Process
Fig. 4.01 Flow diagram for melting furnace operation.
Metal Pouring Practice

Before high-quality molten metal can be poured, it will be subjected to several operations. The most important ones are listed below:

- charging and melting
- metal tapping
- metal inoculation and alloying
- slag skimming
- transport
- pouring the metal

CHARGING AND MELTING

It is obvious that the metal melting plant must fulfil the following objectives:

- provide metal of proper and consistent composition
- provide metal of constant and proper temperature
- supply metal at the required melting rate

The three features mentioned are the output features of the metal melting furnace operation depicted as a flow diagram on Fig. 4.01.

The same three features are the input from the melting plant to the DISAMATIC casting production process. It definitely does not mean that control of all aspects of the melting process is not required to achieve good production results. In particular, control of charging materials and practice have significant influence on the casting quality.

METAL TAPPING

The ladles must be of proper design and size. They must be equipped with a cover, preferably insulated. This contributes to minimizing the metal temperature loss. For instance, a 1000 kg filled iron ladle loses approx. 6°C/min. when uncovered, and only 4°C/min. when covered by a lined cover. The size has also much influence on the heat losses. For example, a full 500 kg ladle loses approx. 12°C/min. which is twice as much as the cooling rate of the 1000 kg ladle.

Generally the cooling rate for an uncovered ladle is:

$$\text{Cooling rate (°C/min)} = \frac{2.3 \times \text{metal top surface area (cm}^2\text{)}}{\text{metal weight (kg)}}$$
and for a covered ladle:

\[
\text{Cooling rate (°C/min)} = \frac{1.1 \times \text{metal top surface area (cm}^2\text{)}}{\text{metal weight (kg) }}
\]

Even a well-designed and sizable ladle will never be a good transport device, if not:
- properly relined and repaired every day
- dried completely after relining
- completely emptied of metal residue from previous use
- cleaned of slag remainders
- preheated to correct temperature before refilling

### INOCULATION AND ALLOYING

The purposes of inoculation are to
- reduce chilling tendency and carbide formations
- increase strength properties of low carbon irons.

It must be stressed, however, that improper inoculation can have negative effect on casting quality. The most important factors are:
- proper inoculant
- proper degree of dispersion of the inoculant which must be adequate for:
  a) metal temperature
  b) bath movement
  c) waiting time between inoculation and pouring.
- short metal distribution time before the inoculation effect fades
- proper amount (an overinoculation can cause increased shrinkage tendency etc.)
- dry inoculant.

Different makes of inoculant dispensers are available on the market, some of which dispense the inoculant pneumatically or mechanically. They do so into the stream of iron, either when being transferred to a transport ladle or later, directly into the metal jet during pouring into the molds by the automatic pouring device.

A good inoculant dispenser has many advantages, such as:
- well-measured amount of inoculant
- good reaction efficiency due to inoculation in the metal stream
- optimal reaction time
• minimum temperature loss
• high consistency of the inoculation.

The purposes of alloying are to:
• increase strength properties
• improve machinability
• obtain better heat resistance properties
• increase hardness, etc.

The addition of alloys must be controlled very accurately. Improper addition is metallurgically dangerous and uneconomical (most alloys are expensive).

SKIMMING

Metal skimming should be introduced as a routine after each metal transfer from ladle to ladle and after any type of melt treatment. There are no gating systems, slag dams or slag traps that can stop slag which was not removed prior to iron pouring.

TRANSPORT

There are some fundamental principles which have to be observed in good iron transportation:
• high iron tapping temperature
• minimum number of iron transfer operations from ladle to ladle
• high moving speed of the ladles
• short transport distance from furnace to mold string.

