



Chapter 4: Curing Treatment and Bonding of Foam Molds

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Drying and Stabilization of Foam Patterns

Due to the contact with steam and water during the forming and processing of foam patterns, freshly produced patterns contain a relatively high moisture content.

The factors affecting moisture content are numerous, with the primary ones being the foaming and forming methods, steam pressure during heating, steam duration, and the cooling method and time. Under normal conditions, the moisture content of a pattern immediately after demolding ranges from 5% to 15%.

To ensure the quality of the lost foam casting, the foam pattern or segments must be thoroughly dried before assembly and coating, reducing the moisture content to below 1%. Additionally, any residual blowing agents trapped inside the foam cells must diffuse and escape during the drying process.

As the pattern dries and is stored, the content of moisture and blowing agents decreases, leading to dimensional changes. For EPS patterns, there is typically an expansion of 0.2%–0.4% within the first hour after demolding, followed by a shrinkage of 0.4%–0.6% within 48 hours (relative to the mold cavity size).

After 15–20 days of storage, shrinkage can reach up to 0.8%. The residual blowing agent and moisture content in the foam, the molding process, and the structural design of the pattern all influence the shrinkage rate.

This aspect requires ongoing study and data accumulation during production to meet the dimensional accuracy requirements of castings.



Deformation Prevention Treatment of Foam Patterns

When a foam pattern is first removed from the mold, it has high moisture content and elevated temperature, making it the softest and most susceptible to deformation. Therefore, during the subsequent drying process, two aspects must be considered:

1. Primary Deformation: For foam pattern products with structures that are prone to deformation, it is essential to prepare dedicated cooling racks and carefully determine their placement orientation.





Deformation Prevention Treatment of Foam Patterns

2. Secondary Deformation: During the drying process, it is necessary to use appropriate jigs and fixtures to prevent and correct existing or potential deformation in foam patterns. Otherwise, the defect rate of foam patterns will be high, and subsequent assembly and bonding will require greater pressure and result in lower efficiency.





4.2 Segmentation of Foam Patterns

4.2 Segmentation of Foam Patterns

For complex foam patterns that cannot be molded as a whole within a single mold, segmentation is required. Each segment is molded separately using its own mold. The segmented foam patterns are then assembled into a complete pattern through bonding. This process route fully demonstrates the flexibility of the lost foam casting technique.

Simple Segmentation

Simple segmentation refers to dividing the foam pattern along flat parting surfaces. After each segment is molded, they can be manually bonded to form a complete pattern.

The lost foam casting process allows for the segmentation and subsequent bonding of foam patterns, which simplifies the production of complex castings. For example, the foam pattern of a four-cylinder cylinder head (cast iron) is composed of four segments. When assembled, these segments form a complex internal cavity. By segmenting and then bonding, even foam patterns with intricate external shapes can be produced. However, the more complex the casting, the more segments the foam pattern requires. This also means a greater number of molds are needed, and the bonding process becomes more intricate.



4.3 Bonding Design and Assembly of Foam Mold Segments

For some complex casting products, in order to facilitate the forming operation of the foam pattern, molds are generally designed with segmentation. Before bonding the gating system, two or more foam segments must be fixed together using either hot melt adhesive or cold adhesive.

Foam pattern adhesives fall into two main categories: hot melt adhesives and cold adhesives. The bonding methods include manual bonding and mechanical bonding. Manual bonding is suitable for simpler foam patterns in small to medium production batches. For complex patterns in mass production, bonding molds are used to ensure bonding precision, and automatic bonding machines are employed to improve production efficiency.

At present, domestic enterprises mainly use the following bonding methods:

Manual adhesive application and bonding

Glue application using an adhesive coater, followed by bonding

Automatic bonding using hot melt adhesive machines



4.3.1 Three Methods of Assembling Foam Pattern Segments by Bonding

1. Manual Glue Application and Bonding:

In this method, cold adhesive is manually applied to the parting surfaces of the foam pattern segments. After waiting a few minutes for the adhesive to become tacky, the segments are manually assembled.

For larger or more complex parts, simple jigs or fixtures may be used to assist in alignment. This method is relatively straightforward and cost-effective, requiring minimal investment. However, the process heavily depends on the operator's experience and skill, making it difficult to standardize.

Due to varying levels of workmanship, the glue seams often need to be sealed with patching compound or adhesive tape to prevent coating penetration, which could lead to slag inclusions in the final casting.





