HPDC runner and gating system design

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High pressure die casting (HPDC) die gating system consists of a biscuit or a sprue, a runner, a gate, overflows and vents. The biscuit forms in the cold chamber HPDC machine shot sleeve and sprue in the hot chamber HPDC die sprue bushing. Sprue bushing is an active element in guiding the metal flow. Cold chamber HPDC shot sleeve does nothing much but offers a closed place to shoot the metal from.

There are two basic runner types: tangential and fan runner. (See images below.) Runner is a carefully designed part of the HPDC die. It controls the metal flow by accelerating and directing it to the right places inside the die.

Overflows gather the oxidised front of the metal and function as heat storages near thin and/or distant parts of the casting. Vents lead gases out of the die cavity. Short die cavity fill time requires more generous venting than longer fill time. Vents and overflows attract the metal front to the wanted directions, but mainly it is the runner, which does the directing.

Image 1. Fan type runner with the basic elements in HPDC die gating systems. Cold runner gating system on the left and hot runner system on the right.

Image 2. Tangential runner for a cold chamber HPDC die.

Both runner types are widely in use. Tangential runner gives better possibility to guide the metal flow in the runner and inside the die cavity. It also gives better possibility to control the metal velocity in the gate and raise the velocity as high as wanted.
HPDC runner and gating system design consists of the following steps:

1. Analysis of the metal flow
2. Selection of the best place for the gate on one side of the casting and vents on the opposite side
3. Calculation of a maximum die cavity fill time and selection of a gate velocity
4. Division of the casting into gating segments
5. Calculation of overflow volumes per segment
6. Calculation of a total gate area and selection of a gate height
7. PQ² analysis
8. Cavity fill time and gate area calculations by segment
9. Selection of a runner type and shaping the runner

Analysis of the metal flow

An ideal casting design allows the metal to pass the die cavity with direct and clear routes. Usually there is a need to compromise. Only seldom it is possible to design an ideal gate and runner system. (See images.)

Image 3. A cup-shaped casting with a flange. Metal flow starts from the parting line and finishes to the parting line on the opposite side. No large bosses outside or inside. Clear flow pattern and enough space for the gate.

Image 4. A flat casting. No high bosses. Clear route. There are blind spots behind the holes in the end of the metal flow path. Metal enters the last point from two directions and it is possible that there will be an area where the mechanical properties are not as good as on the other areas of the casting.

Image 5. A casting with cooling ribs. This is not an optimal solution. Ribs form closed cavities outside the main route of the molten metal.
The part designer should have had considered the part shapes from the castability point of view. Usually there is at least one negotiating and consulting round during which the high pressure die casting foundry personnel gives advice in shaping the part for castability. If these consulting phases are passed, the gating system designer does not have any other option than to try finding the best possible path for the metal to flow through the cavity. This path sets the bounds for placing gates to the die cavity.

**Selection of the best place for the gate on one side of the casting and vents on the opposite side**

All common casting alloys tend to shrink during solidification and cooling. If nothing is done, the finished casting will have various defects caused by the solidification shrinkage. These defects are basically hollow sections, porosity and sinks of different size. In sand casting, gravity die casting, low pressure die casting and for example in investment casting the mould is equipped with risers, which feed liquid metal for compensating the solidification shrinkage. Risers are conical protrusions placed above the heaviest and last solidifying sections in the cast part. The last solidifying sections should not be surrounded with thinner sections, because the thin walls will solidify prematurely and block the flow path of the feeding metal.
High pressure die casting is an exception among casting methods in that there are no risers. The feeding metal is forced through the ingate with a plunger, basically using the same route as during the filling phase. For this reason the casting designer should shape the casting with a path of decreasing sections starting from the ingate and ending to overflows and vents. Unique wall thickness will also do, but usually there are both thinner and thicker sections.

If the part is wisely designed there is a clear path or multiple paths through the volume. The gates are placed on the parting surface towards the thickest sections and directed away from cores and vertical walls if possible. Vents are placed to the opposite side of the part. Select gate and vent positions in order to minimize the flow length across the die cavity.