Our main purpose is to get hot, clean and properly treated iron to the mold string, ready for pouring and as quickly as possible. The heat loss is large during the entire metal handling process between tapping from the furnace or receiver until the last mold is poured from the ladle in question. Heat is lost due to the following factors:
• metal tapping from the furnace
• skimming operation
• each metal treatment
• iron transfer from one ladle to another (up to 100 °C for each transfer)
• iron transfer from one transport device to another
• pouring of each mold (time of one molding cycle multiplied by the number of molds poured from each ladle).
Fig. 4.02 Metal being transferred from a melting furnace to the mold string might be cooled down to a temperature which is much too low for pouring (Example).
Hence, the transportation time must be as short as possible, considering that in most cases the pouring temperature must be high enough, also for the last molds being poured from a ladle. Fig. 4.02 shows how fast the iron temperature may decline during transporting from the cupola furnace to the first mold poured at DMM. In the table below some guidelines for the recommended pouring temperatures for some iron alloys are shown:

<table>
<thead>
<tr>
<th>GUIDELINES FOR IRON POURING TEMPERATURES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<tr>
<td></td>
</tr>
<tr>
<td>GREY IRON</td>
</tr>
<tr>
<td>DUCTILE IRON</td>
</tr>
<tr>
<td>MALLEABLE IRON</td>
</tr>
</tbody>
</table>

POURING THE METAL

The pouring operation is intended to introduce hot and clean metal into the properly produced mold cavities through a well-designed gating system and in the shortest possible time; in the cavities the metal will solidify to form a high-quality casting. However, use of clean, hot metal and an ideal gating system or even properly produced molds is of no use if the pouring method is incorrect.

Manual Pouring

Of course, the old saying that a good pourer doesn't spill metal and doesn't seem to work hard, still holds true, but today it would be expressed differently; a good pourer realizes the importance of his contribution to the casting production process. It is, after all, easier to pour properly be means of a good pouring device than to pour manually. That is why the first part of this section is devoted to manual pouring.

There are a few fundamental principles to be followed by a good pourer:

a) always hold the spout of the pouring ladle as close as possible to the pouring cup

b) hit the pouring cup as close as possible to dead center

c) never tilt the ladle all the way back after each poured mold (it takes time to tilt it forward again)

d) fill the gating system and pouring cup as quickly as possible
Ladle in pouring position  Ladle in mold transport position

After pouring (A), the ladle must be tilted back only slightly (B), so that the iron level does not withdraw too much from the spout tip (C).

In other words, $\alpha_2 - \alpha_1$ must be as little as possible.

Fig. 4.03

It takes too long to fill the gating system (A); all kinds of impurities flow into the casting II and have no chance of rising to the cup surface.

The metal flow in the gating system (B) is continuous and ingate areas act in accordance with the ferrostatic heights on which they are based. The filling of both cavities is almost simultaneous.

Fig. 4.04

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e) follow the changes of metal requirements of the gating system during the entire pouring operation

f) keep the pouring cup full during the entire pouring operation

g) use the pushbutton switch, blocking the DMM before the mold transport operation, with care and release it immediately after the mold has been poured.

Re a)
The spout of the ladle should stay as close as possible to the pouring cup. There are two reasons:

- An excessively long pouring stream has a high velocity and creates more turbulent flow in the upper area of the gating system, which in turn may cause sand erosion and inclusion defects.
- Excessive distance from the spout to the pouring cup makes it more difficult to hit the right area.

Re b)
The flow losses are increased when the metal flow does not hit the pouring cup neck centrally. This can cause an increase of gating system filling time, which in turn prolongs total pouring time. It will also make it difficult to keep the cup full during pouring, and finally, it can result in metal splash over the mold surface.

Re c)
The metal level in the ladle must stay as high as possible (Fig. 4.03) during mold transport when the DMM moves the mold string by one pitch. This ensures that immediately after arrival of the new mold ready for pouring, a minimum tilting movement of the ladle is sufficient to start. Any unnecessary movement of the pouring ladle extends the machine cycle time and reduces productivity.

Re d)
Only a gating system which is filled up to the top of the pouring cup can work in accordance with the calculations; this means that the ingate areas are determined on the basis of the respective ferrostatic pressure heights. If the heights are not obtained, the ingate areas are too small. This results in improper mold filling sequence (Fig. 4.04), which in turn causes:

- Extended pouring time
- Inclusion defects in castings
- Short-poured top parts of the upper castings due to lack of iron pressure in the last phase of the pouring operation.

