Exploration on the Technical Route of Future Development of V-process casting

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General situation of the 13th five-year plan of casting industry

《"13th Five-Year" National Science and technology development planning》（Department of development planning, Ministry of science and technology）
《Made in China 2025》（The first ten years’ programme of action for the implementation of the strategy of making powerful countries by the Chinese government）（The State Council）
《Foundry industry development planning "in 13th Five-Year"》（CHINA FOUNDRY ASSOCIATION）
《The foundry industry and technology development plan "in 13th Five-Year"》
《Casting technology roadmap》（For 2030）（Chinese Technological Association of LFC and VPC）

V-Process Casting technology roadmap for future development

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The basic situation of V-process casting in China

194 v-process casting foundry
121 cast iron parts production enterprises,
76 counterweight;
37 casting steel casting production enterprises;
20 wear-resistant(high manganese steel, High chromium cast iron) casting production enterprises;
21 cast aluminium casting production enterprises;
Two non-metal smelting zirconia corundum manufacturing enterprises;

Sichuan: 8 Hubei: 8 Liaoning: 7 Shanxi: 6 Neimenggu: 6 Tianjin: 6 Shanxi: 4
Hunan: 4 Jiangxi: 3 Beijing: 2 Guangdong: 2 Ningxia: 2 Xinjiang: 2 Chongqing: 2
Heilongjiang: 2 Shanghai: 1 Guangxi: 1 Jilin: 1 Yunnan: 1
The basic situation of V-process casting in China

Application field and accommodative material of V-process

1 Engineering machinery: countryweight, Enclosure, Cast steel stents;
2 Railway locomotive: bolster, side frame, coupling, turnout;
3 Petroleum machinery: Enclosure, crank, stand;
4 Auto parts: bridge shell, brake hub;
5 Agricultural machinery: wheel hub, countryweight, flywheel;
6 Mining equipment: tooth plate, hammer head;
7 Iron and steel metallurgy: blanking plate, furnace frame;
8 Municipal: bathtub, manhole, furniture;
9 Other industries: medical apparatus and instruments, power industry, industrial mold;

Material:
cast iron: gray cast iron; ductile iron; compacted graphite Iron
cast steel: carbon steel, alloy steel
non-ferrous alloy: aluminum-silicon alloy, copper alloy, zinc alloy
non-metallic: zirconium corundum;
The basic situation of V-process casting in China
— Some progress of V-process casting

- Large-scale mechanized production line has been a breakthrough in the individual products to obtain a good application;
- EVA films and V-process special coatings basically meet domestic production needs;
- Individual high-class castings are at the forefront of the world;
- V-process casting for aluminum alloy, ductile iron manufacturers and the number of product cases are gradually increasing;
The basic situation of V-process casting in China
——application status and problems

1. V-process casting is still used to produce low-class casting; development of cast steel, ductile iron, cast aluminum is relatively limited;
2. V-process casting foundry technology still exist fuzzy or blank area, such as the definition of casting defects and design and use of vacuum systems, etc;
3. Quantity of firms with a high class characteristics of the relatively small, including problem production capacity, process control, tooling & equipment, production management, etc.,
4. Professional production, technology, management personnel is relatively small;
5. High class V-process casting equipment to become a domestic bottleneck; auxiliary and patterns basically meet the requirements;
6. The design and construction of V-process casting modernization workshop is insufficient, and its economy and environmental protection have not been well developed.
Exploration on the Technical Route of V-Process Casting

- Development route of V-process Casting Technology
- Development route of V-casting equipment and production line technology
- Development route of V-process casting auxiliary materials technology
- Development route of V-process casting patterns technology
- Development route of V-process casting products
Development route of V-process casting technology

1. Deep research on V-process casting (molding process, vacuum effect)
2. Research on the quality of V-process casting products (micro-structure and casting defects)
3. Research on the application of V-process casting in multi-domain products (material, structure, using the characteristics)
4. Composite research of V-process casting and other processes (molding, core molding, pouring, etc.)

aluminum alloy case  cast iron case  ductile iron case
Selection of molding process and weight relationship with cast iron products—process optional overlap and mutual need

- V-process casting
- Green sand and resin sand
- Resin sand modeling
- Green sand modeling
- Physical modeling
- Mock-up modeling
Contrast of V-process casting with other casting processes