4.3.1 Three Methods of Assembling Foam Pattern Segments by Bonding

1. Manual Glue Application and Bonding: Sealing with Tape or Newspaper



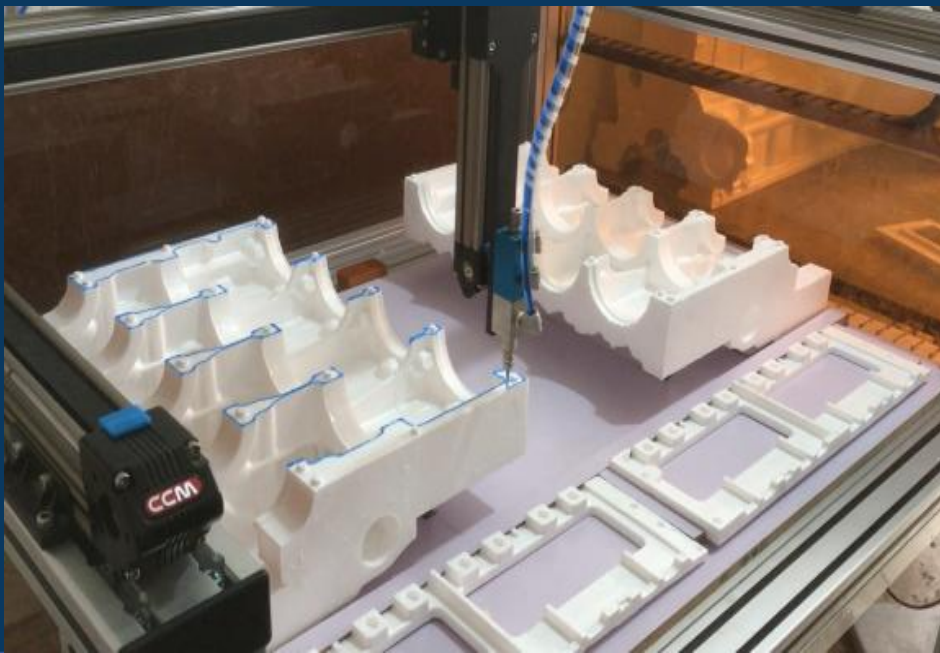


4.3.1 Three Methods of Assembling Foam Pattern Segments by Bonding

2. Glue Application Using Coating Machines:

In some of the enterprises we visited, the use of automatic glue application machines is quite widespread. Originally, these machines were primarily used in the leather and footwear industries but were later adapted by equipment manufacturers for applying glue to foam pattern parts. After further design improvements by specialized institutions, these machines became more efficient and versatile.