Re e)
Each gating system and the casting it is supposed to feed has its own pouring rate characteristics as a function of time. The changes of iron demand during the entire pouring operation depend on:
Fig. 4.05 A sudden drop of the metal level in the system from (A) to (B) will extend the pouring time and press any impurities rising to the surface into the nearest casting cavity.

Fig. 4.06 Illustration of metal requirement changes as a function of time, caused by the difference in the type of gating system.
• type of gating system (top-, side- or bottom)
• design of gating system
• geometry of casting

One of the tasks of a good pourer is to comply with this demand so that the gating system is continuously filled with metal.

Supposing that the system was filled during the initial stage of the pouring operation (Fig. 4.05 (A)) and the ingate areas worked in accordance with the ferrostatic heights in which their calculation was based, and that the possible impurities at this initial stage were rising to the surface of the cup, a sudden drop of metal level in the sprue would reduce the filling speed of the casting cavities and press the impurities while on their way up into the nearest casting cavity (Fig. 4.05 (B)).

Even if the pourer notices the fall in the iron level and corrects it, the impurities will never leave the casting again due to the pressure difference between the pressurized gating system and the casting cavity.

It is difficult to predict how casting geometry affects metal flow changes during pouring, but Fig. 4.06 shows how different types of gating systems influence the profile of the flow curve.

Just as underfilling the mold can cause trouble, overfilling will also give rise to such problems as metal overflow. This will result in:

• metal spillage
• flow of the metal resting on the top face of the mold to the subsequent pouring cup during mold string transport.

Re f)
The aspect of keeping the pouring cup full during pouring has been explained under items (d) and (e).

Re g)
The DMM has a terminal which can be connected to a switch for starting the mold transport operation when the pouring operation is finished. This is mainly used when automatic pouring is applied. However a push-button switch can be connected to the same terminal for manual pouring. The pourer can then stop the DMM before starting the mold transport operation if the pouring has not been completed. This may not cause reduced productivity. The pourer must realize that the entire molding plant is waiting for the switch to be released when pouring is completed.

Therefore, when using the switch, release it immediately after the mold is full (preferably slightly before) and long before you tilt the pouring ladle back to its initial position. The tilting can be carried out during mold string reindexing.
Fig. 4.07  Recommended location of the pouring zone for DMM 2013, DMS 2120/2130, and DMM 2070.
Pouring Zone

Location of the pouring zone in relation to the DMM is a very important factor. The minimum distance of the pouring spout to the DMM is limited by the number of retaining molds sufficient to hold the mold string tight for pouring. The maximum distance of the pouring spout from the DMM is normally limited by the cooling length of the mold transport conveyor (combination of AMC/PMC and SBC). On the other hand, both the length of the retaining molds and the necessary length of the cooling zone depend very much on the type of casting produced. It is therefore recommended to build the pouring platform long enough to obtain some flexibility in choosing the pouring point. The same applies to automatic pouring devices which should be able to move along the mold string to ensure sufficient flexibility.

The sketches on Fig. 4.07 show the minimum and maximum distances between DMM 2013, DMS 2120/2130, and DMM 2070 and the pouring ladle location.

Pouring Position

In our previous literature, the location of the pouring position has often been defined as a specific distance from the last produced mold. The actual distance has been changed from time to time according to the experience we have gained. In future, our Application Department has decided to use the chamber front as the point of reference, and the following distances are now recommended:

Pouring position for DMM 2013 is min. 2500 mm, max. 3500 mm from the molding chamber front. (In a few cases, pouring positions up to 4500 mm from the chamber front have been used, but this is not generally recommended as it increases the risk of mold deformation). For the DMS 2120/2130 and the DMM 2070 the pouring position figures are respectively min. 5000 mm and 5500 mm and max. 6500 mm and 7500 mm.

Automatic Pouring

It is highly recommendable to apply automatic pouring devices for mass production on automatic molding plants. In addition to the obvious advantages, such as:

- reduced costs
- improved casting quality
- better safety and environmental conditions
- serving as a buffer store for molten iron at the pouring station
- improved working moral

there is another fundamental advantage:

- correct and repeatable pouring technique.

