# Mixed Pressurized/ Nonpressurized Gating System for Vertically Parted Molds

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## ABSTRACT

*The production of castings using vertically parted molding (Disamatic) lines is already well established in the foundry industry. High molding speeds and ease of operation and maintenance seem to be the keys to success. Nevertheless, the high metal speeds developed during mold filling commonly lead to a higher incidence of scrap due to surface defects (slag, subsurface blows, excessive roughness, etc.) when compared to the rates experienced with its horizontal counterpart.*

*To face this situation, foundries, in general, develop their own gating systems, which vary upon pattern layout or casting configuration. This approach generally demands several tests or trials before production can start. This testing is time-consuming, and the consistency of results is not guaranteed.*

*This paper introduces the fundamentals of a gating system for solving any problem when dealing with vertically parted molds. The system consists basically of two sections: the first is pressurized, where slag control and flow rate regulation are carried out; the second is nonpressurized, where nonturbulent filling of castings is accomplished.*

*After the principles of design are well understood, the system appears easy to adapt to any layout. Calculations follow a logical procedure and probabilities of success are high. Castings (examples will be shown) have a nice appearance and hardly any differences can be found among castings filled in the different levels.*

*Going through all the calculation can be tedious. To assist in this task, a software program is no doubt the best solution. The author illustrates his own system and how, together with computer-aided design (CAD) software, it is possible to prepare accurate and detailed pattern drawings.*

## INTRODUCTION

Vertically parted molding lines have exhibited a noticeable development in the last 20 years and this trend seems to continue. High molding speeds and excellent dimensional accuracy in a machine that is easy to use and maintain seem to be the keys for its success.

Still, most of the foundries that produce castings that demand high-quality standards find it is not a simple task to devise a suitable gating system to cope with problems related to both turbulent filling and slag entry. Available information for designing gating systems appears incomplete or adequate only to produce castings with little demand for surface quality.

For this reason each foundry develops its own systems and several trials are required before production can commence. In these conditions, consistency cannot be guaranteed. It will be shown through a simple example how, by using elementary principles of hydraulics, it is possible to devise a gating system that satisfactorily performs the expected tasks.

## BASIC PRINCIPLES

Let's take into consideration a simplified system where six castings in three levels (Fig. 1) are filled through equal single gates of cross section "A." Supposing that both the pouring cup and the vertical runner are kept full during mold filling, flow rate (Px) through each single ingate would be, respectively, from top to bottom level:

$$P1 = c \cdot A \cdot v1 = c \cdot A \cdot \sqrt{2 \cdot g \cdot H1} \qquad (1)$$
$$P2 = c \cdot A \cdot v2 = c \cdot A \cdot \sqrt{2 \cdot g \cdot H2} \qquad (2)$$
$$P3 = c \cdot A \cdot v3 = c \cdot A \cdot \sqrt{2 \cdot g \cdot H3} \qquad (3)$$

where c is friction factor (dimensionless)
$v_x$ is metal speed at the level x
g is gravity acceleration (980 cm$^2$/sec)
$H_x$ is generic ferrostatic height measured from the mold top (cm, in.) taken as reference.

It is assumed for simplicity of exposure that the friction factor "c" is unique for the entire system. In the author's experience, this supposition is quite realistic as long as certain minimum area ratios are kept among the gating elements. It is clear that being H3 > H2 > H1, with equal ingate cross section, castings in the lower levels will fill at increasing linear speeds and also with increasing flow rates. This implies in the lower levels:

1. an increased risk of mold erosion with consequent possibility of sand being dragged into the casting cavities;
2. a higher tendency to subsurface defects because of turbulence associated with fast filling;
3. in general, a higher roughness in the castings situated in the lower levels.

### Balancing Flow Rate in All Levels

The first countermeasure appears to be that of proportioning the ingate cross section in all levels in such a way as to get similar flow rates in them. This is easily accomplished by assuming A1, A2 and A3 as the ingate cross section for the three levels and making P1 = P2 = P3. Solving as function of A1, we obtain:

$$A2 = A1 \cdot \sqrt{H1/H2} \qquad (4)$$
$$A3 = A1 \cdot \sqrt{H1/H3} \qquad (5)$$

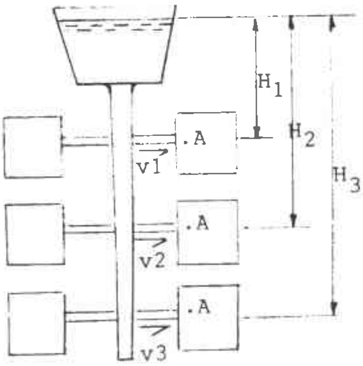


*Fig. 1. Basic system for a vertically parted gating system.*

*Example 1*: Suppose in Fig. 1 that the unitary casting weight is 1 kg (2.2 lb), that H1 = 15 cm (6 in.), H2 = 25 cm (10 in.) and H3 = 35 cm (14 in.), that the filling time for each casting is four seconds and that "c" = 0.4. Solve for the ingate cross section in all levels.

$$Pu = 1/4 = 0.25 \text{ kg/sec} <> 36 \text{ cc/sec (unitary flow rate)}$$

$$Pu = c \cdot A1 \cdot \sqrt{2 \text{ g } H1} = 0.4 \cdot A1 \cdot \sqrt{2 \cdot 980 \cdot 15} = 36 \text{ cc/sec}$$

Solving the equation we find:

$$A1 = 0.53 \text{ cm}^2$$
$$A2 = A1 \cdot \sqrt{15/25} = 0.41 \text{ cm}^2$$
$$A3 = A1 \cdot \sqrt{15/35} = 0.25 \text{ cm}^2$$

With this simple calculation, flow rates are balanced in all levels.

