The EVA plastic film for V-process and steel castings by V-process in China

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Abstract: EVA plastic film is the key material for V-process. Through decades of research, special EVA film for V-process has been produced. The film has adequate elongation; its maximum is about 800% in longitudinal direction and 750% in transversal direction. The single width of the film is 2.8 m and the double width is 5.6 m, which is the widest sheet film for V-process in China. Sheets with different thickness ranging from the thinnest 0.08 mm to the thickest 0.35 mm can meet different demands in China. The film can be used not only for V-process of iron castings, but also for the manganese steel railway frog, steel rocking support and side frame castings for train and the steel bridge box for engine truck.

Key words: V - Process; EVA plastic film; steel castings


V-process casting, the third generation of physical molding method after the mechanical molding method and the chemical molding method, was originated in Japan in 1969. This method has the advantages of simplified mold making with unbonded sand, high dimensional precision in casting, easy peeling and high return rate of sand at 95% etc. After several decades of development, it becomes a mature technology. The Modern Casting reported in 1995 that the number of companies that possessed V-process casting production lines were about 180 in Japan, 85 in Europe and 10 in USA. Although in recent years the developed countries have reduced their casting production, the superiority in environmental protection and emission reduction of V-process makes it still a prominent technique.

Since Professor Cao Wenlong of Huazhong University of Science and Technology introduced the V-process into China through his book Vacuum Molding Process, Beijing Chemical Equipment Works employed V-process in 1983 to manufacture iron tub successfully. Later, EVA (ethylene-vinyl acetate copolymer) plastic film for V-process casting was studied and produced in China, but problems such as uneven thickness, poor resistance to bake, blemish, bad adhesion etc. severely degraded the quality of the plastic film. These problems restricted the development of V-process casting in China.

EVA plastic film

EVA plastic film is the key material in V-process casting.

Table 1 Comparison of the Hengde film and Japanese film

<table>
<thead>
<tr>
<th>Properties of EVA plastic film</th>
<th>Hengde film</th>
<th>Japanese film</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fracture tenacity MPa</td>
<td>Horizontal</td>
<td>20.1 – 25.0</td>
</tr>
<tr>
<td></td>
<td>Vertical</td>
<td>19.7 – 26.0</td>
</tr>
<tr>
<td>Maximum elongation %</td>
<td>Horizontal</td>
<td>589</td>
</tr>
<tr>
<td></td>
<td>Vertical</td>
<td>717</td>
</tr>
</tbody>
</table>

In order to promote the V-process in China, by applying temperature control technology, new trapped-air process and multivariate linkage film blending technology (as shown in Figs. 1 and 2), Hengde Co. built four EVA production lines during the period of 2002 to 2004, with a production capacity of 12 tons per day.

Hengde Co. is the largest company in producing plastic film for V-process in China. In 2007 its output was over 1,300 tons, accounting for 95% share of Chinese domestic market. The varieties of the Hengde EVA plastic film, with thickness varied from 0.08 mm to 0.38 mm and single width from 1 m to 2.8 m, can meet different demands from hundreds of V-process casting companies in China. These kinds of EVA plastic film have replaced the imported ones and used in the production of iron castings as well as large size steel castings, such as manganese steel railway frogs, steel castings of rocking support and side frame for train. The breakthrough in film production technique indicates the mature of the V-process in China.
Examples of V-process in producing large size steel castings

Example 1: The manganese steel railway frogs

Manganese steel railway frog is the key part of railway to resist strong impact. With the increase in train speed, the People’s Republic of China Ministry of Railways sets high standard in railway related materials: the manganese steel railway frog had to sustain the forward train speed up to about 120 km/h and side speed up to about 80 km/h. In Japan, Russia, Germany and America, these railway frogs are produced by resin bonded sand casting process or sodium silicate bonded sand casting process. In 1984 China Railway Shanhaiqun Bridge Group Ltd. (CRSBG) brought in V-process production line from Japan. With the production experience of 20 years, CRSBG has successfully applied V-process to manufacture manganese steel railway frog castings. In 2007, the output reached 8,000 tons, not only meeting the domestic requirement but also exported to USA and EU.

The large-sized manganese steel railway frog casting is 6,300 mm long and weight 1.3 ton. The sand flask is 7,100 mm × 780 mm × 300 mm in size, filled with olivine molding sand. Figures 3 to 6 show the drag (Fig. 3), cope (Fig. 4), mould closing (Fig. 5) and frog castings (Fig. 6).