All the aspects mentioned in the section "Manual Pouring" will be fully observed when applying a good automatic pouring device.
Fig. 4.08 Transverse positioning of a pouring device.
• The correct filling rate ensures short filling time of the gating system and serves to keep the pouring cup full.

• Accurate positioning of the spout over the pouring cup ensures that the metal jet hits its center, and prevents metal splashing and ensures the minimum flow losses in the cup.

• An accurate metal measuring system prevents overflow of metal on the top face of the mold.

• Changes of metal demand during pouring can be obtained with many types of automatic pouring devices.

• Release of the transport operation of the DMM takes place immediately after the mold has been fully poured.

• Slag entry into the gating system will be reduced due to minimized turbulence in a constant, well-controlled metal stream and various slag eliminating provisions, such as syphon systems (pressurized pouring types of devices), natural slag elimination by floating on the metal bath surface (bottom stopper rod types of devices), or slag trap systems (tilt ladle devices).

The following aspects must be considered when purchasing an automatic pouring device:

1. Compliance with capacity demands.

2. Proper longitudinal movement along the mold string to meet dimensional demands listed in Fig. 4.07.

3. Does it ensure sufficient length of the transverse movement so that the spout can reach sufficiently onto either side of the mold string center line?

It is recommendable to ensure the proper transverse movement of the pouring device in order to be able to position the spout orifice over the pouring cup. The ideal solution ensures the same travel (A) in both directions from the mold string symmetry line (see Fig. 4.08). The size of the stroke depends on the type of the DISAMATIC and is:

<table>
<thead>
<tr>
<th>DISAMATIC TYPE</th>
<th>STROKE (A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td>200</td>
</tr>
<tr>
<td>2120/2130</td>
<td>250-280</td>
</tr>
<tr>
<td>2070</td>
<td>320</td>
</tr>
</tbody>
</table>

However design of some pouring devices does not allow the same size of the stroke in the forward- and reverse movement. In such cases the reverse stroke must still have the size "A" but the forward stroke may be reduced to a minimum 100 mm.
4. Minimum distance between the spout and the upper face of the mold string (between 100 and 200 mm).

5. Easy accessibility for metal supply and maintenance.

6. Reliable metal metering system.

7. Sufficient pouring temperature.

8. Longitudinal positioning system should be simple and require minimum arrangements on the pattern plate at the mold parting line.

9. Possibility for applying a metal jet inoculant dispenser.
Fig. 4.09 Typical DISAMATIC automatic casting production line.
Process Control

After having run-in the DISAMATIC automatic molding line, some production control routines must be established to ensure:

- maximum utilization of existing equipment
- maximum utilization of personnel
- consistent casting quality
- good working and environmental conditions
- optimal general economy of the foundry.

PROCESS DOWN-TIME

Fig. 4.09 shows a typical DISAMATIC castings production line. Molding, coresetting, pouring, mold transport, casting shake-out and recycling of the molding sand must work in perfect coordination to ensure correct automatic production. On the other hand, a short stoppage in one of the mentioned elements will cause a complete installation stop. Automatic equipment operates best when run continuously, a short stoppage can cause huge increases in production costs and can strongly influence casting quality.

For example, a sand recycling plant which cannot supply sand at the required rate causes a stoppage in mold production, which in turn stops pouring, and after a short time the iron-filled ladle (if not heated) has to be sent back and emptied because of metal temperature loss.

Therefore, it is absolutely necessary to record the causes of stoppage to more easily determine where the "weakest link" of the process lies and to eliminate the causes.

The recording of the correct stop cause must be made randomly and at unexpected times during the shift. DISA recommends use of a special sheet for recording stop causes (see Fig. 4.10).

STAFF TRAINING

To utilize the skilled personnel who run the DISAMATIC line to advantage, it is important to instruct them in production activities. These should include the individual's working routine and how every single worker's area is connected to the other processes. In order to make sure that the production cycle is continuous, working routines must be prepared for each worker and for every specific activity requiring such.