If we assume a casting yield of 50%, the expected pouring time would be around 7–8 seconds. Still, the castings in the different levels will not fill simultaneously. In these conditions, the filling of castings will proceed in the sequence bottom → top levels since metal pressure is exercised by the gating system over the lower ingates, even before the system is full.

If flow rates are balanced, the time lag between the filling of a casting placed in the bottom and that at the topmost level normally can be in the order of one second. Otherwise, it may exceed two seconds, since filling will tend to be progressive; that is, that the whole flow rate will be absorbed by the bottom level and only after filling this level will it fill the next level, and so on. However, balancing flow rates in the different levels will only reduce the time lag but not eliminate turbulence and the associated problems—as long as the speed at the ingates in the different levels remains as before. We shall see later how to reduce the speed.

## Control of Slag

A system like that of Fig. 1 clearly will not prevent slag particles from entering the casting cavities as long as it does not have horizontal runners where slag can float and collect. On the other hand, considering that slag flotation is favored by low ferrostatic heads (which means reduced turbulence),[1] it is clearly convenient for this scope to place the horizontal runner on top of the pattern plate (Fig. 2).

This arrangement is not new,[2] it has only been refined further. For the same reason, the worst solution is to place the runners on the bottom of the pattern plate (Fig. 3).

To ensure that slag can float and collect in the runner, the following measures should be taken (Fig. 2):

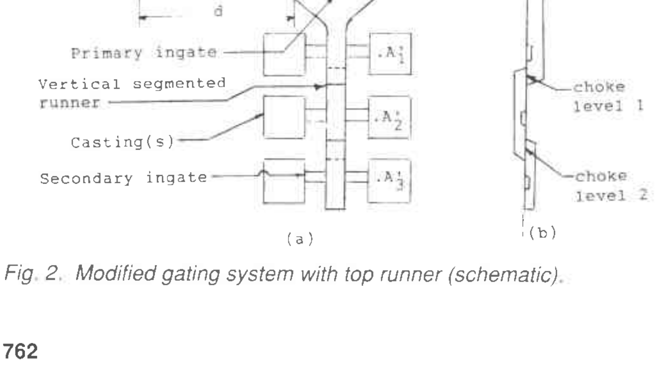


*Fig. 2. Modified gating system with top runner (schematic).*

1. Choke at the exit. In so doing, the runner will become pressurized.
2. Keep a minimum safety distance "d" between the pouring cup and the ingate. It is suggested at least 100 mm (4 in.).
3. Reduce adequately the metal speed in the runner to accelerate slag separation. This can be accomplished by keeping a runner:choke cross-section ratio between 2:1 and 2.5:1. Higher figures are not more effective.

As additional measures, the following are suggested:

1. Extend the runner past the last gate (around 30–40 mm, 1.25–1.5 in.)
2. Taper the runner end in order to speed flow stability during the early stage of pouring.
3. Exert a first choke at the pouring cup-runner junction, especially if stream inoculation is practiced.

## Influence of Automatic Pouring

In shifting from manual to automatic pouring (for instance with Presspour furnaces), an increase of flow rate is commonly experienced. The reason is obvious: the increased pressure height over the choke implies an augmentation of flow rate. In the author's experience, the system works, apparently having an additional pressure height of around 10 cm (4 in.).

*Example 2*: Supposing the runner choke (primary ingate) is placed at a level with a physical height of 7 cm (2.8 in.) in respect to the mold top, solve the system of Fig. 2. (Rest of data as in Ex. 1.)

The primary runner choke (Ach) will regulate the flow rate for the entire system (six castings). That is:

$$P = 6.36 \text{ cc/sec} = 216 \text{ cc/sec}$$
but $$P = c \cdot Ach \cdot \sqrt{2 \cdot g \cdot (7+10)}$$
solving $$Ach = 295 \text{ cm}^2$$

This means a gate dimension of 5x57 mm (0.2x2.4 in.). Where possible, it is suggested that gate heights not exceed 5–6 mm (0.2–0.25 in.).

Runner area: $Ar = 2.5 \cdot Ach = 7.4 \text{ cm}^2$
Runner dimens: 19x38 mm (0.8x1.6 in.)