To produce large-sized steel casting, the Hengde EVA plastic film with great elongation and little resilience was used. The film thickness is 0.12 mm. The elongation and resiliency testing is shown in Fig. 7. A piece of 200 mm × 200 mm film was heated at 120°C for 3 minutes, then put on the top of a
Example 3: Rocking support and side frame steel castings for railway train

The rocking support and side frame are important parts in railway train. Most of the domestic factories produce these parts by sodium silicate bonded sand molding or resin bonded sand molding process. In 2005 Tianrui Group Ltd. brought in the V-process molding equipment from German HWS Ltd. with the corollary equipment supplied by Shuangxing Casting Machinery Company. The production line has the production capacity of ten thousand truck rocking supports and side frames (as shown in Fig. 10).

Table 2 Three methods of making rear axle housing castings

<table>
<thead>
<tr>
<th>Molding method</th>
<th>Representing company</th>
<th>Output (in 2007)</th>
<th>Advantages and disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Furans sand molding</td>
<td>Guangxi Liulin Machinery Co., Ltd</td>
<td>15,000 tons</td>
<td>Stable quality, high production efficiency, high cost and pollution</td>
</tr>
<tr>
<td>Sodium silicate sand molding</td>
<td>Fujian Minxi Wuqi Machinery Co., Ltd</td>
<td>14,000 tons</td>
<td>Low cost, sand recovery difficult</td>
</tr>
<tr>
<td>V-process molding</td>
<td>Fujian Longyan Changfeng Machinery Co., Ltd</td>
<td>12,000 tons</td>
<td>Easy casting cleaning and sand recovery, some surface defects</td>
</tr>
</tbody>
</table>

Example 2: Cast steel rear axle housing for engineering truck

Rear axle housing is the load-bearing part of engineering truck. The material of rear axle housing is cast steel. There are three ways to cast rear axle housing in China (refer to Table 2).

With 3 V-process molding lines, Fujian Longyan Changfeng Machinery Co., Ltd is the biggest company in manufacturing cast steel rear axle housing by V-process in China. Its output reached 12,000 tons in 2007. Two castings in a mold design was applied in the V-process production of cast steel rear axle housing. The cope and the rear axle housing casting are shown in Fig. 8 and Fig. 9, respectively. The superiority of V-process is that the casting is easy to be cleaned, and the sand return rate is as high as 95%.

stick with a height of 1,700 mm and pulled down to the stick’s bottom. The film almost shows no resilience.

Fig. 6 Frog castings

Fig. 7 Elongation testing of the EVA plastic film
Technical parameters:
◊ Dimension of flask: Side frame 3,000 mm × 1,900 mm × 450/450 mm
  Rocking support 3,000 mm × 1,900 mm × 350/550 mm
◊ Production rate: 20 molds/h, 2 castings/mold
◊ Sand for molding: quartz sand, contains 98% of SiO$_2$, with granularity of AFS 100
◊ Sand circulation: 160 t/h, sand temperature is lower than 40°C.

In order to promote the production of rocking support and side frame by V-process, Hengde Co. built a new production line in 2006 to manufacture EVA plastic film with a width of 5.6 m (the widest film in China so far). The film quality has been tested strictly by German HWS Company. In 2007 Tianrui Group Ltd. produced railway train rocking support castings (880 kg) and side frame castings (480 kg) with stable quality (as shown in Fig. 11). This V-process line is the most advanced and environment friendly steel casting line in China; no vacuum tubes and loose sand can be found in the factory.
The production of steel rear axle housing castings for engineering truck and rocking support castings for railway train marks a new stage of V-process in China. The castings produced by V-process have a smooth surface and a more precise dimension than the castings produced by resin bonded sand and sodium silicate bonded sand processes. Besides, the foundry for V-process is cleaner, sand recovery process is relatively simple and the labor intensity is reduced. However, no casting process is perfect. As for V-process steel castings, small gas holes may be found on the casting surface, sand and slag inclusions may be found inside the casting as well. To popularize and promote the application of V-process, researchers and producers have to make an effort to develop the V-process and to reduce the casting defects to an acceptable level.

Fig. 11 Railway train rocking support casting and side frame casting by V-process