The staff of a DISAMATIC production line normally consists of:

- a molding machine operator acting also as the core setter operator
- a pourer.
### Foundry Field Report

**Recording of Stop Causes**

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<th>Customer:</th>
<th>DISAMATIC type:</th>
<th>Date:</th>
<th>Sign:</th>
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<table>
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<tr>
<th>Time Recording</th>
<th>Causes</th>
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<td>From</td>
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**Total stop time**

<table>
<thead>
<tr>
<th>Stop time grouped acc to causes</th>
<th>Sheet No.</th>
<th>of</th>
</tr>
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</table>

**Fig. 4.10** Recording of causes of stops helps find the "weakest link" in the process.

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The foreman coordinates the work of these two workers and organizes the work around the production line.

The two workers are backed up by two others:

- a sand plant operator
- a shake-out operator.

The core supply depends only on the core shop supervisor, and the metal supply on the melting plant supervisor. The duties of these two persons will not be discussed here as they normally supervise other production lines as well as the DISAMATIC.

All these people must be properly instructed through routine descriptions. The description must be as detailed as possible in order to minimize the risk of human error in the production process. It is obvious that the higher the safety factor built into each routine the better. Once introduced, the routine is easy to maintain, although it could be slightly amended from time to time to suit local conditions.

The general rule must be that the production line should be established to only make good castings. These can be a counter-weight casting, where the type of metal used is fairly immaterial with regard to dimensional accuracy and the extent of surface imperfections or inclusions tolerated. Perhaps even an automotive casting like a cylinder head or an engine block, where the metal composition must be correct, dimensions within close tolerances, and no casting defects accepted. These types of castings require widely differing quality control arrangements and methods, but production methods and personnel routines may be very similar.

Production Routines

The following section discusses control routines for various people and different activities essential to obtain a smooth production process. Attention must be paid to the fact that the following routines deal with main aspects only. Each foundry will have to expand the suggested routines with emphasis on their particular problems, e.g.:

- production program
- special auxiliary equipment
- local labor and environmental regulations
- other conditions due to foundry installation layout etc.

The routines described below may be broken down as follows (Fig. 4.11):

1. Molding routine
   
   a) Pattern change  
   b) Mold string preparation  
   c) Mold production  
   d) Core setting  
   e) Mold transport  

   sub-routines
Fig. 4.11 Division of the production process into routine areas.
2. Pouring routine
3. Shake-out routine
4. Sand recycling routine.

**Molding Routine**

The DISAMATIC foreman must go through the following items before production starts:

1. Start the DISAMATIC machine.
2. Reset the mold counter on the control cabinet panel.
3. Make sure that the pattern plates and core masks to be used in the production are available:
   a) by the machine (the first item to be produced)
   b) in the preheating cabinet (the next items).
4. Make sure that the patterns have no scratches and show no signs of damage.
5. Check scraper strips and protecting strips for damage.
6. Check the wear plate on the pouring cup for wear (no draft on top surface) and scratches.
7. Check the guide pins/bushings for wear.
8. Check the tightness of the pattern locking screws.
9. Make sure that the core racks are filled with the proper amount of quality cores.
   • no cracked cores
   • sufficient core sand strength (the sand must not "crumple away" when rubbed between the fingers)
   • the skin on the surface of the core is not damaged. Special attention should be paid to imperfections at the parting line.
10. Check if the lining of the pouring ladles and/or spout of the automatic pouring device is repaired and preheated, and if the slag dams of the ladles fit well. The spout head orifice size on the automatic pouring device must be properly selected.
11. Check that a sufficient number of pyrometer cartridges are available by the machine.
12. Fill up the dispenser with the correct inoculant.
13. Make sure that the DISAMATIC hopper is filled with fresh molding sand.
Fig. 4.12 The pattern plates for DMM 2070 must be placed so that the right end faces the machine in the pattern-plate rack prior to changing plates.