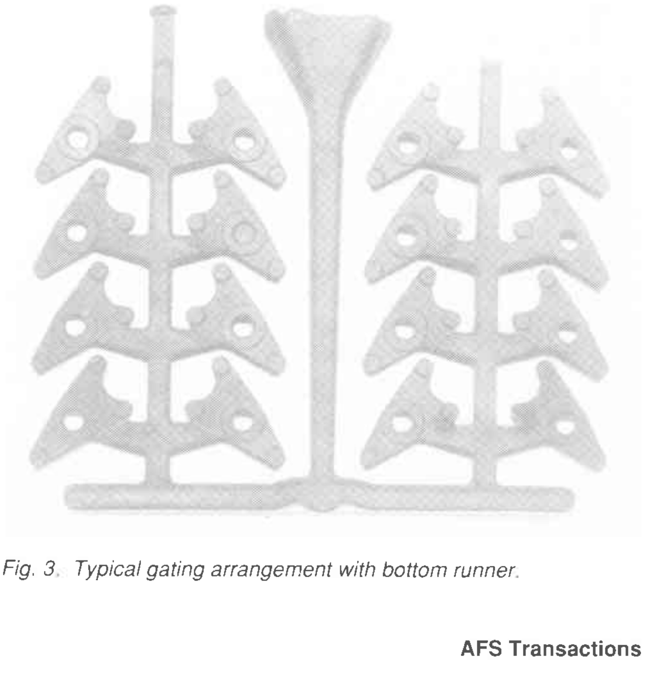


*Fig. 3. Typical gating arrangement with bottom runner.*

$$Pu = c \cdot A1 \cdot \sqrt{2 \cdot g \cdot (15+10)} = 36 \text{ cc/sec}$$

where $A1 = 0.4 \text{ cm}^2$ (or $40 \text{ mm}^2$)

$A2 = 0.4 \cdot \sqrt{(15+10)/(25+10)} = 0.34 \text{ cm}^2$ ($34 \text{ mm}^2$)

$A3 = 0.4 \cdot \sqrt{(15+10)/(35+10)} = 0.30 \text{ cm}^2$ ($30 \text{ mm}^2$)

Note that when calculating the casting ingate cross section (secondary ingates), the overpressure of 10 cm (4 in.) has also been considered.

## Reducing Turbulence in the Vertical Runners

To reduce turbulence in this part of the system, take into consideration a concept applied in hydraulics to reduce kinetic energy in open channels where water flows downstream through a stepped channel (Fig. 4).

This concept can be recreated in the mold by avoiding a straight vertical runner and substituting it with a stepped one, as shown in Fig. 2b. Liquid metal in this system is forced to continuously change direction as it goes down across the parting.

Additionally, choke the iron each time the runner changes direction (see also Fig. 5). In doing this, we get three effects:

1. Liquid metal falls over liquid metal and loses its kinetic energy in a cushioned way (splashing is thus minimized).
2. Due to this sort of labyrinth, time lag between levels is nearly zero: all levels start to fill nearly simultaneously.
3. As long as casting gates (secondary gates) no longer have the task of regulating flow rate, they can be made larger. Consequently, metal speed is clearly reduced.

The gating system so devised can be defined at this stage as a mixed pressurized/nonpressurized one.

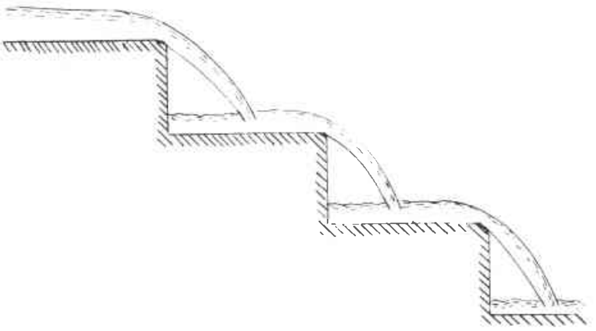


*Fig. 4. Reducing kinetic energy in an open channel (schematic).*

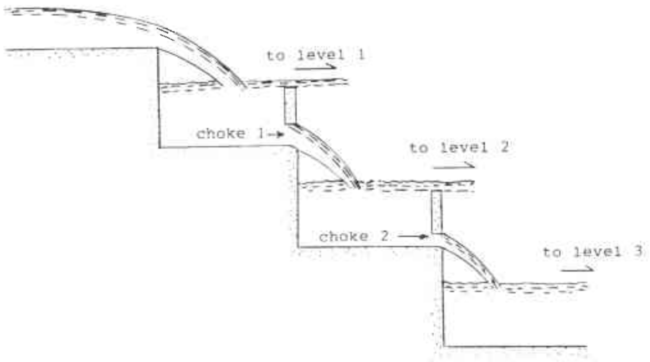


*Fig. 5. Reducing kinetic energy, turbulence and splashing by consecutive chokes as in modified gating of Fig. 2, nonpressurized section (schematic).*

## Defining Chokes in the Vertical Runner

*Example 3:* The first part of the vertical runner, starting at the primary gate, will convey the entire flow at the rate 1.5 kg/sec or 215 cc/sec. Past the first level, we should choke the runner in order to allow that only 2/3 of the metal flow can go through as long as the remaining 1/3 serves to fill the first level.

How can this be achieved? At level 1, the unitary choke per casting is 40 mm$^2$ (which was the calculated unitary gate cross section). This means that six castings at this level would demand $6 \cdot 40 = 240$ mm$^2$ of choke while four castings (2/3 of total) will demand 2/3 (240), which means 160 mm$^2$ (Ach1).

Therefore, this is the choke we should create at the first step of the vertical runner and, theoretically, just after the top level ingates. Past the second level, we should choke the metal flow for two castings (last level) while the difference will serve for the second level.

Thus, we reason in the same way: at the second level, the unitary choke per casting is 34 mm$^2$, while for two castings the choke will be $2 \cdot 34 = 68$ mm$^2$ (Ach2). This is then the choke at the runner just after the second level. Errors during execution of these chokes in the pattern shop will alter the distribution of flow in the different levels but will hardly alter the total pouring time. The choke ideally is placed midway between levels and it is created, preferably, by overlapping. Sections can appear surprisingly small but it is just an impression.