- Resin sand
- Clay sand

Vacuum shape

- Medium/large pieces
- Small pieces

- Cost
- Environmental sand regeneration
- Labor intensity
- Process

- Sodium silicate sand
- Precision casting
- Cast steel
- Cast iron

- Environmental
- Sand regeneration
- Labor intensity
- Product quality
- Efficiency

- Labor intensity
- Equipment process
- Product quality
- Environmental

- Cost
- Efficiency
- Energy consumption
- Process
Technical route for the development of V-casting equipment and production line
Experience and analysis of failed V-process casting projects for equipment

- Process is difficult to guarantee
- Efficiency can not be achieved
- Economy is not good
- High labor intensity
- Low level of environmental protection

process design
system engineering design
mechanical technology
production technology
environmental awareness

Casting industry 1.0? 2.0? 3.0? 4.0?
HWS V-process case (1976~2009,57)

<table>
<thead>
<tr>
<th>Material</th>
<th>Scope of the material</th>
<th>Casting type</th>
<th>Molding efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>cast iron</td>
<td>gray cast iron, ductile iron</td>
<td>tub, piano frame, mechanical base, panel</td>
<td>35S/box~30min/box</td>
</tr>
<tr>
<td>cast steel</td>
<td>steel, high manganese steel, stainless steel, alloy steel</td>
<td>railway engine casting, valve, windows of the casting</td>
<td>10min/box~50min/box</td>
</tr>
<tr>
<td>Colored alloy</td>
<td>aluminium alloy, copper alloy</td>
<td>casting the windows, artwork, etc</td>
<td>4min/box~30min/box</td>
</tr>
</tbody>
</table>

Mechanization, Atuomation, Intelligent

《Videos of V-process casting》
Development route of V-process casting pattern

1 pattern structure:
   solid molding (Chuzhou jinnuo patent)
   Second modling (solve mold problem by process)

2 pattern material:
   (1) low-cost environmental materials — small batch
   (2) good stability material — large scale
Second modeling technique

1, pattern carries, 2, transition flask, 3, flask
Comparison of traditional pattern materials and new materials

<table>
<thead>
<tr>
<th>Material</th>
<th>Merits and demerits</th>
<th>Cost</th>
<th>Adaptive range</th>
</tr>
</thead>
<tbody>
<tr>
<td>paraffin wax</td>
<td>It is easy to produce sticky knife because of its general processability</td>
<td>30000-40000/m³</td>
<td>Small batch</td>
</tr>
<tr>
<td>Surface treatment EPS foam</td>
<td>Good processability, resin brushing, grinding trouble</td>
<td>600/m³</td>
<td>Small batch</td>
</tr>
<tr>
<td>polyurethane</td>
<td>Good processability. Easy to produce dust</td>
<td>2000/m³</td>
<td>Small batch</td>
</tr>
<tr>
<td>High density board (15mm thickness)</td>
<td>Good processability, easy to produce fluffy debris</td>
<td>450-600/m³</td>
<td>Medium batch</td>
</tr>
<tr>
<td>Glass fiber reinforced plastic (15mm thickness)</td>
<td>Good processing performance, powder, because of hard texture, cutting tool wear</td>
<td>350-400/m³</td>
<td>Large batch</td>
</tr>
<tr>
<td>Acrylic board (15mm thickness)</td>
<td>Good processability, but the details of the text easily produce chipping</td>
<td>90-120/m³</td>
<td>Large batch</td>
</tr>
<tr>
<td>Lumber (pine)</td>
<td>It is easy to produce sticky knife</td>
<td>2600-3000/m³</td>
<td>Large batch</td>
</tr>
</tbody>
</table>
Development route of V-process casting auxiliary materials

The five materials——EVA film, coating, sand, riser, chiller

EVA film: development and use of high-ductile thin film (product coverage, casting quality influence, cost of production)

Coating: special coatings (performance, cost, environmental protection)

Sand: reusability, environmental protection, process assurance

Riser: specificity, stability, high efficiency

Chiller: convenience, generalized, flexibility
Technical route of V-process casting development

1 Material: high quality cast iron, ductile iron, alloy cast iron

2 Basic research: solidification characteristics, microstructure, mechanical properties,

3 Hard and difficult technique:
   (1) Effects of Graphite Morphology on Mechanical Properties of Cast Iron
   (2) Coordination of Ductile Iron in the Production of Graphite Floating and Shrinkage
   (3) The importance and particularity of chilling technology in cast iron
   (4) High carbon cast-iron solidification for special requirements of production equipment
Gray cast: More conducive to the formation of ferrite matrix, more likely to produce A-type graphite; graphite shape is relatively large; low eutectic hot metal V method easier to saturation;

