Study on the production of the flange by the centrifugal forming method (Part 1)
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Abstract: The connection flange of the FRP pipe, from the three-dimensional structure, cannot be a product formed without using the second processing method of molding a tube fabricated by arranging a unidirectional reinforcing fiber. This study reports the findings of a centrifugal forming method made possible 1 pc production in 10 minutes to 2 hours and not require secondary processing the ASA150 flange up to 3.5m from the minimum 50 mm.

Keywords: FRP flange, forming method, ASA150 flange, short time molding, centrifugal molding

1. Introduction

Flange axis-symmetric inner surfaces in three-dimensional structures are the structures that can be centrifugal casting, it can be formed without seals. Figure 1 is a centrifugal molding machine and its products of small front open type.

Figure 1. Small flange and molding machine

It characterized that drilling such as a screw part is compensated by molding, the bubbles are able to be defoamed by centrifugal casting, and after introducing reinforcing materials such as glass fibers in the direction required by dry method, resin is able to be centrifugal casted, the ideal reinforced laminate and resin laminate are formed, by using a heating mold, resin is cured and mold-released with high-speed.

Figure 2. Large flange and molding machine

Figure 2 is a large-sized molding machine. Since generally settled horizontally, molding machine of a maximum diameter of 3.5 m is able to be operated by just one working person. On the top crane for such type of handling is incidental. Mold temperature is generally 90 °C, if needed to use epoxy resin, 150 °C is possible. Generally 100G, at least 40G of centrifugal force is required for molding.

2. The basic structure of the developed centrifugal molding machine

Figure 3 shows a typical basic structure of centrifugal molding machine for flanges developed by NBL. The rotating shaft in a cantilever, a frame type with a flange bolt type is fixed by a chuck similarly product extrusion piston interior of the rotation type of lathe, it covers the lightweight molding opposite the uneven surface of the plane of the flange to the open surface, material is introduced from the center hole, and then dry-pressed reinforcing fibers by the inner surface pressing ruler, hardened by resin charged impregnated defoaming, then removed the light weight cover type to extract the product. The feature of this method is that it is easy to input of reinforcement material in the dry molding and it is possible to remove bubble completely from product during curing of the resin. Figure 4 shows each of molding machine flange frame type with a screw that forms basic of handling, lightweight type molding for FRP that of easy-handling and its assembled state, and in-mold lamination state of the rotation step of the state was charged with chopped strand reinforcing fibers in the molding, respectively.

Molding material shown at here is only an example, an example of a wide low-volume production type, although in the FRP-type are inserted in the electric heater, the heating
maximum temperature is lower than 90 ℃. In the case of mass production molding, aluminum material is suitable for molding material and the production of the heating furnace is recommended. Since addition of fully automatic molding equipment is also possible, when defining the basic specifications of the equipment, chosen to suit the purpose is desired.

Incidentally, the reinforcing fiber chosen may be formed all at the same reinforcing fibers, in the case of casting, it is necessary to cast the reinforcing fibers (CS) first to outer circumferential surface of the flange pin molding, shown in Figure 3. As shown in Figure 3, it is also necessary to cast laminated CS at a low speed of 1G ~ 2G (multiples of gravitational acceleration) in a state of putting the press rolls.

3. Necessary function of the molding machine

Figure 5 illustrates a press roll in the entire inner flange rotation after the lamination of the flange pin portion is completed. While putting all the necessary strengthening material, pressing, function of rolling compaction filling fibers with about 70wt%, and to uniform inner surface.

Centrifugal casting speed is usually, with a filling speed of about 1kg / minute. In addition, CS laminated inner surface is in the rotation stop state and compaction fiber does not collapse. The maximum centrifugal force of the press roll is about 100G. Before introduction of resin eliminates the press roll, turning on the cured resin under centrifugal force of about 100G. Standard condition is as follows; impregnation degassing time is about a few minutes and the average curing time is for more than 20 minutes.

On the other hand, in the case of lamination of other materials, to push the glass fibers in the laminate which had been previously laminated molded into the mold before the mold mounting of using a continuous fiber, and set in a rotary machine, further if necessary, add the CS to the inner surface laminated, and then after adding a press roll, molded by curing resin.