## Vertical Runner Dimensioning

In the author's experience, a ratio of 1.5:1 can be kept between the runner (Av) and the choke relative to the portion under examination. We have then:

$Av1 = 1.5 \cdot Ach = 1.5 \cdot 2.95 = 4.4 \text{ cm}^2$
(say 21x21 mm or 0.85x0.85 in.)

$Av2 = 1.5 \cdot Ach1 = 1.5 \cdot 1.6 = 2.4 \text{ cm}^2$
(21x12 mm or 0.8x0.5 in.)

$Av3 = 1.5 \cdot Ach2 = 1.5 \cdot 0.68 = 1 \text{ cm}^2$
(21x5 mm or 0.85x0.2 in.)

Vertical runners of the nearly squared section in the first portion are preferred. After this portion, and for simplicity of execution, one of the dimensions can be kept constant. The junction between the primary choke (Ach) and the vertical runner should be made in such a way as to avoid any accidental choking.

## Secondary Ingate Dimensioning

Again, in the author's experience, a ratio between 1.3:1 and 1.5:1 between the casting ingate's cross section (Ax′) and their relative chokes (Ax) is recommended. In the case under study, we would have:

$A1' = 1.3 \cdot A1 = 1.3 \cdot 40 = 52 \text{ mm}^2$
(or 3x17 mm or 0.12x0.7 in.)

$A2' = 1.3 \cdot A2 = 1.3 \cdot 34 = 44 \text{ mm}^2$
(or 3x15 mm or 0.12 0.6 in.)

$A3' = 1.3 \cdot A3 = 1.3 \cdot 30 = 39 \text{ mm}^2$
(or 3x13 mm or 0.12x0.5 in.)

The gates defined in this way can be arranged in order to fill the casting (with or without a riser) either from the bottom or from the side or from the top.

## PRACTICAL APPLICATIONS: A CASE HISTORY

Figure 6 shows a typical multiple-print casting that was designed following the aforementioned principles. To make full use of pattern surface, secondary ingates were eliminated. This is strongly advocated in risered castings, because riser necks can perform that role perfectly. Chokes are, in this, case created between risers.

*The problem:* Fifteen castings (0.6 kg or 1.32 lb each) arranged nonsymmetrically in three rows and three (equally spaced) levels are to be produced in ductile (spheroidal graphite) iron. Also, H1 = 130 mm (5.1 in.), H2 = 230 mm (9 in.) and H3 = 330 mm (13 in.). Thus, spacing that is regular is 230 – 130 = 100 mm (4 in.). Assume 43% casting yield, 0.6 for "c" (friction factor) and automatic pouring.

In order to show calculations in a real case, a casting pouring time (tc) of four seconds will be assumed. This decision will be justified later. In reality, total pouring time (t) rather than casting pouring time (tc) is normally used to define the gating system. This will not alter the pouring rate but the pouring time. The unitary pouring rate (Pu) is:

$$\mathrm{Pu} = \text{casting weight} / \mathrm{tc} = 0.6/4 = 0.15\ \mathrm{kg/sec} <> 21.4\ \mathrm{cc/sec}$$

Solving for A1, A2 and A3 using Equations 1, 4 and 5:

$$\mathrm{A1} = \mathrm{Pu} / (\mathrm{c}.\sqrt{2 \cdot 980 \cdot (13+10)} = 21/127.4 = 0.17\ \mathrm{cm}^2$$
$$\mathrm{A2} = \mathrm{A1}\ \sqrt{\mathrm{H1}/\mathrm{H2}} = 0.17 \cdot \sqrt{(13+10)/(23+10)} = 0.14\ \mathrm{cm}^2$$
$$\mathrm{A3} = \mathrm{A1}\ \sqrt{\mathrm{H1}/\mathrm{H3}} = 0.17 \cdot \sqrt{(13+10)/(33+10)} = 0.124\ \mathrm{cm}^2$$

To define the chokes between levels, it must be remembered that the pattern layout is not symmetric. The central row is single while the two other rows are double (Fig. 6).

Starting with the single row, we reason as before: the first part of the vertical runner will convey the entire flow at a flow rate relative to three castings (3 Pu or 64.2 cc/sec). Past the first level, we should choke between risers in order to allow that only 2/3 of the metal flow can go through. At level 1, the unitary choke per casting is A1 = 0.17 cm$^2$ while for three castings it is 3·A1 or 0.51 cm$^2$. This means that the choke between levels 1 and 2 should be 2/3·(0.51) or 0.34 cm$^2$ (6x6 mm or 0.25x0.25 in.).

At level 2, the unitary choke per casting is 0.14 cm$^2$ while for 2 castings it is 2·A2 or 0.28 cm$^2$. Thus, the choke between levels 2 and 3 will be 1/2·(0.28) or 0.14 cm$^2$ (4x4 mm or 0.15x0.15 in.).

For the double rows, the figures for the consecutive chokes will be exactly twice as much as those for the single row. So, in order from top to bottom, they will be: 2·0.34 or 0.68 cm$^2$ (8x8 mm or 0.32x0.32 in.), 2·0.14 or 0.28 cm$^2$ (5x6 mm or 0.2x0.2 in.).