Tangential gating system gives good possibilities to direct the metal flow where the fan gate gives only a little or no possibilities for directing. Both gate types can be used with multiple runners or divided runners. If the part is designed with multiple thick sections, it is possible to divide the runner and place a gate towards each thick section. (See images below.)

Avoid two metal fronts to encounter in distance from the gate (See image 4). This is an unwanted situation on the whole, but sometimes not avoidable. For this reason frame shaped castings should be gated from inside. Weak points in center gate construction are that it does not allow multiple cavities and that the flow velocity drops inside long runners before the metal enters the die cavity. Large openings can also be provided with runners.
Calculation of a maximum die cavity fill time and selection of a gate velocity

Fill time
The casting should have enough space on the parting line for the gate and vents. The gate length is the gate area divided by the gate thickness. The gate area depends on selected die cavity fill time and gate velocity. Die cavity fill time is selected on the grounds of:

- **Thinnest casting wall thickness**: Thick wall allows longer fill time than a thin wall. Thin walls tend to solidify prematurely if the fill time is too short. Also the flow length is critical. If there are large areas of thin walls or the thin walls are in distance from the gate, the fill time must be selected shorter.
- **Thermal properties of the casting alloy and die materials**: Liquidus temperature, width of the solidification range and thermal conductivity of the mould material. These influence the solidification time.
- **Combined volume of the casting and overflows**: Thin wall castings, castings with long flow distances through the cavity and castings with special surface quality requirements need large overflows. Large volume of the metal is able to keep the heat longer than a smaller volume.
- **Percentage solidified metal allowed during filling**: The better the wished surface quality the less solidified metal is allowed and the shorter the die cavity fill time.

One of the best known formulas for determining die cavity fill time is the NADCA fill time equation by J. F. Wallace and E. A. Herman\(^1\): the equation takes slightly different forms in different literature. The following equation and parameters are modified from Mike Ward: Gating Manual, NADCA, USA, 2006.

\[
    t = K \left( \frac{T_f - T_f + SZ}{T_f - T_d} \right) T
\]

\(t = \text{maximum fill time, s}\)
\(K = \text{empirically derived constant related to the thermal conductivity of the die steel}\)
\(T = \text{characteristic thinnest average wall thickness of the casting, mm}\)
\(T_f = \text{liquidus temperature, } ^\circ\text{C}\)
\(T_i = \text{metal temperature at the gate, } ^\circ\text{C}\)
\(T_d = \text{die surface temperature just before the shot, } ^\circ\text{C}\)
\(S = \text{percent solids at the end of fill, } \%\)
\(Z = \text{solids units conversion factor, } ^\circ\text{C to } \%, \text{ related to the width of the solidification range}\)

The part of the equation between the brackets sets a relation between the consumable heat during the cavity fill time and the temperature difference between the minimum flow temperature and die cavity surface temperature. Constant K relates this to the die material thermal conductivity and T to the thinnest wall thicknesses of the casting.

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Constant K is:

- \(0.0312\) s/mm between AISI P-20 (pre hardened nitriding plastic mould steel) and zinc alloys
- \(0.0252\) s/mm between AISI H-13 (hot working tool steel alloyed with chromium) and AISI H-21 (hot working tool steel alloyed with chromium and tungsten) and magnesium alloys
- \(0.0346\) s/mm between AISI H-13 and AISI H-21 steels and zinc, aluminum and brass alloys
- \(0.0124\) s/mm between tungsten and magnesium, zinc, aluminum and brass alloys

Solidified material can be allowed according to the Table 1.

Table 1. Recommended percentage of solidified material as a function of the average thinnest wall thickness. If there is a need to have good surface quality in the casting, use lower values. Mike Ward: Gating Manual, NADCA, USA, 2006.