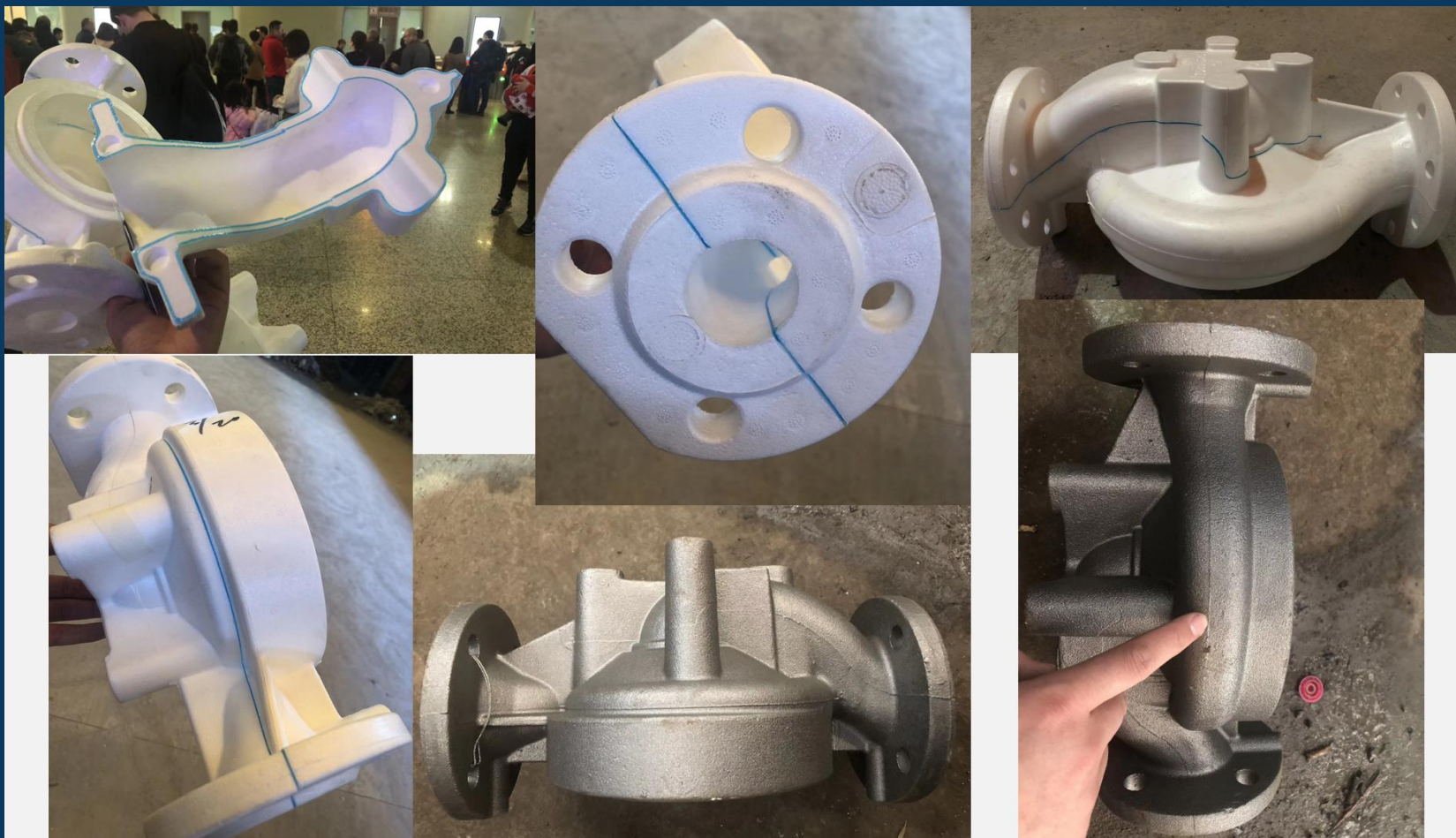
With the successful development of specialized adhesives, automatic coating lines now offer uniform adhesive application, high efficiency, and the added benefit that the glue seam does not require additional processing after the mold is assembled. This method simplifies the operation process, improves labor efficiency, and facilitates the standardization of operations, making it a popular choice among numerous production enterprises.





4.3.1 Three Methods of Assembling Foam Pattern Segments by Bonding

2. Glue Application Using Coating Machines (No Need for Tape, Paper, or Repair Paste):





4.3.1 Three Methods of Assembling Foam Pattern Segments by Bonding

3. Hot Glue Automatic Bonding Machine:

In some of the enterprises we visited, a few used automatic bonding machines, particularly for high-efficiency operations. For example, a domestic manufacturer producing engine cylinder heads uses specialized hot glue as the adhesive. This operation process is highly efficient, and the mold assembly cools quickly, without the need for special treatment of the glue seam. However, the process requires the creation of specialized jigs (similar to mold designs), which can be costly. Additionally, disassembling the jigs can be cumbersome, making this method more suitable for large-scale production of a single product type.

The three methods outlined above are currently the most commonly used foam pattern bonding techniques in domestic enterprises. Depending on the product structure, quantity, and on-site conditions, manufacturers can reasonably choose the most suitable method for their production needs.



4.3.1 Three Methods of Assembling Foam Pattern Segments by Bonding

Third, Hot Glue Automatic Bonding Machine:



a Hot Glue Automatic Bonding Machine:



b. Hot Glue Automatic Coating Machine



4.3.2 Considerations During Model Piece Adhesive Bonding and Assembly

In actual production, companies select the appropriate adhesive bonding method based on their existing hardware facilities and product structure. The following issues should be paid attention to during the operation:

Correction for Thin-Walled Parts and Deformation-Prone Models:

For thin-walled parts and foam models that are prone to deformation during subsequent operations, correction should be performed before mold closure. This can be done using fixtures, wooden strips, or fiber rods to prevent deformation. Fixtures can be made from materials such as aluminum alloys or insulation boards to ensure precision.