Now, solve for the pressurized section considering a pressure head of 7 cm (2.8 in.) over the primary gates in the top runner, knowing that the total flow rate is P = 15·Pu or 321 cc/sec:

$$\mathrm{Ach} = \mathrm{P}/(\mathrm{c} \cdot \sqrt{2 \cdot \mathrm{g} \cdot (7+10)} = 2.93\ \mathrm{cm}^2\ (0.45\ \mathrm{in.}^2)$$

This section is relative to three primary gates where two of them are equal and the other conveys only one-half of the flow rate. Mathematically, the number can be expressed as 2.5.

Solving for the bigger ones:

$$\mathrm{Ach1} = 2.93/2.5 = 1.17\ \mathrm{cm}^2\ (0.18\ \mathrm{in.}^2)$$
(say 4x29 mm or 0.15x1.2 in.)

The small one:

$$\mathrm{Ach2} = \mathrm{Ach1}/2 = 0.59\ \mathrm{cm}^2\ (0.09\ \mathrm{in.}^2)$$
(say 3x20 or 4x15 mm, or 0.12x0.8 in.)

Considering that one runner is comprised of one double row and the other is comprised of a single and a double row and, with a ratio Ar/Ach in each case of 2.5, the runners' cross sections are:

1. for the small runner (left one):

$$\mathrm{Ar1} = 2.5 \cdot \mathrm{Achl} = 2.5 \cdot 1.17 = 2.93\ \mathrm{cm}^2$$
(say 12x24 mm or 0.5x1 in.)

2. for the larger runner (right one):

$$\mathrm{Ar2} = 2.5 \cdot (\mathrm{Ach1}+\mathrm{Ach2}) = 2.5 \cdot 1.75 = 4.38\ \mathrm{cm}^2$$
(say 15x30 mm or 0.6x1.2 in.)

Again, mathematically expressed, the number of runners is 1-2/3 or 1.67 since this is the ratio of flow rate they convey. This figure and that from the primary gates will be employed for solving with a software program. The choke between the pouring cup and top runners can be made one-half of the relative runner's cross section. That is, their dimensions can be, respectively, 12x12 mm (smaller runner) and 15x15 mm (bigger runner).

Due to pattern layout, the safety distance (100 mm or 4 in.) between pouring cup and first gate was not kept. Still, castings were clean (Fig. 7). Note, also, that there is little difference of appearance between castings in the different levels. See, also, the contrast between the surface of the top runner (pressurized section) and the riser and castings (nonpressurized section).

The total expected pouring time (t):

$$\mathrm{t} = \mathrm{tc} \cdot 100/\text{casting yield} = 4 \cdot 100/43 = 9.3\ \mathrm{sec}$$

The actual pouring time as measured in the foundry is 8.6 sec, while the true casting yield is 42% (poured weight: 21.42 kg). The actual pouring rate is then:

$$\mathrm{P} = \text{poured weight}/\mathrm{t} = 21.42/8.6 = 2.5\ \mathrm{kg/sec}\ (5.5\ \mathrm{lb/sec})$$

Traditionally, in this foundry, it is preferred not to exceed 2.5 kg/sec (5.5 lb/sec) when pouring in vertically parted molds. This is the reason why four seconds was chosen for starting calculations. In the author's opinion, 3 kg/sec (6.6 lb/sec) normally could be attained without difficulties in molding lines of this type. Nevertheless, the sand + machine + pattern conditions will dictate the limits in each particular situation.

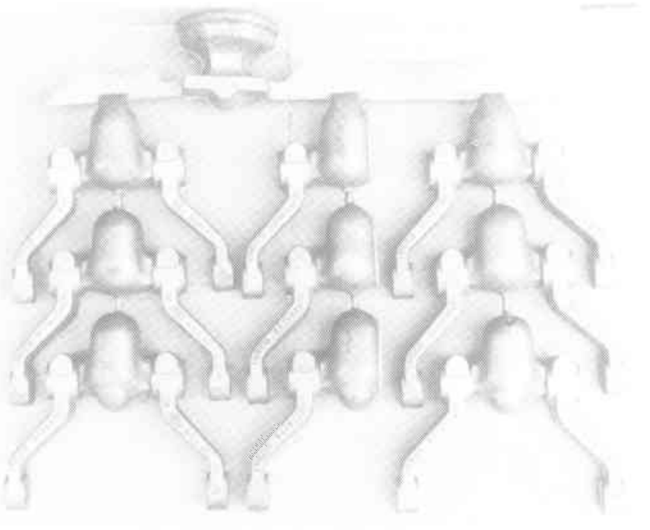


*Fig. 6. A view of a practical application of a mixed pressurized/nonpressurized gating system for vertically parted molds. (Photo courtesy of Peraro For Foundry, Rovigo, Italy.)*

### Comments

This approach can appear too simplistic for purists. The author does not claim that the proposed approach respects 100% reality, but results confirm, very positively, the claims of the method: clean and visually appealing casting surfaces. Some authors suggest different friction factors for each component of the gating system. This approach leads to rather small runners and increased friction losses.

In the author's experience, provided that the top runner/primary choke rate cross section is not lower than 1.8, a unique "c" can be applied for the entire system. By the way, depending on the method of pouring, it can vary between 0.3 and 0.6. Clearly, lower figures are more adequate for manual pouring.

In these conditions, pouring time is directly related to primary choke cross section and varies proportionally with it. If the ratio is lower than 1.8, this proportionality is invalid and it becomes very difficult to anticipate pouring time with good precision (1 sec). Another application is shown in Fig. 8.

