BASICS OF COLD RUNNER TECHNOLOGY
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11. Closed cold runner block

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PROJECT PARTNERS
In average, just the material costs are 60% of the production costs of elastomer products!

With elastomers, the compound price depends very much on the employed basis polymer. Depending on the requirements the compound must satisfy, there are extreme price differences for fluorocautchouc and silicone rubber compounds.

Since the required properties can usually not (yet) be achieved with low-price material, reducing the waste content in production as far as possible is the obvious thing to do.

<table>
<thead>
<tr>
<th>BASE POLYMER (RUBBER TYPE)</th>
<th>MNEMONIC</th>
<th>COSTS PER KG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural rubber</td>
<td>NR</td>
<td>approximately 2.50 €</td>
</tr>
<tr>
<td>Ethylene-propylene-diene rubber</td>
<td>EPDM</td>
<td>approximately 3.50 €</td>
</tr>
<tr>
<td>Nitrile-butadiene rubber</td>
<td>NBR</td>
<td>approximately 3.50 €</td>
</tr>
<tr>
<td>Butyl rubber</td>
<td>IRB</td>
<td>approximately 4 €</td>
</tr>
<tr>
<td>Fluorine rubber</td>
<td>FPM</td>
<td>approximately 25...1,500 €</td>
</tr>
<tr>
<td>Silicone rubber</td>
<td>VMQ</td>
<td>approximately 5...500 €</td>
</tr>
</tbody>
</table>
1.3 PRODUCTION METHOD AND WASTE CONTENT

For the reasons discussed above, the precious raw material should be processed as efficiently as possible. On the other hand, the investment costs for new production systems should be as low as possible in order to obtain a short amortization period.

If you compare in an existing plant the ratio of used material and marketable items, there is frequently a large gap between the two values. Even if the existing waste share is assumed as being “no further optimizable”, there remain potential savings of approximately 12% of the production costs from the vulcanized by-products, such as sprue, overflow grooves, and flash (20% of the material costs are approximately 12% of the production costs).

1.3.1 OVERFLOW GROOVES AND ARTICLE FLASH

It has already been possible for some time to produce perfect articles practically without any flash waste using the ITM (Injection Transfer Moulding) process. Today, such perfect articles can also be successfully produced using the IM (Injection Moulding) process along with appropriate machinery and tools, for example, in the production of seals. Whether or not there are still potential savings that can be exhausted in special cases depends very much on the individual articles. For large complex geometric structures with inserted parts, for example, this can only be achieved with very high investments. This makes profitability frequently questionable. You must therefore check each individual case. There is not usually a universal method (tool) that can be used to avoid flashes.

1.3.2 SPRUE WASTE

In this field “reduction of sprue waste”, there are frequently very efficient methods to save material. This is true irrespective of the geometry of the specific article. We therefore urgently recommend that you make exact comparison calculations when selecting your production method.

<table>
<thead>
<tr>
<th>Compound?</th>
<th>Article?</th>
<th>Production-quality?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type?</td>
<td>Price?</td>
<td>Special features?</td>
</tr>
<tr>
<td>Type?</td>
<td>Dimension?</td>
<td>Inserts?</td>
</tr>
<tr>
<td>Manufacturing Concepts</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CM, TM, IM, ITM</td>
<td>Runner systems?</td>
<td>No. of cavities?</td>
</tr>
<tr>
<td>Layout?</td>
<td></td>
<td>Article quality</td>
</tr>
<tr>
<td>Period of amortization?</td>
<td>Manufacturing costs</td>
<td>Selling price</td>
</tr>
</tbody>
</table>

TYPICAL AVERAGE MOULD COMPONENT

PRODUCTION: (Injection moulding procedure without cold runner technology)

Employed Material: 1,000 kg
By-products (sprue, flash, etc.): -200 kg
Eject fraction: -50 kg
Marketable items: 750 kg

→ Total waste content 25%!
2. TEMPERATURE CONTROL

Cooling large areas of the spreader in order to prevent the material in there from pre-curing is the object of a cold runner system. After the cure time has expired, you need not remove this material together with the articles. It can be used with the next injection for new articles.

Unfortunately, standard technology does not allow the entire spreader to be cooled – the cold nozzle tip would excessively cool down the cavity. This would result in a significantly longer cure time, or a poorly vulcanized spot on the article. The standard cold runner therefore requires some vulcanized sprue. This distance to the cavity is frequently used for a subdistribution from one cold runner nozzle to several cavities. A 12-nozzle cold runner, for example, can thus feed 48 cavities.

Nevertheless, implementing a temperature gradient from the cold area to the hot area that is as steep as possible is extremely important. To obtain a clearly defined separation between “fresh” and vulcanized material, the transition distance should only be a few millimetres long. This is the only way to prevent pre-cured material from the nozzle to be flushed into the cavities during the next injection (contamination with old rubber).

This requires a very powerful cooling of the nozzle, the best insulation possible between nozzle and mould, and a powerful mould heating.

