Lecture 5.6: **Compression molding**

Compression molding is a well known technique to develop variety of composite products. It is a closed molding process with high pressure application. In this method, as shown in figure 1, two matched metal molds are used to fabricate composite product. In compression molder, base plate is stationary while upper plate is movable. Reinforcement and matrix are placed in the metallic mold and the whole assembly is kept in between the compression molder. Heat and pressure is applied as per the requirement of composite for a definite period of time. The material placed in between the molding plates flows due to application of pressure and heat and acquires the shape of the mold cavity with high dimensional accuracy which depends upon mold design. Curing of the composite may carried out either at room temperature or at some elevated temperature. After curing, mold is opened and composite product is removed for further processing. In principle, a compression molding machine is a kind of press which is oriented vertically with two molding halves (top and bottom halves). Generally, hydraulic mechanism is used for pressure application in compression molding. The controlling parameters in compression molding method to develop superior and desired properties of the composite are shown in figure 2. All the three dimensions of the model (pressure, temperature and time of application) are critical and have to be optimized effectively to achieve tailored composite product as every dimension of the model is equally important to other one. If applied pressure is not sufficient, it will lead to poor interfacial adhesion of fiber and matrix. If pressure is too high, it may cause fiber breakage, expulsion of enough resin from the composite system. If temperature is too high, properties of fibers and matrix may get changed. If temperature is low than desired, fibers may not get properly wetted due to high viscosity of polymers especially for thermoplastics. If time of application of these factors (pressure and temperature) is not sufficient (high or low), it may cause any of defects associated with insufficient pressure or temperature. The other manufacturing factors such as mold wall heating, closing rate of two matched plates of the plates and de-molding time also affect the production process. Generally, the raw materials used to fabricate composites through compression molding process are given in table 1.
Figure 1 compression molding method
**Application:**

1. Method is equally applicable for both thermosetting and thermoplastic polymer based composites.
2. A very wide application spectrum ranging from kitchen goods to automobiles, toys, electrical items and aeroplane parts.
3. Typical products include automobile panels, roof, life gates, battery trays, fenders, hoods, bumpers, spoilers, air deflectors furniture kitchen bowls and trays, dinnerware, buttons, large containers, recreational vehicle body panels, medical equipments (ultrasound equipments).

<table>
<thead>
<tr>
<th>Materials used</th>
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<tr>
<td><strong>Matrix</strong></td>
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<tr>
<td>Thermosetting: Epoxy, polyester, polyvinyl ester, phenolic resin, Unsaturated polyester, polyurethane resin, Urea formaldehyde. Thermoplastic: polypropylene (PP), polyethylene (PE), nylon, polycarbonate (PC), polyvinyl chloride (PVC), cellulose acetate, polyether-ether ketone (PEEK), Acrylonitrile-butadiene-styrene (ABS), polystyrene (PS) biodegradable polymers such as poly lactic acid (PLA), poly vinyl alcohol (PVA), soy based plastic, starch based polymers etc.</td>
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<tr>
<td><strong>Reinforcement</strong></td>
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<td>Glass fiber, carbon fiber, aramid fiber, natural plant fibers (sisal, banana, nettle, hemp, flax etc.) (all these fibers may be in the form of unidirectional mat, bidirectional (woven) mat, stitched into a fabric form, mat of randomly oriented fibers, short fibers, chopped fibers)</td>
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**Advantages of the Compression Molding Process**

1. Production rate is high as the mold cycle time is in few minutes.
2. Good surface finish with different texture and styling can be achieved.
3. High part uniformity is achieved with compression molding process.
4. Good flexibility in part design is possible.
5. Extra features like inserts, bosses and attachment can be molded in during the processing.
6. Raw material wastage is minimum.
7. Maintenance cost is low.
8. Residual stresses are absent or negligible in the molded component.
9. Twisting and shrinkage in product is reduced therefore dimensional accuracy is good.

**Disadvantages of compression molding process**

1. Due to expensive machinery and parts, the initial capital investment associated with compression molding is high.
2. The process is suitable for high production volume. It is not economical for making a small number of parts or for prototyping applications.
3. It is a labour intensive process.
4. Sometimes secondary processing (trimming, machining) of product is required after compression molding.
5. Sometimes uneven parting lines are there.
6. There is limitation on mold depth.