Fig. 4.13 Pattern plate and mask for DMS 2120/2130 must be placed in a quite defined way on the roller conveyor for change.
14. Make sure that dirt is blown off the DISAMATIC machine, especially in the area next to the molding chamber. Dirt hanging over the mold string can fall down into the mold cavity during molding, thus causing casting defects.

**Pattern Change Subroutine**

The following must be observed when changing pattern plates:

1. Make sure that the plates are properly preheated and that the patterns are free from mechanical damage.

2. Check that the pattern locking screws are tightened.

3. Blow off all dirt carefully from the rear side of the pattern plates and heating plates on the machine.

4. Before pattern change, make sure that the correct ones are mounted on the counterpressure and the squeeze side. For DMM 2070, the plates must be placed so as to face the machine on the pattern change arrangement (Fig. 4.12). For DMS 2120/2130, the plates and masks must be placed on the roller conveyor for change on the way shown in fig. 4.13 (see DISA publication: 2120/2130 Pattern Plate Coding System).

5. Before a new set of plates is installed on the machine, new production data must be supplied. The most important settings are compiled on a PRODUCTION SHEET (Fig. 4.14 and 4.15). The last part of the sheet relates to a stopper rod type of automatic pouring device. This part of the sheet must be changed accordingly if the molds are poured by any other method.

A booklet with a set of Production Sheets for all patterns in production should be handed to the DISAMATIC foreman.

The following pattern data should be recorded:

a) Thickness of the pattern plates on counterpressure and squeeze plates (when using DMM 2070),

b) Pattern heights on counterpressure and squeeze plates (when using DMM 2070),

c) Pre-calculated chamber depth for molding with DMM 2013,

d) Core mask height (for DMM 2070),

e) Adjustment of the proper shock absorber position on the core setter (for DMM 2013).

The following molding data should be recorded:

a) Blow pressure,

b) Squeeze pressure,

c) Transport pressure,
**Fig. 4.14** Immediately after a set of pattern plates has been run-in, a PRODUCTION SHEET will be prepared where all optimum machine settings are recorded. The above example is for DMM 2013.
d) Mold retaining pressure,

e) Pattern stripping speed on counterpressure and squeeze sides (for DMM 2070),

f) Mold thickness correction factor (for DMM 2070 and DMS 2120/2130).

g) Control Cabinet Switches.

When automatic pouring and inoculant dispenser is applied, the relevant data must be recorded for the respective devices, too.

6. Blow off all dirt carefully from the rear side of the pattern plates and the heating plates on the machine.

7. Change the plates according to the Instructions for Use.

8. Make sure that the pattern plates mate tightly with the heating plates over their entire surface.

9. Adjust the separating fluid nozzles so that their positions comply with the pattern requirements.

10. After producing a mold with the new set of plates, stop the machine before the mold is pushed out of the chamber and carefully examine both sides for:
   - tear-off and cracks
   - loose sand
   - even hardness distribution.

11. Complete the core setting cycle, check core setting results and then close the mold carefully and adjust the mold retainers. They must not hit the parting line areas of the mold, such as pouring cup surfaces, overrun etc. and are sufficiently far away from the parting lines of the molds.

12. Mark the mold properly in order to establish the beginning of a new mold string part.

Mold String Preparation Subroutine

When patterns have been mounted and mold quality controlled, mold string production can start.

1. Produce a specified length of the mold string (called retaining molds). These molds will not be poured, but act as a firm block against which the poured molds will engage. The length of the retaining mold string depends on the type of casting, pattern plate utilization, sand/metal ratio in the mold, etc. But in general, the following distance is recommended:
   - For DMM 2013: between 2 and 4 meters.
   - For DMS 2120/2130: between 3 and 6 meters.
   - For DMM 2070: between 5 and 7 meters.
**PRODUCTION SHEET**