<table>
<thead>
<tr>
<th>Wall thickness, mm</th>
<th>Recommended amount of solidified material (S), %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Aluminum</td>
</tr>
<tr>
<td>&lt; 0.8</td>
<td>5</td>
</tr>
<tr>
<td>0.8 - 1.25</td>
<td>5 - 25</td>
</tr>
<tr>
<td>1.25 - 2</td>
<td>15 - 35</td>
</tr>
<tr>
<td>2 - 3</td>
<td>20 - 50</td>
</tr>
</tbody>
</table>

Constant Z is:

- \(4.8\) °C/% for aluminum alloys ASTM 360, 380 ja 384, all under eutectic, less than 12 % Si containing AlSi(Cu/Mg) alloys
- \(5.9\) °C/% for aluminum alloy ASTM 390, over eutectic AlSi(Cu/Mg) alloy
- \(3.7\) °C/% for magnesium alloys
- \(3.2\) °C/% for zinc alloys 12 and 27
- \(2.5\) °C/% for zinc alloys 3, 5 and 7
- \(4.7\) °C/% for brass

Brass HPDC die fill time can be determined by multiplying the wall thickness with a constant:\(^2\):

\[
s < 2 \text{ mm}: t = s \times 7
\]
\[
s = 2 - 3 \text{ mm}: t = s \times 10\] where \(t = \text{fill time in ms}\)
\[
s = \text{average minimum wall thickness in mm}
\]

**Gate velocity**

Gate velocity has an influence on the casting mechanical properties and on the properties in the casting surface quality. High gate velocity produces higher mechanical properties and less porosity than lower gate velocity. New HPDC machines are capable of producing gate velocities up to 100 m/s, but the die erosion starts to increase already around 40 m/s. For that reason the higher velocity range from 40 m/s to 100 m/s is not very practical.

Gas porosity can be reduced without raising the gate velocity by designing the gate and runner system to maintain smooth, continuous flow profiles and by designing the casting so that no backflow occurs. Backflow can occur if there are protrusions on the way of the metal flow (See images 3 - 9).

The following table presents recommended gate velocities for different alloy types.

<table>
<thead>
<tr>
<th>Alloy</th>
<th>Recommended gate velocity, m/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>Vacuum</td>
</tr>
<tr>
<td>Aluminum</td>
<td>20 - 60</td>
</tr>
<tr>
<td>Zinc</td>
<td>30 - 50</td>
</tr>
<tr>
<td>Magnesium</td>
<td>40 - 60 (up to 90)</td>
</tr>
<tr>
<td>Copper</td>
<td>20 - 50</td>
</tr>
</tbody>
</table>

**Division of the casting into gating segments**

Gating segments are tools for visualization the metal flow. Basically they are portions of the casting where metal naturally tends flows to a relatively coherent direction. Avoid closed ends: There should always be a vent on the opposite side of the gating segment. Tangential runner gives good possibilities to direct the metal flow. (See images.)

- Image 12. A cup shaped casting with narrow rib-type projections in the middle. The metal flow is directed through the flat projections in the sides of the casting – both in upward and sideward directions. The rib-type projections will cause problems.

- Image 13. Overflows for the casting.

- Image 14. Segmented casting. The rib-shaped projections form closed cavities in the middle segment and make the metal flow more complicated. It is possible that some backflow occurs in the middle segment. Backflow mixes gas to the metal and causes porosity.

- Image 15. Modified design. The long rib-shape projections are now smaller. Metal flows better to the right directions and there are no closed shapes.
Each gating segment should:
- provide a coherent and unrestricted flow of metal through the cavity
- have unique wall thickness or sections of thicker walls towards the gate and thinner walls towards venting
- have a enough parting line to place the gate and venting

**Defining the overflow volume**

Overflows are local heat storages and also storages of an oxidized, bad quality melt. Overflows are necessary if the casting wall thickness is small or there is a need to keep the casting warm for some other reasons. The common reason is that some distant parts have cored holes around which the melt flows through narrow walls from two directions. The melt has to be sufficiently hot to be able to form a tightly knitted wall. There might also be a need to move a hot spot away from a critical area by keeping some other area nearby warm for a longer time.

