Research of Pure UHMWPE Pipe Molding in Barrel Technology and Analysis of Pipe Properties

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ABSTRACT

Ultra High Molecular Weight Polyethylene (UHMW-PE) is a kind of thermoplastic engineering plastic with excellent comprehensive properties which structure behaves linearly. Because of super high molecular weight, it has a series of outstanding properties with which no other types of plastic can compare. The method of molding in barrel is a new technology of pure UHMW-PE pipe continuous extrusion which overcomes the difficulties of pure UHMW-PE pipe molding. This article will introduce the main features of this technology. In accordance with relevant national standards, Pipe specimens are tested for properties analysis to provide valuable reference data for the engineering application of pure UHMWPE pipe. The test specimens are made from M-III UHMW-PE and GUR® UHMW-PE which are produced by Beijing Oriental Oil Co., Ltd. and TICONA.

KEYWORDS

UHMW-PE; Molding in Barrel; Molecular Weight Testing; Analysis of Wear Resistance

THE BASIC PRINCIPLES OF UHMW-PE MOLDING IN BARREL METHOD

The molding characteristics of UHMW-PE raw material. UHMW-PE is a kind of thermoplastic engineering plastic with unique characteristics of molding. This material isn't in a state of viscous flow which the general polymers have but in a state of high-elastic when the temperature is between 136□ and 240□, the melting

temperature (T_m) and the decomposition temperature (T_d). UHMW-PE raw material in the high-elastic state has a strong memory and there is "from the mode expansion" phenomenon in the process of molding which the general polymers have. By means of gas-assisted molding and stereotyping, lowering the temperature smoothly helps to reduce the internal stress of pure UHMW-PE pipe and a certain degree of traction is in favor of stereotyping and molecular orientation. Based on the unique discipline of pure UHMW-PE pipe, the new equipment for UHMW-PE pipe molding has been designed to extrude the pure UHMW-PE pipe continuously and efficiently of which the extrusion speed reaches about 12m/h. This technology is called the method of UHMW-PE molding in barrel.

Schematic drawing of UHMW-PE molding in barrel method. The designs for barrel and screw are the core of pure UHMW-PE pipe molding in barrel method. The barrel is based on section construction as illustrated in Fig.1. Each part is connected with flange. There is a booster liner with spiral grooves in the back end of barrel which is used to generate sufficient pressure on the extrusion.

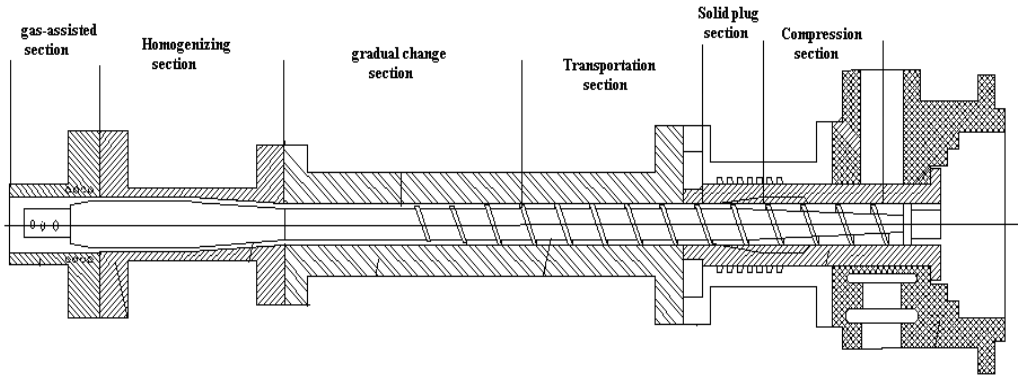

Figure 1. Schematic drawing of UHMW-PE molding in barrel method

Screw is the most critical component of the equipment for molding the pure UHMW-PE pipe in barrel which doesn't only play roles of compaction of raw materials, generating extrusion pressure, melting and homogenization but also molding of UHMW-PE pipe. From the respective of working role, screw is divided into six sections such as compaction section, solid plug section, gradually changed screw section, molding section and gas-assisted section. The height of screw flight decreases linearly meanwhile the thread pitch remains unchanged so that the raw materials are gradually compressed. The value of screw flight height becomes more and more constant in the compaction section and the raw materials have been completely compressed. In the gradually changed screw flight section, the screw flight height changes gradually form a constant value which is equivalent to the

depth of flute spiral to zero. There's no screw flight in the molding section. Taking into account the reversible deformation of molding process, the range of polished rod diameter is 85%Ds＜Dg＜115%Ds. (Ds: root diameter of the screw flight transition section; Dg: diameter of the polished rod)