## USING A SOFTWARE PROGRAM

Calculation of the entire system appears lengthy and, in fact, is. For this reason, a specific software was developed by the author around five years ago.

The software has undergone several modifications to fit the foundry needs and also to improve its friendliness in operation. It is called "Quickalc-Mixto Press" and Figs. 9a and 9b show the hard copies relative to the example developed manually. ("Quickalc" is the name of the software pack of which Quickalc-Mixto Press is a part and is intended for the Iron Foundry Method Department.) It is written in IBM Basic and can be run on any PC 100% compatible.

In the top half of the hard copy (Fig. 9a) the data section can be seen. The spacing between levels (data n.6) substitutes the entry of H2, H3, etc. (the rest of data is self-explanatory).

From the additional data shown in the lower half, a preliminary evaluation of casting yield can be made. In fact, given the weight of the pouring cup, the weight of the risers/casting, the length of both the top runner and the vertical runner (all of them known), the program makes an evaluation of casting yield with an excellent approximation (43% in this case against the actual 42%). Usually the error is around 2–3%.

After introducing this data, the program defines a preliminary value of seven sec for the pouring time but with two constraints: the resultant pouring rate should not be inferior to 1.5 kg/sec and should not exceed 3 kg/sec (these limits can be varied at will). Subsequently, it defines all dimensions as in the manual calculation (Fig. 9b).

Then it is possible to modify any data plus pouring time, thickness of primary ingates and friction factor. In our case, the system was designed for a pouring time of nine sec (in place of seven sec) to avoid exceeding a flow rate of 2.5 kg/sec.

### Capabilities

With Mixto-Press, it is possible to solve the following events:

1. Castings equally spaced in the pattern plate as in the example, whether or not arranged symmetrically.
2. As above, but with castings spaced arbitrarily.
3. Simultaneous filling but with differentiated flows in the different levels. This is the case, basically, of single castings.

### Applying the CAD Technique

Figure 10 illustrates examples of the joint application of Mixto-Press and AUTOCAD 10 from Autodesk to produce the detailed drawings of a multiple-print ductile iron casting for the pattern shop. Bending of the vertical runners (Fig. 10) permits an increase of the safety distance "d" ( see Fig. 2).

This version of CAD is able to emulate a DOS interface while designing, thus allowing the loading of any utility, which, in this case, is the software under discussion. When calculations are finished, it is possible to go back to the drawing under execution to complete the design without the need of reloading the CAD program.

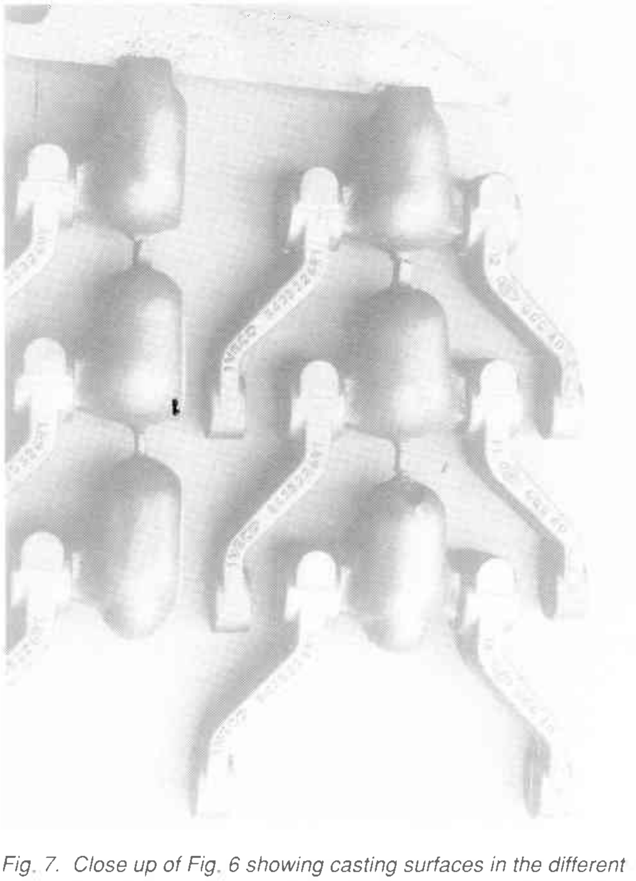


*Fig. 7. Close up of Fig. 6 showing casting surfaces in the different levels. Note the top runner surface. (Photo courtesy of Peraro For Foundry, Rovigo, Italy.)*