With a 3D-CAD software it is relatively easy to find out the characteristic or the smallest wall thickness in each of the gating segments. Based on this information, the overflow volume is selected (See the following table). If the die is designed for a vacuum casting method, the overflows are typically rather small if existing at all.

<table>
<thead>
<tr>
<th>Characteristic (or the smallest) wall thickness in the gating segment, mm</th>
<th>Overflow volume, percentage of the segment volume</th>
<th>Requirements of an excellent surface quality</th>
<th>Some cold defects allowed</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.90</td>
<td>150 %</td>
<td>75 %</td>
<td></td>
</tr>
<tr>
<td>1.30</td>
<td>100 %</td>
<td>50 %</td>
<td></td>
</tr>
<tr>
<td>1.80</td>
<td>50 %</td>
<td>25 %</td>
<td></td>
</tr>
<tr>
<td>2.50</td>
<td>25 %</td>
<td>25 %</td>
<td></td>
</tr>
<tr>
<td>3.20</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

Overflows should have the shape presented in the following image.

Image 16. **The shape and dimensions of an overflow.** A = Land length (2 – 5 mm); B = Overall length of the overflow gate (5 – 8 mm); C = Overflow gate height (Al 0.6 – 1.2 mm, Zn 0.3 – 0.8 mm, Ms 0.8 – 1.5 mm). Vent height is as follows: Al 0.10 – 0.15 mm, Zn 0.06 – 0.10 mm, Ms 0.1 – 0.15 mm.
Calculation of a total gate area and selection of a gate height

Total gate area is calculated with the cavity fill time, gate velocity and total casting + overflows volume according to the following formula:

\[ A_{gate} = \frac{V_{part} + V_{overflows}}{v_{gate} \times t_{fill}} \]

where
- \( A_{gate} \) = total gate area
- \( V_{part} \) = part volume
- \( V_{overflows} \) = overflows volume
- \( v_{gate} \) = gate velocity
- \( t_{fill} \) = cavity fill time

Possible gate thickness range depends on the selected gate velocity (or vice versa) according to the following formula:

\[ V_{g}^{1.707} \times T_{g} \times \rho \geq J , \]

where
- \( V_{g} \) = gate velocity (m/s)
- \( T_{g} \) = gate thickness (mm)
- \( \rho \) = alloy density (kg/m²s)
- \( J \) = constant, 998 000 for aluminum, magnesium and zinc alloys

The formula gives a limit to the gate thickness as a function of a gate velocity. It is not a good practice to choose a low velocity with a thin gate. Typical gate thickness is 0,8 - 3 mm for aluminum alloys, 0,7 - 2,2 mm for magnesium alloys, 0,35 - 1,2 mm for zinc alloys and from 1,5 mm up to 4 mm for brass alloys.

PQ² analysis and the machine locking force

PQ² analysis matches the selected gate velocity to the HPDC machine plunger hydraulic system. The plunger hydraulics consists of nitrogen bottles, accumulator, computer controlled valve system, and a hydraulic cylinder to which the plunger is attached. The purpose of the plunger hydraulics is to move the plunger and fill the die cavity. (See image)

\[ 3 \text{ Modified to metric dimensioning system from Mike Ward: Gating Manual, NADCA, USA, 2006. 1,707 (or } 1 + 1/\sqrt{2} \text{) is used as power instead of 1,71 in the original equation.} \]
Plunger movement has three phases:
- Slow phase during which the runner is filled up to the gate.
- Fast phase during which the cavity and overflows are filled. Fast phase is adjusted to fill the mould cavity in the calculated fill time.
- Intensification phase during which a casting is pressed with a high pressure.