The molding process of UHMW-PE pipe. The UHMW-PE Resin in the form of solid powder bed are quickly compressed after entering into the compaction section of which the depth of flute spiral decreased gradually. Then the Resin are pushed forward in the form of solid plug in the solid plug section of which the root diameter remains unchanged. After that, the solid plug goes through the gradually changed screw flight section of which the screw flight height changes gradually to zero so the inner diameter of solid plug increased gradually to a constant value. When the solid plug reaches the molding section without screw flight, the space between barrel and screw is full of the UHMW-PE raw material and the tube is formed. As to the melting process, the raw materials become opaque crust and then a layer of translucent sticky-like material which can be regarded as the melt film under the combined effect of frictional heat, barrel heat and screw heat. As the solid plug moves along the flute spiral, the heat continues to spread into the inner layer of solid powder bed so that melting layer becomes thicker. The solid powder bed melts completely into the elastomers near the machine head and the tube is formed. The pure UHMW-PE pipe is extruded and shaped precisely through a special machine head. A photograph of extruding the pure UHMW-PE pipe with the method of molding in barrel is illustrated in Fig.2. (Note: Adding a gas-assisted device, the technology of molding in barrel has been improved and the surface of pure UHMW-PE pipe is very smooth.)

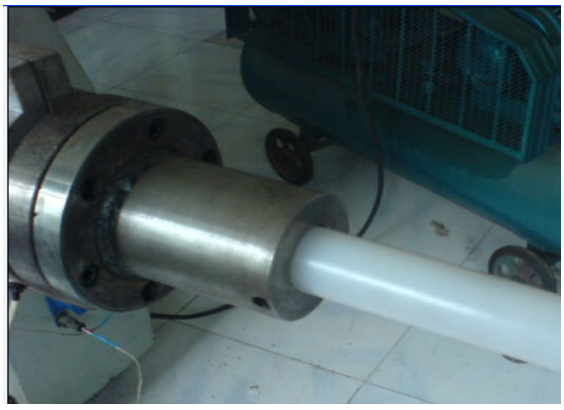

Figure 2. A photograph of extruding the pure UHMW-PE pipe with molding in barrel

The property analysis of the pure UHMW-PE pipe with the method of molding in barrel. There are three 44×3 pure UHMW-PE pipes , Specimen NO.1 is made from M-III UHMW-PE of average molecular weight 3 million produced by Beijing Oriental Oil Co., Ltd , Specimen NO.2 is made from GUR® UHMW-PE of average molecular weight 5.4 million and Specimen NO.3 is made from GUR® UHMW-PE of average molecular weight 9.2 million produced by TICONA. In accordance with the relevant standards of the state, the specimens are tested respectively for molecular weight, friction coefficient, mortar wear rate, etc. and the results are shown in Table 1.

Table 1. Integration Test for the Pure Uhmwpe Pipe Properties

Test item	Testing method	Specimen NO.1	Specimen NO.2	Specimen NO.3
Molecular weight	GB3960—83	2.98	5.44	9.18
Friction coefficient	QB/T 2668—2004	0.11	0.08	0.07
Mortar wear rate /%	QB/T 2668—2004	0.38	0.34	0.3
Bursting pressure (MPa)	QB/T 2668—2004	3.2	4.5	5.5
Hydrostatic strength	800C hydrostatic strength (165 h)	Unbroken	Unbroken	Unbroken
Longitudinal shrinkage rate /%	QB/T 2668—2004	2.8	2.7	2.2
Oxidation induction time (200□)/min	QB/T 2668—2004	23	34	35

CONCLUSIONS

Based on the unique discipline of pure UHMW-PE pipe, the method of molding in barrel is an original and completely new technological process of pure UHMW-PE pipe extrusion. The pure UHMW-PE pipe is extruded continuously and the features of pure UHMW-PE pipe in the high-elastic state are revealed clearly. This method

overcomes the processing difficulties of the pure UHMW-PE pipe which is nearly immobile in the molten state. The integration test for properties show the pure UHMW-PE pipe extruded by the method of molding in barrel has maintained its excellent properties, which produced from GUR® UHMW-PE have more outstanding performance. In future, the further research for the stability of molding process will make it possible to achieve the goal of industrialization.

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