Furthermore, when using compound material and resin (SMC · BMC and mortar materials), changed to the proper chip and charged into a rotary mold, to close the mold, and compaction and the vacuum degassing by a press roll, enable to perform compound by centrifugal molding.

As a special case, the surface is covered with CS mat and roving cross, the center is in the dry mortar after press roll forming of the inner surface CS layer, in the case of forming
sandwich structure of FRPM molding by the introduction of curing resin (such as the structure of low pressure large flange is optimal), mixing of mortar about 80 wt%, resin 15 wt%, and reinforcing fibers 5 wt%, product with the same level of strength of the BMC can be obtained with high-speed molding.

Figure 5 shows after the completed state of lamination of the flange pin portion and diagram illustrating a press roll in the entire inner flange rotation. While put all the necessary weighing strengthening material, pressing, function of compaction filling of reinforcing fibers solicitation rate with about 70 wt%, and the inner surface homogenization are needed.

![Figure 5. Compaction of chopped strand glass](image1)

Centrifugal casting speed is usually, with a filling speed of about 1 kg / minute. In addition, CS laminated inner surface after compaction in the rotation stop state, of the rolling depressurized not collapse of compaction fiber is The maximum centrifugal force of the press roll is about 100 G. Before introduction of resin eliminates the press roll, turning on the cured resin under centrifugal force of about 100 G. Impregnation degassing time the average curing time is about a few minutes is the standard for more than 20 minutes.

On the other hand, in the case of lamination of other materials, to push the glass fibers in the laminate which had been previously laminated molded into the mold before the mold mounting of using a continuous fiber, was set in a rotary machine, further the CS if necessary the inner surface laminated is, after it, such as adding a press roll, and molded by introduction cure similarly resin.

Furthermore, when using compound material and resin (SMC - BMC and mortar materials) are charged into a rotary mold in the proper chip, the compaction and the vacuum degassing by a press roll to close the mold, of the compound it is possible to perform the centrifugal molding. The surface as a special case is covered with CS mat and roving cross, the center in the dry mortar, after press roll forming of the inner surface CS layer, to FRPM molding (such as the structure low pressure large flange of the sandwich structure to be introduced curing the resin is optimal In the case of), mortar about 80% wt, resin 15% wt, the strength of the BMC par can be obtained at the mixing of the reinforcing fibers 5% wt, I can high-speed molding.

![Figure 6. Take-out mold](image2)

Figure 6 illustrates the demolding function for performing secondary processing after centrifugal molding. Lightweight type is removable by opening the mounting screws. It is retracted the hydraulic piston type of mold center, de-mold the mold by extrusion jig.

This demolding purpose is of the inner surface machining.
such as the required finishing products. Figure 7 illustrates the grinding process for bonding the tube end face of the flange inner surface. Processing is rotated at the required grinding speed molding rotary Similarly mold to discharge grinding debris in a vacuum cleaner grinding the FRP material by grinding blades.

Grinding surface, the adhesive bonding the case of an adhesive inner surface-laminated connection grinding the lamination bonding outer surface. Grinding speed a few minutes in the small-diameter, it is about 10 minutes by a large

Figure 8 shows a de type of product. When the finishing is completed, it will be removed from the mold extruding the product by the piston type. The removal from the mold the product is a finished product. Required flange surface accuracy, bolt hole accuracy is guaranteed by the mold, surface grinding

After demolding by performing the reassembly of the mold shown in Figure 9, to repeat the molding process sequence. It should be noted, (including bar code display) identification of Toresabiritei IC chip for the quality control of the product is to tack to the flange outer surface at the time of mold assembly, by interpolating to be incorporated into the resin injection, product check of GPI traceability meets the system requirements.

Figure 8. Coupling flange product demolding

Figure 10 shows a product example of applying. One side has a bolt hole in the flange surface, flange products are joined tube and the inner surface adhesion and outer surface lamination. In application diameter 25 to 3500 mm of ASA150, breakdown voltage 5MPa (up to 10 MPa) to apply.

