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Refinement of resin transfer molding (RTM) method

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Refinement of resin transfer molding (RTM) method

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1. INTRODUCTION

FRP products include residential materials (bathroom units, sewage purification tanks, water tanks, etc.), ships, cars, construction materials, vessels and industrial machinery and because of its variety, many products must use the hand lay-up and spray lay-up methods which are labor intensive [1].

However, these molding methods involve essentially an open molding method and environmental problems such as sputtering of resin and glass fibers and styrene emission, and other problems such as the shortage of trained workers, low productivity due to manual labor and difficulty in handling the increase in demand have yet to be resolved [2].

In order to produce large-sized molding products in small to medium quantity of production, the RTM method has been selected as one of the development projects by the Small Business Development Agency in 1976 to satisfy the requirement of (1) Smaller capital investment; (2) Better working environments; (3) Higher production efficiency. As its development results were publicized, general interests in this molding method from the community of small business manufacturing companies rose [3].

Since the introduction of the RTM molding method in 1980 by our company and the beginning of half unit production, many improvements have been introduced on the production line solidus production mold in order to resolve various problems such as manufacturing and needs for various products. This report addresses those problems.

2. WHAT IS RTM (RESIN TRANSFER MOLDING)?

In the RTM method, a female–male matched FRP mold (often an electroforming or metal mold) is used and reinforcing materials (mainly preform with glass fibers and insertions) are placed in the gap of the matched mold. After clamping, the matrix

(normally unsaturated polyester resin is used but phenol resin and epoxy resin are also acceptable) is poured under relatively low pressure (10 kg/cm^2) to be cured with the reinforcing materials and thereafter the mold is opened to pull out the molded product [4].

3. CHANGES OF RTM METHOD

Table 1 shows the variation of RTM molding methods according to their differences in production mold design, molding temperatures and production lines. Figure 1 shows required time of lower mold cycles of each method (from gel coat application to product demolding and mold release processing).

In the early 1980s, the RTM method generally referred to the RTM–I method. The required time of one cycle of the lower mold by this molding method is 120 min. Because of this, the number of monthly productions for one set of production mold (combination of one upper mold and two lower molds) was 120 units at maximum and three and four sets were needed for monthly production of 300 or 500 units, respectively, which required a large space for production lines.

The RTM–II method was introduced to resolve this problem. The characteristics of this molding method are to use an electroforming mold with thermostats for both upper and lower molds as the production mold. Because of this, no gel coat curing

Table 1.
Variation of RTM method

	RTM–0	RTM–I	RTM–$_{JR}$II	RTM–II
Production mold	FRP (Polyester)	FRP (Epoxy)	Upper: FRP (Epoxy) with thermostats Lower: FRP (Epoxy)	Electroforming with thermostats
Mold clamping	Vacuum assisted bolting	Machine press and bolting	Automatic clamp	Automatic clamp
Molding temperature	Room temperature	Room temperature	Upper: 60°C Lower: room temperature	Over 60°C
Production line	Merry-go-round system	Merry-go-round system	Upper: fixing Lower: merry-go-round system	Upper: fixing Lower: shuttle system
Cycle time of a lower mold (min)	190–210	110–130	70–90	30–50
The best quantity for one set mold per month	30–60	60–120	120–240	240–480

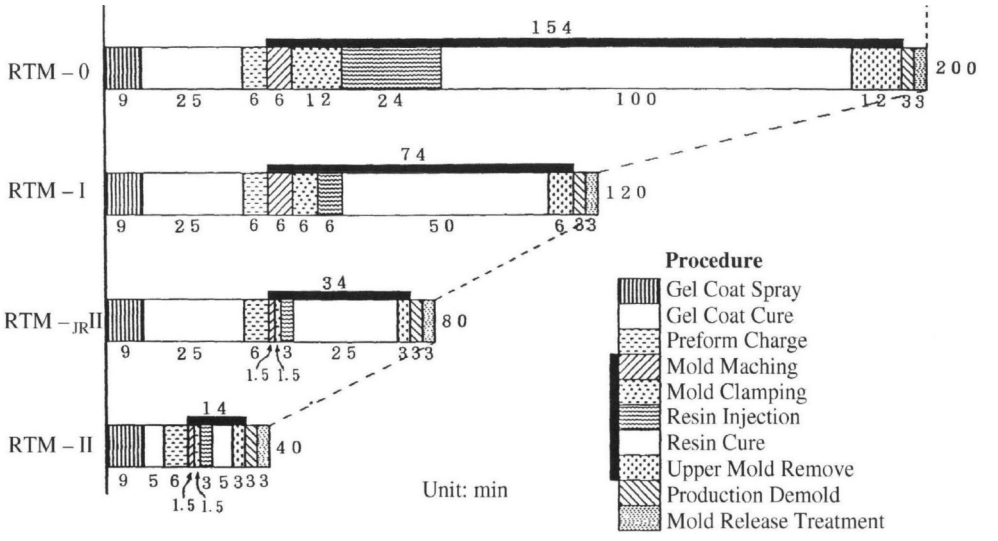

Figure 1. Cycle pattern of lower mold.

ovens are needed. The required time for lower cycles is also shortened to 40 min which made a maximum of 480 units as monthly production for one set of production mold, which is suitable for medium scale production.