Gate velocity depends on the metal pressure during the fast shot phase according to the following formula:\(^4\):

\[
P_m = \left( \frac{\rho}{2g} \right) \left( \frac{V_g}{C_d} \right)^2
\]

- \(P_m\) = metal pressure \(Pa\)
- \(\rho\) = metal density \(kg/m^3\)
- \(g\) = gravitational constant \(m/s^2\)
- \(V_g\) = gate velocity \(m/s\)
- \(C_d\) = coefficient of discharge

HPDC machines have unique pressure and velocity profiles. The coefficient of discharge represents the variation between machines. Typical value is 0.45 - 0.5.

HPDC foundries analyze their machines to find out the dependence between the velocity and the pressure inside the plunger hydraulics. \(P_m\) is theoretical, actual value can be different.

The HPDC machines are classified by their locking force. Locking force is the force, which resists the mould opening in the end of the shot. At the instance when the mould is totally filled, a high pressure forms inside the mould cavity. The pressure is still increased in the third, intensification phase of the shot. These pressures form a force which is proportional to the projected area of the casting. Projected area is the area of the casting in the parting surface direction. (See image.)

Metal pressure creates a breaking force which is proportional to the projected area with the equation \(F = P \times A\). This calculation is used in estimating the required HPDC machine size. For example if the intensification pressure is 550 bar = 550 \(x\) 10⁵ \(N/m^2\), the projected area of 1.49 \(dm^2\) creates a die breaking force of 820 kN. This force would require a 82 kilotons HPDC machine, which is very small. Present HPDC machine size varies from 100 to 1000 kilotons. The actual clamping force should be at least 25% higher than the theoretical value.

\(^4\) Mike Ward: Gating Manual, NADCA, USA, 2006
Consequence of the dependences between the metal pressure and gate velocity and on the other hand the gate velocity and the pressure inside the die cavity is, that it is not always possible to produce wide casting with high gate velocity and/or high end pressure. There is a need to compromise.

The following table presents recommendations for an intensification pressure for different part types and different alloys.

Table 4. Intensification pressure for different alloys and part types

<table>
<thead>
<tr>
<th>Part requirements</th>
<th>Intensification pressure, bar</th>
<th>Aluminum and magnesium alloys</th>
<th>Zinc alloys</th>
<th>Copper alloys</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard parts, no special mechanical or other requirements</td>
<td>&lt; 400</td>
<td>100 - 200</td>
<td>300 - 400</td>
<td></td>
</tr>
<tr>
<td>Technical parts with special mechanical requirements</td>
<td>400 - 600</td>
<td>200 - 300</td>
<td>400 - 500</td>
<td></td>
</tr>
<tr>
<td>Parts with pressure tightness requirements, inspection required</td>
<td>800 - 1000</td>
<td>250 - 400</td>
<td>800 - 1000</td>
<td></td>
</tr>
<tr>
<td>Parts to be chrome plated</td>
<td>-</td>
<td>220 - 250</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

Cavity fill time and gate area calculations by segment

Total cavity fill time and gate area is divided to the gating segments in terms of the volume of each segment and overflows. Gate area is calculated with the following formula:

\[ A_{gate\ segment} = \frac{A_{gate} \times (V_{segment} + V_{segment\ overflows})}{V_{casting} + V_{overflows}}, \]

where

- \( A_{gate\ segment} = \) gate area of the segment
- \( A_{gate} = \) total gate area
- \( V_{segment} = \) segment volume
- \( V_{segment\ overflows} = \) overflow volume in the segment
- \( V_{casting} = \) total casting volume
- \( V_{overflows} = \) total overflows volume

Vent cross-section area

Vent cross section area is ingate cross section area divided by 4. Sufficiently large vents assure that air inside the die cavity does not exit with too large velocity. Vacuum casting equipment needs special considerations.