Checking the Integrity of Bonded Pieces:

After bonding the model pieces, the integrity of the foam model should be checked. Non-conforming products should not proceed to the subsequent production processes. Many companies use paper tape or repair paste to fix any issues. The automatic glue applicator ensures uniform glue seams, which offers significant advantages in terms of bonding consistency.



4.3.2 Considerations During Model Piece Adhesive Bonding and Assembly

③ Proper Placement of Bonded Foam Models:

The bonded foam models should be placed on dedicated drying racks, not randomly stacked (in many of the companies we visited, most were placed on the floor, and dedicated personnel were assigned to inspect and repair them before coating). This is to prevent deformation and damage during transportation.

④ Adhesive Used for Bonding Foam Models:

The adhesive used for bonding foam models should be an organic adhesive. During the metal casting process, some physical and chemical changes occur, which can lead to potential quality issues for both the internal and external surfaces of the casting. Therefore, while ensuring the quality of the model piece bonding, it is advisable to use minimal adhesive, reducing the gas emission from the entire model, and consequently lowering the likelihood of casting defects. (In some of the companies we visited, the glue seams were specially re-applied with a hot melt glue gun, particularly at the junctions of the pouring system, which can be quite hazardous.)



4.4 Hot Bonding Molds

1. Mechanical Hot Melt Adhesive Bonding Process:

Hot melt adhesive has the advantages of fast bonding speed and high initial bonding strength. However, it has a relatively narrow temperature range. It requires a contour adhesive coating plate to apply the hot melt adhesive onto the bonding surface of the foam mold pieces. The mold pieces are then bonded using an upper and lower mold to achieve quick and precise bonding, ensuring the quality of the bond. The hot bonding mold mainly consists of the upper and lower molds, as well as the adhesive coating plate.

The working steps of the hot bonding machine are as follows:

1. Placing Foam Mold Pieces: The two foam mold pieces (Piece 1 and Piece 2) to be bonded are placed separately in the upper mold (Mold 3) and lower mold (Mold 5).
2. Adhesive Coating: The upper mold moves to the hot melt adhesive pool. Then, the adhesive coating plate (Plate 8) is raised to apply the hot melt adhesive onto the bonding surface of the upper mold piece.



4.4 Hot Bonding Molds

(3) The adhesive coating plate returns to the melting pool, and the upper mold moves back to its original position.

(4) The lower mold is lifted, and the upper and lower molds are aligned to complete the bonding process.

(5) The lower mold returns to its original position, and the bonded foam mold is manually removed.



4.4 Hot Bonding Molds

Design Key Points of the Adhesive Coating Plate:

The key design point of the adhesive coating plate is to ensure that the adhesive seals the bonding seam without allowing the adhesive to protrude excessively (the protrusion height of the adhesive should be controlled between 0.5 to 1.5mm). The adhesive surface on the coating plate should be designed with a raised structure, with the height of the raised portion being 5 to 10mm. The shape of the raised portion should match the bonding surface of the foam mold. When the coating plate rises from the melting pool, a layer of hot melt adhesive is applied to the raised portion, and excess adhesive flows back into the melting pool through the large and small holes on the coating plate.

Drawbacks of Hot Adhesive Bonding Process:

1. It is not suitable for bonding on surfaces with large undulations or curved lines. This is because the hot melt adhesive tends to flow on the sloped surfaces of the coating plate, which can affect the bonding strength of the corresponding parts.
2. The hot adhesive bonding machine consumes a large amount of electricity and emits smoke, which can impact the environment.



4.4 Hot Bonding Molds

The design concept for the single and double raised portions of the hot melt adhesive coating plate is the same. The adhesive application pattern is determined based on the width and narrowness of the bonding surface, which decides whether to use a single line or a double line for coating.

The structure of the cold adhesive bonding mold is very similar to that of the hot adhesive bonding mold. The upper mold still includes vacuum suction nozzles and compressed air pipelines. The difference is that 50-60° C warm air is introduced into the lower mold to accelerate the evaporation of organic solvents in the cold adhesive, improving bonding strength and efficiency. Therefore, the upper and lower molds for cold adhesive bonding have a double-layer structure (inner mold with an outer sealing frame).

Compared to the hot adhesive bonding machine, the cold adhesive bonding machine has the disadvantage of requiring a longer adhesive application time and drying and curing time due to the mechanical hand and heating process. This results in a longer overall bonding process, making the efficiency lower than that of the hot adhesive bonding machine.