It should be noted that FIG. 10 shows ribbed flange Similarly the axis target flange spacer (of different diameter flange connection reducer, turn the flange surface spacer angled to the joint), and the like, molding as well spacer kind necessary to the flange member able to do.
4. GPI threaded to the product inner surface

Screw on the connection between the flange and the pipe end face, buttress screw (BTC: square thread) and round screw (RTC: Round head screws), there are other. Both apply the GPI standards to be applied up to 100MPa, it is necessary to permit the lamination conditions of stress dispersion having a corrosion resistant surface by the high-pressure resin injection molding of the threaded portion. 11 shows a screw additional molding method of product. The flange of performing addition processing of the screw by the conditions under which processing surface is ground, the connection coupling part of the flange, a high pressure tube similar materials, it is a condition that is made of laminated structure. In this case, the threaded portion and the screw-type and the flange products attached to the lower heater plate frame and sealed by O-ring shown in figure, for proper screws resin and by high-pressure injection of 10MPa ~ 20MPa, the reinforcing fibers of FRP surface leading to the layer can injection and corrosion-resistant layer formation of resin.

In general, the screw connection of the flange is 600 mm (24 inches) or less, the sealing performance is high RTC8 (8 mountain / inch) is adopted. It becomes possible coupling Similarly coupling with flange with with pin cap tube of GPI standard in these cases.

Removed from the mold after additional processing of the screw, after dismantling the type as shown in Figure. 12, by the lever the product to screw mock open.

Figure 12. taken out from the mold of the screw product

Figure 13 shows the flanges product threaded. It has a GPI coupling similar connection function by means of a screw machining.

The performance of the coupling screws in order to apply the high pressure up to 100MPa, is necessary and sufficient for ASA150 flange of the pressure Max10MPa. However, it requires sufficient attention to the construction criteria of the coupling connection. For more information see Resources.

FIG. 14 is a flange of the laminate junction (Hand-Lay UP) to be applied to ASA150 flange of more than 350 mm. In this case, the bonding outer surface is grinding finish.

L1: flange thickness, L2: flange joint surface length,
D4: flange outside diameter, D3: pipe inner diameter

Figure 14 shows the basic shape of the large flanges used for 5MPa below. Connection is carried out in a secondary molding by the outer surface lamination of the tube. In particular, buried pipe and a large tube of process piping, the material has many FRPM material, such as in this case, such as flange material also adopt similar FRPM material, the low-pressure pipe applications that require attention to be different from the high-pressure pipe.
5. Packing flange connection

Figure 15 shows the structure of the packing used in the flange. Packing flange tube generally there is a rubber ring packing to target the following planar 1MPa following a low-pressure seal form 10MPa called plate-shaped gasket. Here, the packing of the joint surface to target 10MPa or less, adjust the error of the flange surface accuracy at the time of the flange assembly including a centering function.

By using a ring underlying the resin of the rubber rings that ensures the accuracy required for packing to give the sealing performance. Ring material, the extruded product of the thermoplastic nylon resin or PE resin is recommended that the use of welding the ring. Similarly rubber ring also fits well with the adhesive molded ring processed products ③.

Incidentally, if it exceeds 10 MPa requires a combination of the backup ring in addition to the rubber ring also select the material of high surface strength such as a ring member the 13 Cr steel, rubber ring also has a reinforced surface for high pressure it is necessary to change the material, where it will be omitted.

6. Conclusion

In the FRP flange molding method, there are FW molding method where donut-shaped FRP wound around the axis target is made into flange by machining, hand lay-up method where flange shape is layered/ molded by hand, and compression press method into mold.

However, efficiency of these methods are all very low, and the quality is also not satisfactory.

Performance results obtained in this study, when it is applied to a general ASA150 flange molding, are such that flanges with about 2 times or more of endurable pressure can be produced, and production speed is about 10 times of about 30 minutes per 1 pcs.

This achievement as well as patent application procedure, we want to start the international provision of equipment and technology.

It should be noted that the design method is also reported in a separate sheet of paper (Part 2).

References