<table>
<thead>
<tr>
<th>Project No:</th>
<th>DISAMATIC type:</th>
<th>Date:</th>
<th>Sign.:</th>
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<tbody>
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<tr>
<td>Pattern height (front plate)</td>
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<tr>
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<tr>
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<tr>
<td>Cycle time (sec)</td>
<td></td>
<td>Productivity molds/hour</td>
<td></td>
</tr>
<tr>
<td>Stopper rod lifting height mm [inch]</td>
<td></td>
<td>Pouring hole diameter mm [inch]</td>
<td></td>
</tr>
<tr>
<td>Pouring temperature °C (°F)</td>
<td>max</td>
<td>min</td>
<td></td>
</tr>
<tr>
<td>Total pouring time (sec)</td>
<td></td>
<td>Pouring cup filling time (sec)</td>
<td></td>
</tr>
<tr>
<td>Weight of metal/mold kg [pound]</td>
<td></td>
<td>Metal/sand ratio</td>
<td>1:</td>
</tr>
<tr>
<td>Weight of casting kg [pound]</td>
<td></td>
<td>Inoculant %</td>
<td>g [pounds]</td>
</tr>
<tr>
<td>Setting of inoculant feeder (Flow rate) g [pounds]/sec.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Fig. 4.15 Immediately after a set of pattern plates has been run-in, a PRODUCTION SHEET will be prepared where all optimum machine settings are recorded. The above example is for DMM 2070.*
Note: Too long a mold retaining string will cause trouble at the shake-out. Too short a mold retaining string may cause mold gapping at the parting lines.

When producing the retaining molds, the maximum chamber depth may be used. This contributes to

- more stable, thicker retaining molds
- prescribed retaining length reached earlier.

Make sure that no core setting is made in the retaining molds.

2. Observe the quality of the molds produced as retaining molds. This will indicate whether the molding is satisfactory.

3. Adjust the mold retaining cylinders so that they step between the parting lines and do not press the top face of the mold at its weakest point.

4. After having obtained positive results from the examination of molds and after having produced a sufficient length of retaining molds, production of molds to be poured can start.

5. Mark the first mold to be poured.

6. Produce the next molds as fast as possible while observing the mold quality. Continue until the marked mold has reached the beginning of the pouring zone.

The mold string is now ready for production.

Mold Production Subroutine

The DISAMATIC molding machine is an automatic unit but nevertheless requires constant supervision. It must be borne in mind that its high production capacity applies not only to quality castings, but also to rejects. The molding process must be sufficiently supervised.

The machine operator is responsible for the following:

1. Every 10 - 15 molds use a good portable torch, mirror or other equipment to check the following:

   - both sides of the mold cavities for tear-off and cracks
   - pattern plates for sticking sand or sand cod pull-out
   - both sides for loose sand, both in casting cavities and in runners and pouring cups
   - whether the parting fluid nozzles spray properly
   - mold retainer shoes for proper operation
   - whether excessive parting spray is being used.

2. If any molding defect is discovered, the machine should be stopped immediately; the cause of the defect should be remedied, and the de-
ective molds must be marked to avoid core setting and pouring into these molds.

When producing a trial casting, any deterioration of mold quality can only be allowed to be temporary, such as caused by:

- sudden aggravation of the molding sand quality
- sudden pattern damage due to wear or metallic residual blown into the chamber together with the molding sand
- foreign particles, such as dirt or core lumps, in the molding sand.

3. Remove all sand lumps from the bottom plate after each mold break-off or core drop. Unwanted left-over sand lumps will be pushed in between the mold parting lines during close-up and mold string indexing, causing mold string cracking and irregular mold string transport.

4. Check the consistency of the molding sand quality, either by controlling the consistency of mold thickness (for DMM 2013), or by controlling the compressability factor on the digital display of the control cabinet of the DMS 2120/2130 and DMM 2070.

The mold thickness tolerance should not exceed ±5 mm, which in terms of the compressability factor will yield:

18-24%,

depending on the model of the DISAMATIC and machine settings (see "Molding Sand").

5. Any substantial deviation from the above figures must be reported to the foreman, who in turn should immediately report to the sand plant operator. This will ensure that necessary steps will be taken as quickly as possible.

Core Setting Subroutine

The DISAMATIC operator running the core setter is responsible for the following:

1. Eliminating defective cores, such as:
   - cracked or broken cores
   - cores with damaged skin, especially at the parting line.