Ductile iron: More conducive to the formation of ferrite matrix, the number of eutectic groups less, larger graphite ball;

V-process castings type A graphite
Resin sand casting type A graphite

Low carbon yield, the tensile strength of vacuum process product is higher than that of clay sand
High carbon yield;
Technology route of cast steel by V-process

Material: medium class carbon steel, high carbon steel, alloy steel
Basic research: solidification characteristics, microstructure, special casting defect, etc.
Hard and difficult technique:
1 Complexity of Cast steel Technology of V-process
2 Influence of V-process casting on cast steel material (coating, film)
3 V-process characteristics on the follow-up process of steel, such as heat treatment
Casting products:
1 Large cast steel casting, small cast steel;
2 Multi-breed small batch casting;
Complexity of Cast Steel Process

Cope molding

Spraying

Core setting

Reprocessing procedure
Case of abnormal organization cast steel

Sodium silicate sand (*500 Times)

V-process casting (*500 Times)
The process of producing nonferous alloy by V-process casting

Material: aluminum and magnesium alloy, copper alloy, zinc alloy, etc.

Basic research: solidification characteristics, microstructure, mechanical properties

Hard and difficult technique:
1. The influence of V-process casting on the formation of defects
2. V-process casting is combined with other casting processes

Casting products:
1. Large cast aluminum castings of thin-walled
2. High precision products
Study on Metallographic Microstructure of Aluminum Alloy

Found: Microstructure of white needle for eutectic silicon, larger organizations of the silicon and V-process casting sample diffuses, acicular structure is relatively bulky, length is long, the clay sand and resin sand just the oppsity.
Key issues and technical bottlenecks

1. Casting defects basis and reliable solutions
2. The abnormal structure and the solution of the cooling property
3. Efficient and reliable mechanized molding equipment
4. Environmental protection, reliable, low consumption of sand processing equipment
5. Efficient, stable vacuum system
6. High malleable EVA film
7. Relationship coating characteristics and casting quality
Advanced technology for international V-process casting

1. Multi-sation rotation/high automation V-process casting production line (HWS,SINTO)
2. Cast steel V-process casting technology (Russian valve factory)
3. Thin wall complex structure cast aluminum V-process casting (USA HARMONY casting, BOEING)
4. The use of high-end resin materials in V-process patterns (Russian factiry)
5. Application of ultrathin EVA film on V-process casting (Japanese factories)
6. V-process casting produces high quality ductile iron (SINTO)
7. Digital management of V-process casting shop (Japanese factories)
Sakata factory for Toyota on Japan

Basic information
1. Modelling: 7 box/hour
2. Percent of pass: 100%
3. Sandbox size: 1600*1600*400/900mm
4. Construction area: 8500㎡
   Workshop: 6750㎡
5. 45000 Ton/year
6. Single class sculpt personnel: 7
7. Direct employees 52, Indirect employees 38

Basic history
In 2007, the preparation
In 2008, began production
In 2009, received IOS14001 certification
In 2011, received IOS9001 certification
The United States of Minnesota company, as the world's leading manufacturer of wear-resistant castings, V-process casting has long been used to produce all kinds of wear-resistant castings, especially the ball mill liner, and achieved good results. At the same time the company's V-process production line for wear-resistant casting of the production process to do a lot of useful improvements in the protection of the smooth implementation of the requirements on the basis of both the protection of the production, but also to achieve a reasonable flow of sand box. The production line design is reasonable, high production efficiency, in the production line design and process with the degree of worthy of the relevant domestic enterprises for reference.
Since 1979, the introduction of V-process casting, has been engaged in aluminum alloy casting production for more than 30 years; its annual output of more than 5,000 tons, the products are mainly used for aerospace, military industry, medical equipment, automation, energy and electricity industries. Over the years, the company has formed a perfect transition from product to service, from the early casting production, to now provide complete sets of products and engineering services; company has a complete CAD / CAE / CAM service process, at the same time with a strong CNC machining Ability, and equipped with component analysis, non-destructive testing, mechanical performance testing, pressure test, heat treatment and a series of advanced means.
Thanks for listening

Chinese Technological Association of LFC and VPC
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