However, with the versatility of market needs, the monthly order of each product became a maximum of 250 along with rapid model-changes and the RTM–$_{JR}$II method was developed as an intermediate molding method between the methods I and II in 1988 when the capital investment amount for the electroforming mold of method II became a problem. The characteristics of this method are to use the epoxy FRP mold of the method as a production mold while the automatic clamp of the method II is adopted as mold fastening. For this reason, the investment amount for molds was as low as the method I, the required time for one cycle of a lower mold was 80 min and a maximum of 240 units was made possible for monthly production for one set of production mold, thus, achieving twice the production capability of method I. Thus, the RTM–$_{JR}$II method became a major operation.

Recently, transition from the hand lay-up molding method to the RTM method began for those products with a maximum monthly order of 40. In 1992, the RTM–0 method was developed in which the production mold was similar to that in the hand lay-up method for both the upper and lower molds and the mold fastening method was changed to vacuum from press. In this molding method, the required time for one cycle of lower mold is as long as 200 min and for this reason the monthly production number for one set of production mold is 60 units at maximum but cost reduction of product molds and shorter delivery were made possible, thus making this method the most suitable for products in small lots.

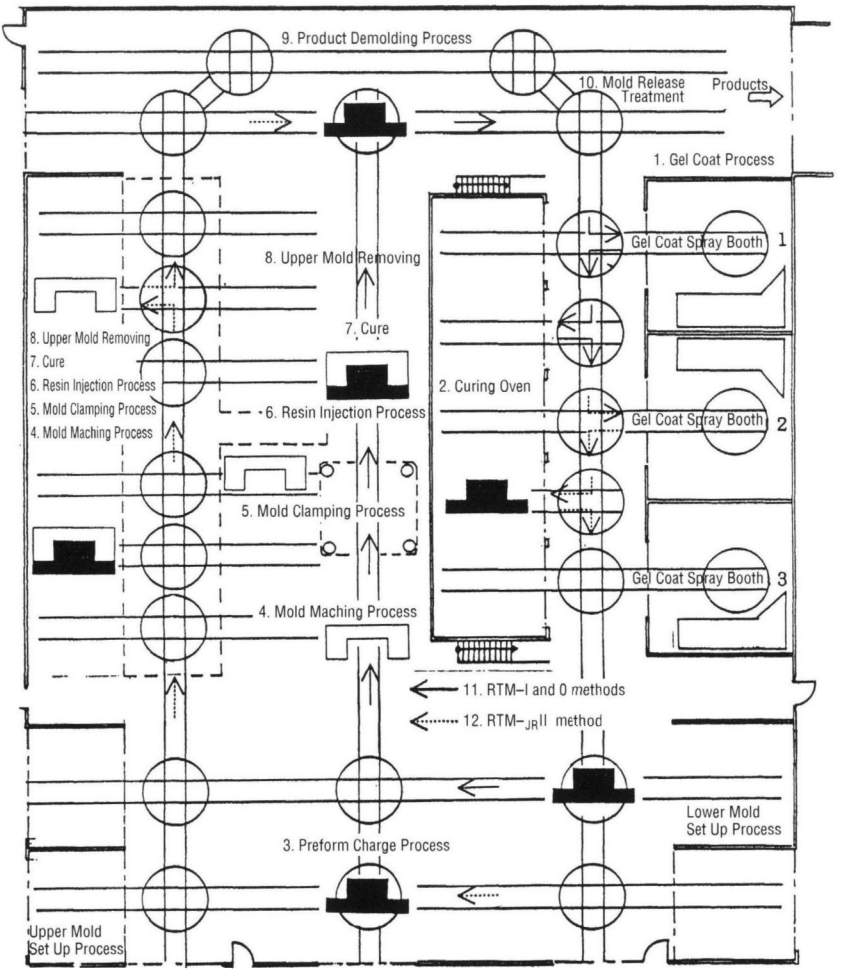

Figure 2. Molding line of RTM factory. 1. Gel Coat Process; 2. Curing Oven; 3. Preform Charge Process; 4. Mold Maching Process; 5. Mold Clamping Process; 6. Resin Injection Process; 7. Cure; 8. Upper Mold Removing; 9. Product Demolding Process; 10. Mold Release Treatment; 11. RTM–1 and 0 methods; 12. RTM–$_{JR}$II method.

4. FACTORY LAYOUT

Figure 2 shows the molding line of our RTM factory which was completed in 1994. For the flow of the process, the RTM 1 and 0 methods are shown by the solid lines (—>) and the RTM–$_{JR}$II method is shown by the dotted lines (· · · >).

5. SUMMARY AND FUTURE ISSUES

Since the introduction of the RTM method (RTM-I method) in 1980, it has been developed into II, $_{JR}$II and 0 methods to respond to market needs.

As a result, a multi-type mass production system in which an RTM method suitable from a small lot of monthly production of 30 to a medium lot of monthly production of 480 can be placed in the same line.

As the market needs are expected to be further specialized in the future, this RTM molding methods needs further improvement and not only a single RTM molding method but also combination with other FRP molding methods need to be examined.

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