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Selection of a gate type and shaping runners and gates

There are two basic gate types: tangential and fan gate. Both gates are usually designed with converging cross sectional area. Fan gates can be divided into small openings, but the possibility to guide the metal flow through the gate(s) is minimal. Tangential gates come in two basic types, which can be guided or unguided:

- continuous undirected gate
- continuous directed gate
- divided undirected gate
- divided directed gate

Selection between the gate types depends on the part requirements. Fan gate is the simplest in structure and easiest to machine. The unfavourable characteristic is that most of the flow comes out from the centre of the gate. Tangential gates are more difficult to design and machine, but the design is flexible and easy to adapt to different technical requirements.

Both gate types can be divided into two sections:

- main runners
- gate runners

Main runners lead the metal from a hot chamber die casting machine sprue or a cold chamber die casting machine chamber to the gate runners. Gate runners lead the metal to gates to die cavities.

Cross section shape of main runners

The shape of the runner cross-section should be a trapezoid with side draft of 10 degrees. Main runner height to average width ratio should be between 1:1 – 1:3. Typical ratio is 1:2. See image below.

![Image 19. Main runner height \( h_r \) and width \( W_r \). In this example the ratio height to average width of 1:2 has been used. \( h_r = 1, W_r = 2 \).]

If the runner is divided to branches, the total cross-section of runner branches should enlarge by 5 – 30% after each crossing if the direction from gates towards the sprue or biscuit is considered. See image 20 next page.
Fan gate

Fan gates can be constant in cross-sectional area or converging. Constant cross-sectional area means that the gate area is same as the opening from the main runner. In converging gate the cross-sectional area of the gate is smaller than the opening from the main runner. A suitable gate to runner opening ratio is 1:1.0 – 1.5. The ratio depends on alloy type and the size of the casting. Small castings require large gate to runner ratio where smaller ratios are more practical to large castings.

The following gate to runner ratios are recommended in the reference Mike Ward: Gating Manual, NADCA, USA, 2006 although some references recommend larger ratios:

- **Aluminium**: 1:1,1 – 1:1,4, flow angle should be between 10 – 35 degrees with ratios ≤ 1:1,3 and larger than 35 degrees with ratio 1:1,4
- **Zinc**: 1:1.05 – 1:1,15, the small ratios are due to the size of sprue or nozzle opening cross-section; runner cross section should be smaller or equal to the sprue opening
- **Magnesium**: similar to aluminium with ratios from the smaller end and higher runner velocities

Flow angle sets limits to the total length of the gate. Flow angle should be 10 – 45 degrees. Over 45 degrees flow angles are not practical. Fan gate flow angle is the angle between the centreline of the gate and a straight line drawn between the gate corner and gate side at ¼ of the total length of the gate. The smaller the flow angle the narrower and longer the gate. See image below.
A constant cross-sectional area fan gate width grows according to the following formula:

\[ W_i = \frac{A_{\text{gate}}}{h_g + \left( \frac{h_r - h_g}{L} \right) l} \]

where

- \( W_i \) = gate width at distance \( l \)
- \( A_{\text{gate}} \) = gate cross-sectional area
- \( h_g \) = gate height
- \( h_r \) = runner height
- \( L \) = fan gate total length
- \( l \) = distance from the gate

And a converging fan gate width grows according to the formula:

\[ W_i = \frac{A_{\text{gate}} + \frac{(cr - 1) \times A_{\text{gate}}}{L}}{h_g + \left( \frac{h_r - h_g}{L} \right) l} \]

where

- \( W_i \) = gate width at distance \( l \)
- \( A_{\text{gate}} \) = gate cross-sectional area
- \( cr \) = converge ratio \((1.05 - 1.4)\)
- \( h_g \) = gate height
- \( h_r \) = runner height
- \( L \) = fan gate total length
- \( l \) = distance from the gate

These formulas do if the height of the runner grows linearly. Present day 3D CAD systems offer a possibility to shape the runner without any specific formulas. They are equipped with tools with which the user can shape a solid or surface object between two different shape profiles and guide the feature with one or more guiding curves. There is a need to dimension end profiles like gate and runner cross-section and model a feature between these two. (Image 22.)