2.1 LIQUID TEMPERATURE CONTROL

A temperature control system consists of circulation pump, sensor, heater, cooler, connecting lines, and temperature-controlled component (consumer). In a DESMA system, the temperature-controlled medium is heated / cooled centrally in the “temperature control device”. The circulation pump ensures a continuous flow from the temperature control device to the consumer (cold runner, for example), and back. The temperatures of heat transfer medium and consumer adjust to each other. The advantage over direct heating (or cooling) is the very uniform temperature distribution in the temperature-controlled component. A directly installed heating or cooling element, in contrast, has only a local effect. Due to the low space requirements of the temperature-control ducts, very filigree components (such as cold runner nozzles) can very efficiently be temperature-controlled.
The temperature control device contains circulation pump, heating / cooling, and temperature sensor. Although the temperature sensor sits mostly in the return line of the temperature control device, it may also be installed directly on the consumer if there is sufficient space.

To cool the temperature-controlled medium, a valve opens to feed cold liquid (mostly on water basis, ≈20 °C) from a separate cooling circuit through a heat exchanger. This cools down the heat transferring medium / the consumer. To increase the temperature, the valve is closed and electric heater coils (similar to an immersion heater) are activated.

A sufficiently high flow is crucial for liquid temperature control. This is the only way to reach turbulent flow and thus a good heat transfer (Reynolds number > 2,300).

The flow rate is chiefly determined by the viscosity of the heat transfer medium, the installed pump, and the pressure loss of the consumer. The pressure loss depends on cross section and length of connecting lines and temperature control ducts. The connecting lines should therefore be as short as possible and of a large cross-section. Quick-acting couplings frequently cause a very large pressure drop.

With a low flow rate (due to a contaminated or kinked hose, for example), temperature control is very inaccurate and the heat up / cooling down times increase drastically. Furthermore, the risk of overheating rises significantly. This leads to a chemical destruction of oil-based media (cracking). The medium darkens heavily. The subsequent formation of clots can rapidly obstruct the entire system. Heat exchanger, connecting lines etc. can frequently not be cleaned any more and must completely be replaced. Consequently, check the flow rate at regular intervals. If the flow rate is low, find and eliminated the cause as quickly as possible!

The cooling performance, too, is determined to 100% by the cooling water supply. Adequate supply must therefore be ensured (even if all machines are cooling at the same time). Ideally, the cooling water temperature should be at a constant level (20 °C ± 3 K) all over the year.

2.2 FLOW AND TEMPERATURE CONTROL PERFORMANCE

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2.3 HEAT TRANSFER MEDIUM

Temperature control liquid on oil basis (temperature control oil)

<table>
<thead>
<tr>
<th>ADVANTAGES</th>
<th>DISADVANTAGES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperatures up to approximately 300 °C possible</td>
<td>Less heating / cooling performance</td>
</tr>
<tr>
<td>Long unproblematic operation of the temp. control system ensured</td>
<td>Higher viscosity than water (large duct cross-sections required)</td>
</tr>
<tr>
<td>Lubrication of pump and valves</td>
<td>Contained additives are frequently harmful</td>
</tr>
<tr>
<td>Does not attack metallic surfaces</td>
<td></td>
</tr>
<tr>
<td>No problem with bacterial invasion / decomposition</td>
<td></td>
</tr>
</tbody>
</table>

Temperature control liquid on water basis

<table>
<thead>
<tr>
<th>ADVANTAGES</th>
<th>DISADVANTAGES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Best cooling / heating performance</td>
<td>Special treatment required (against corrosion, lime, bacterial invasion)</td>
</tr>
<tr>
<td>Good fluidity</td>
<td>Without special temperature control devices only max. 95 °C possible</td>
</tr>
<tr>
<td>Most parts of leaked liquid evaporate</td>
<td>With special pressurized water devices max. approximately 140 °C (danger from system pressure)</td>
</tr>
</tbody>
</table>

**RECOMMENDATION:**

Due to the high power demand (in particular in the narrow temperature control ducts of the cold runner nozzles), water-based temperature control media are recommended for the cold runner section. Oil-based media, in contrast, are particularly suitable for the temperature control of the injecting unit.

2.4 TEMPERATURE CONTROL DEVICES

Devices with open temperature control circuit (pressureless)

Here, temperature control circuit and cooling circuit are completely separate. Since there is no risk of mixing liquids, you can use a water-based or an oil-based medium as heat transfer medium. Due to the pressureless circuit, the maximum temperature is limited to approximately 90 °C when water-based media are used. These devices are therefore preferably used for temperature control of the injecting unit (with oil).

**Operation:**

1. Refill opening (for temperature control medium)
2. “Level” indicator lamp
3. Specification of the temperature-controlled component
4. Rating plate with performance specifications
5. “Control circuit” connection
6. “Load circuit” connection
7. Overtemperature switch
8. Tank overflow opening
9. Drain plug (for temperature control medium)
10. Cooling liquid inlet (feed)
11. Cooling liquid outlet (return flow)
12. Temperature control medium outlet (feed)
13. Temperature control medium inlet (return flow)
Around 6,000 injection moulding machines of DESMA are globally in operation.

8. THIS PROJECT WAS SUPPORTED BY THE FOLLOWING COMPANIES.
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- Better rubber flow
- Various slip levels
- Reduced downtime

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- Besseren Gummi-Fluss
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