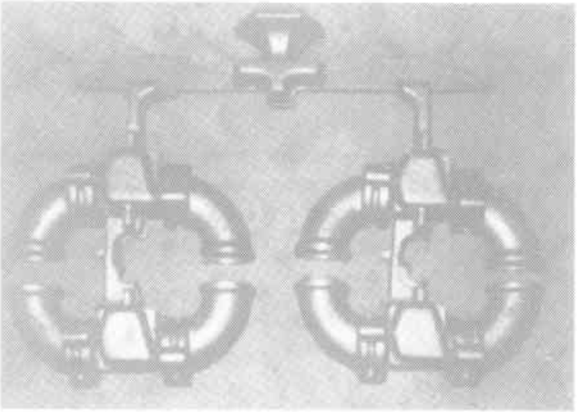
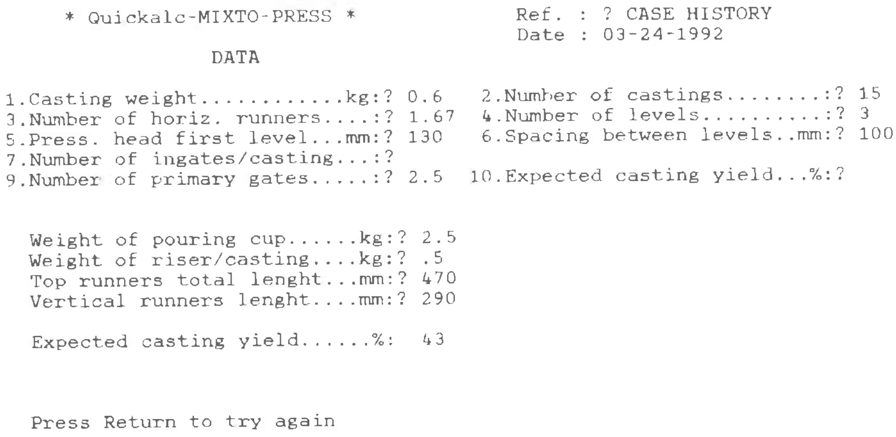


*Fig. 8. Another application of the proposed system. (Photo courtesy of Peraro For Foundry, Rovigo, Italy.)*



```
      * Quickalc-MIXTO-PRESS *                Ref. : ? CASE HISTORY
                                              Date : 03-24-1992
                      DATA

1.Casting weight............kg:? 0.6   2.Number of castings........:? 15
3.Number of horiz. runners....:? 1.67  4.Number of levels..........:? 3
5.Press. head first level...mm:? 130   6.Spacing between levels..mm:? 100
7.Number of ingates/casting...:?
9.Number of primary gates.....:? 2.5  10.Expected casting yield...%:?


  Weight of pouring cup......kg:? 2.5
  Weight of riser/casting....kg:? .5
  Top runners total lenght...mm:? 470
  Vertical runners lenght....mm:? 290

  Expected casting yield......%:  43



  Press Return to try again
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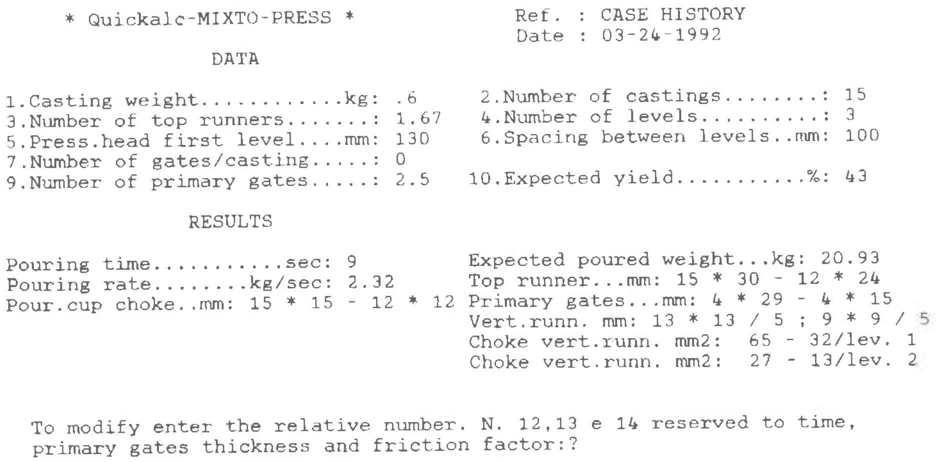
*Fig. 9a. Hard copy resulting from data entered (top half) and casting yield evaluation (bottom half) with "Mixto-Press" referred to in the case history.*



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      * Quickalc-MIXTO-PRESS *                Ref. : CASE HISTORY
                                              Date : 03-24-1992
                     DATA

1.Casting weight...........kg: .6      2.Number of castings........: 15
3.Number of top runners.......: 1.67   4.Number of levels..........: 3
5.Press.head first level....mm: 130    6.Spacing between levels..mm: 100
7.Number of gates/casting.....: 0
9.Number of primary gates.....: 2.5   10.Expected yield..........%: 43

                   RESULTS

Pouring time...........sec: 9         Expected poured weight...kg: 20.93
Pouring rate........kg/sec: 2.32      Top runner...mm: 15 * 30 - 12 * 24
Pour.cup choke..mm: 15 * 15 - 12 * 12 Primary gates...mm: 4 * 29 - 4 * 15
                                      Vert.runn. mm: 13 * 13 / 5 ; 9 * 9 / 5
                                      Choke vert.runn. mm2:  65 - 32/lev. 1
                                      Choke vert.runn. mm2:  27 - 13/lev. 2


  To modify enter the relative number. N. 12,13 e 14 reserved to time,
  primary gates thickness and friction factor:?
```

*Fig. 9b. Typical hard copy with data+results using "Mixto-Press" referred to in the case history (cs: cross section, lev: level, vert: vertical, runn: runner).*

## CONCLUSIONS

Through a simple example, and using elementary hydraulics, the author has reviewed the principles for designing vertically parted gating systems.

