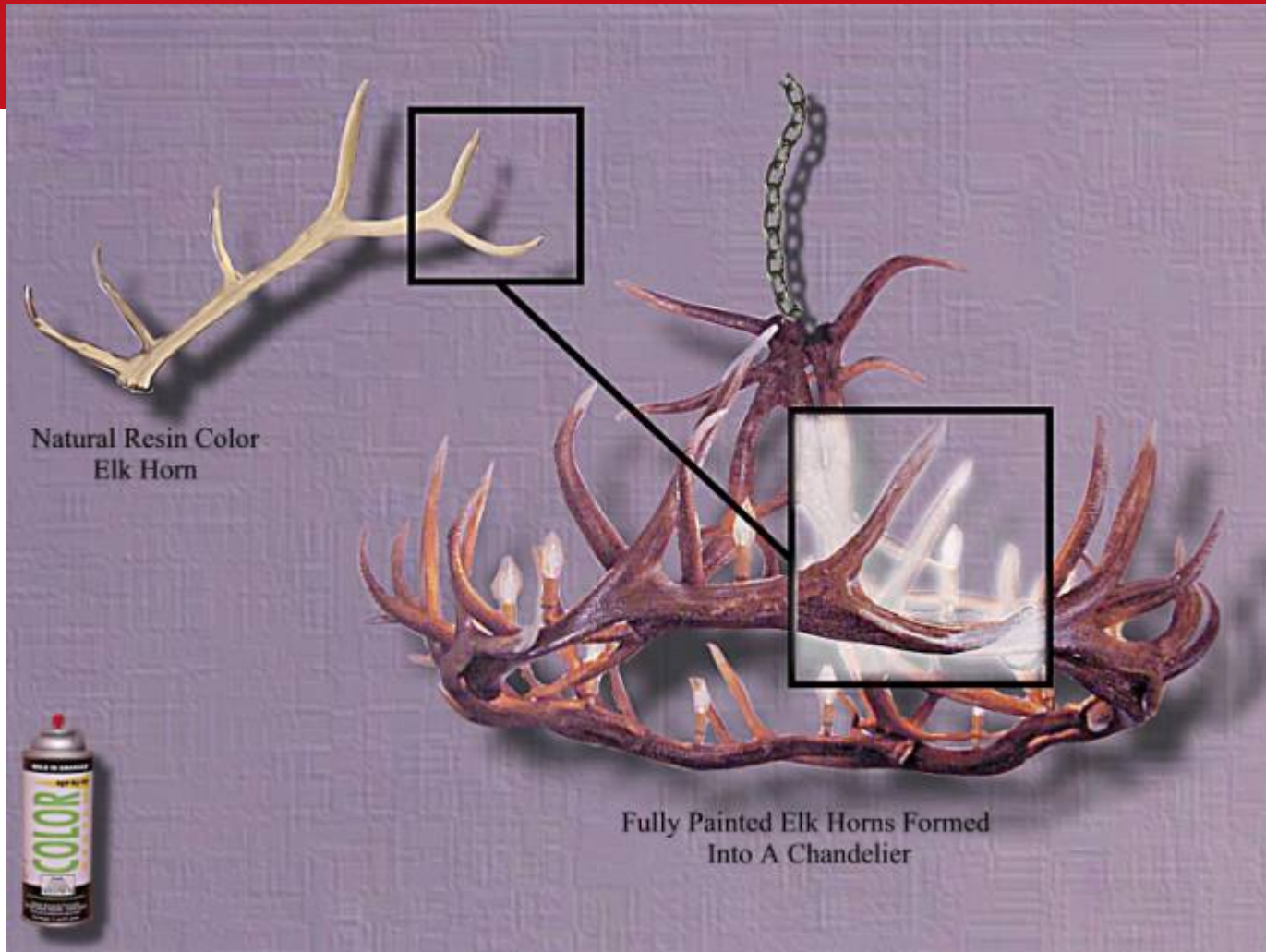
# Mold-In Graphics



# Mold-In Graphics



# Spray On Graphics



# Mold-In Graphics



# Spray Adhesive onto the mold



# Burnish the graphic onto mold



# Add resin



# Rotomoulded part



# Mold-In Graphics



# Mold-In Graphics



# Mold-In Graphics



# Mold-In Graphics



# Mold-In Graphics



# Mold-In Graphics



# Spray On Graphics



# Spray On Graphics



# Spray On Graphics



# Spray On Graphics



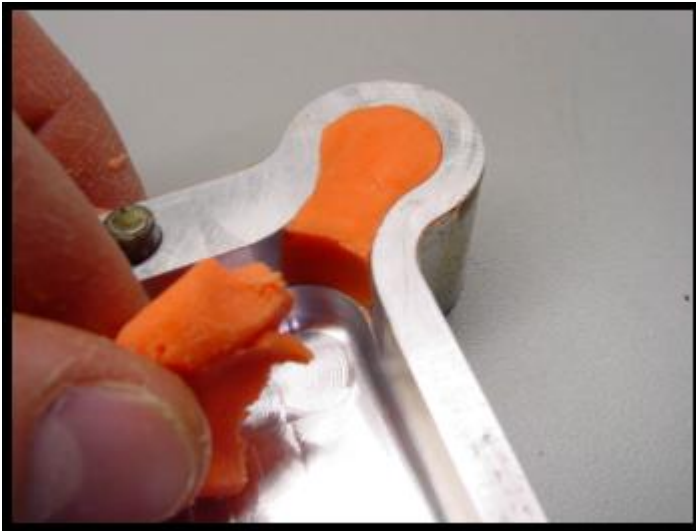
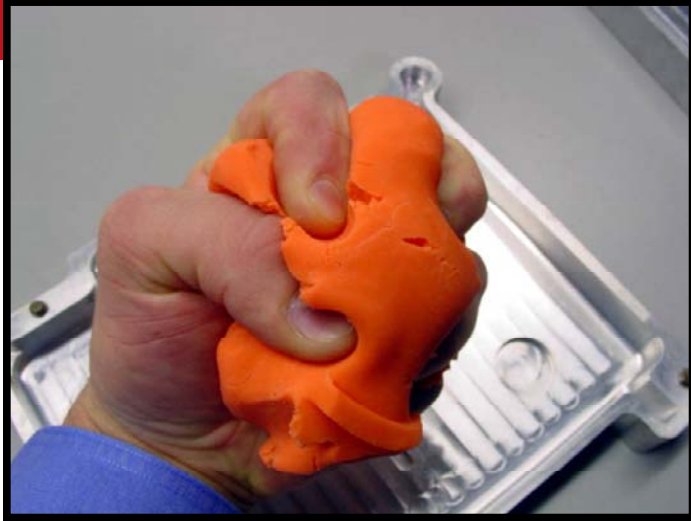
# Spray On Graphics



# Spray On Graphics



# RMC<sup>3</sup>



RMC<sup>3</sup>