Image 22. Shaping a runner with SolidWorks tools. In the left image there is a straight fan gate, which is shaped with two profiles. The right image presents shaping runner with end profiles and a guiding curve. If user wants to be sure of the shape or the shape should be more complicated, it is recommended to use more than two profiles and calculate the shape with the formulas below.
**Image 23.** Fan gate dimensioning symbols

**Tangential gate**

Tangential gate is named after the converge factors according to which the gate is designed. The gate cross section converges towards the gate borders with a factor of tangent of the flow angle. The tangential runner area for any cross-section is the ingate area, which it feeds divided by the flow angle cosine. For example, if the gate height is 2 mm and the runner feeds the last 10 mm of the gate length, it is then feeding 20 mm² cross-section of the ingate and the runner area should be 20 mm² / \cos \phi, where \phi is the flow angle. Flow angle is usually set between 26° and 45°. Other values are possible, but not practical.

The gate runner’s cross section is presented in the following image. The main dimensions of the gate runner are: approach angle, draft angle, aspect ratio, height and average width. Aspect ratio is the average width to the height of the gate runner. Typical approach angle is 30° and typical aspect ratio 2:1. Aspect ratios of 1:1 and 3:1 are also possible. The larger the ratio the wider the runner and the more heat is lost to the mould material. Average width is the width in the runner centreline.

**Image 24.** Tangential gate runner cross-section. \( \alpha = \text{draft in the back face (80°)}; \beta = \text{approach angle}. \) Aspect ratio is the average width divided by the height of the gate runner profile. Average width is the width at the middle of the profile. Runner cross section enlarges with a coefficient of gate area / \cos \phi, where \phi is a flow angle.
The tapered cylindrical shape protrusion in the end of the gate runner is called a shock absorber. The function of a shock absorber is to prevent the casting metal splashing into the die cavity. It should be fed with a tangential channel and the diameter should be approximately a square root of the ingate area.

If so wanted the runner and gating designer can:

- divide the ingate into segments, which are fed from one single gate runner
- use multiple ingates to feed different segments in a casting or fill from different directions; in this case each ingate is fed with a separate gate runner
- use multiple ingates and calculate flow angles separately for each feeding gate runner
- direct the metal flow from the ingate by shaping the gate runner

Image 25. Segmented and directed ingate. The segmented ingate is fed from two symmetrical gate runners, which meet in the main runner.

Image 26. Multiple ingate positions around the part. The ingates can be fed with two gate runners, which will meet at the main runner as in the image below. The ingates can also be fed with two branching gate runners.

The metal is directed with the following technique presented in Mike Ward: Gating Manual, NADCA, USA, 2006. The aim is to shape the front edge of the gate runner with curvature, which will force the metal to flow to a wanted direction.

- Draw a vector to the direction of the wanted metal flow (1.). The vector should start approximately from the gate runner front.
- Draw a vector perpendicular to the flow direction vector (2.).
- Draw a vector, which starts from the same point as the first vector and which is set to an angle of the selected flow angle (3.). Pay attention to the metal flow direction.
- Draw a vector, which is perpendicular to the last drawn vector (4.).
- Draw a vector from the end point of the last drawn vector to the gate and set this line perpendicular to the gate (or vertical) (5.).
- Draw the gate runner front guiding curvature by keeping the corner of the two last created vectors as a center point (6.).

1. Metal flow directing technique.

Gate runners meet in the main runner. The main runner cross-sectional area is larger than the cross-sectional area in the gate runner. The cross-sectional area should grow equally towards the main runner and the approaching curvature should be wide enough. (See images.)

2. Image 27. Metal flow directing technique.

3. Gate runners meet in the main runner. The main runner cross-sectional area is larger than the cross-sectional area in the gate runner. The cross-sectional area should grow equally towards the main runner and the approaching curvature should be wide enough. (See images.)

References

Koskenniska, V. edit. Muotin suunnittelu ja valmistus, Valimoinstituutti, Tampere, 2004