A proposal to counteract the effects of turbulence in the vertical runners has been presented. In this way, a mixed pressurized/nonpressurized gating system has been defined. This mixed system shows no limitations and, thus, can be applied to single castings or multiple-print castings (with symmetrical or nonsymmetrical placement).

Also, one or more gates (whether evenly spaced or not) per casting, for top or bottom or side pouring, can be chosen at will and depending on the specific needs. It ensures, also, a more than satisfactory separation of slag in the top runner, ensuring at the same time a nearly simultaneous and nonturbulent filling in all levels.

Also, the pouring rate remains constant during mold filling despite casting positioning in the pattern plate. In this way, rejection due to surface defects (because of sand, slag, metal splashing or cold metal) can be minimized and castings with high standards of surface quality can be produced.

A case history has been used to illustrate the steps for designing and also to show the results obtained. Dimensioning of the entire gating system can appear tedious to a certain extent. For this reason a specific software has been developed. Its practical application to the case history has been discussed.

The data obtained can be used in conjunction with CAD software to produce the detailed drawings for the pattern shop. Some applications have been illustrated. This approach does not demand special skills or costly hardware and for these reasons is, no doubt, convenient for foundries possessing vertical parted molding lines.

## ACKNOWLEDGMENT

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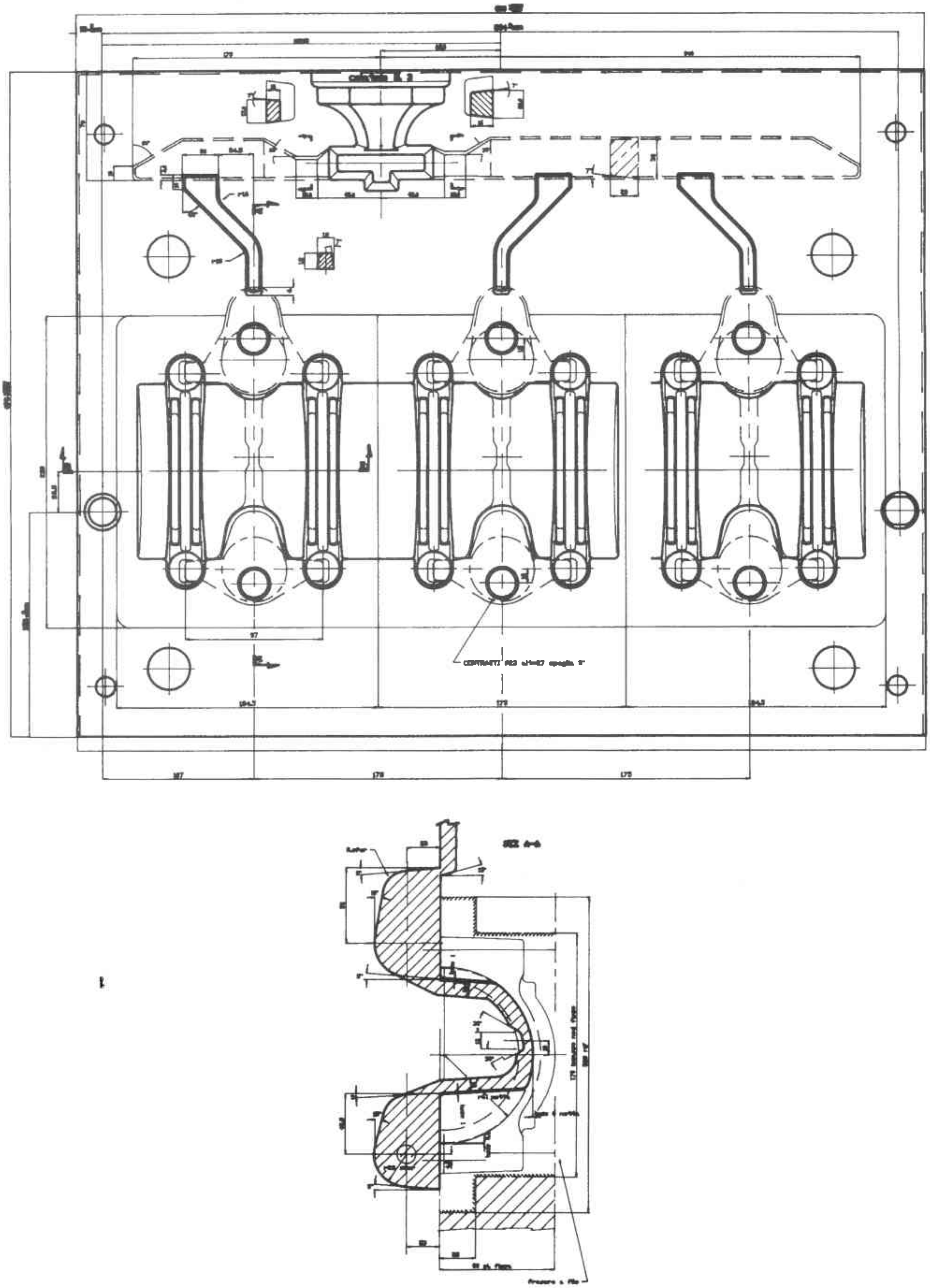

*Fig. 10. The CAD technique can be used in conjunction with "Mixto-Press" to produce detailed drawings for pattern plate construction. In this case, vertical runners are bent to increase the safety distance "d". (Photo courtesy of Studio Causin, Spresiano, Italy.)*