2. Ensuring that loose sand is blown off the core-setter mask.

3. Observing the molding process to avoid core setting into a mold marked as defective.

Note: It is recommendable that the first core setting cycle for each job will be carried through stepwise.

Mold Transport Subroutine

The DISAMATIC foreman is responsible for the following:
1. Supervision of mold marking.

2. Watching mold close-up operation for:
   a) careful touch-up of the parting lines,
   b) pull-back of the recently produced mold by the retracting ram.

3. Observing probable mold mismatch visible on the top surface of the mold string.

4. Checking pouring cup cavities for dirt from the environment (sand conveyors, dust from dirt deposits on various parts of the installation, etc.).

5. Ensuring that production downtime does not exceed the critical stand-still time of the mold string left on the mold conveyor (AMC or PMC).

   The critical stand-still time of the mold string is the maximum time that the poured string can be left on the conveyor without causing transport troubles.

   • The molding sand which is thermally shocked by the hot metal, loses its strength properties, after some time causing the mold to disintegrate.

   The first stage of disintegration - mold side fall-off - does not destroy casting metallurgy or mold string transport, as it is strictly superficial.

   Further mold collapse takes place in the next stage reducing rigidity, integrity and the contact area of the mold parting lines, thus hampering transport conditions.

   • The molds into which the hot metal is poured are fairly damp because of the moisture content of the sand. The effect of pouring hot metal castings is to cause condensation on the conveyor rails, as heat from the castings transfers moisture through the molds.

   This results in:

   • reduced strength of the mold so that the rails of the conveyor cut into the mold bottom, preventing further mold string transport.
   • sticky sand in the bottom of the molds adheres to the conveyor rails.

The critical mold string stand-still time depends on many factors, such as:

• casting geometry
• safety distances from the casting and gating system to mold sides
• type of gating system
• pattern plate utilization
• sand/metal ratio
• etc.
Hence it is difficult to determine it theoretically. Every foundry must
determine it by trial and error.

If production on the molding line has to stop for a period of time that
cannot be determined, a critical stand-still time must be considered and
the mold conveyor should be emptied (as far as the SBC) in good time.

Pouring Routine

To ensure a continuous production process, the foreman of the DISAMATIC
must make sure that:

1. There is a continuous, fast and regular flow of metal transport
   ladles between the melting plant and the mold string (or automatic
   pouring device).

2. Slag is skimmed properly before pouring.

3. Metal temperature is checked and recorded when any new metal transfer
   is made at the mold string, and that it stays within the specified
   tolerances.

4. A ladle containing metal which is too cold is returned immediately for
   emptying; for example, an installation stoppage could make the metal
   too cold during pouring.

5. The inoculant dispenser works properly (if metal is inoculated into
   the mold pouring jet).

The pourer is responsible for:

1. Slag skimming:
   - Before metal transfer form the transport ladle to the pouring ladle
     (or automatic pouring device).
   - Before pouring the first mold from a manual ladle.
   - Currently, if any new slag has been produced at the pouring spout of
     the iron surface of the ladle.

2. Metal temperature measurement of each new ladle (when pouring with un-
   heated ladles), and half hour measurements in the spout (when pouring
   with a heated pouring device).

3. When pouring:
   a) Keep the ladle spout as close to the pouring cup as possible.
   b) Fill the pouring cup as quickly as possible and keep it full dur-
      ing the entire pouring process.
   c) Hit the pouring cup with the metal jet as centrally as possible.
   d) Do not return the ladle to its full upright position until it is
      empty.
e) Follow the metal demand fluctuations of the gating system during the whole pouring process: do not pour short and do not overfill the pouring cup.

When using molding stop switch for pouring, release the button immediately after the metal jet has been interrupted.

f) Keep the ladles moving: fill, drain and refill the ladles as rapidly as possible to minimize temperature loss. The faster the ladle turn-around time, the hotter they will remain, and the lower the scrap percentage.

Casting Shake-out Routine

The responsibility of the shake-out operator is:

1. To make sure that the sand is well separated from the castings.

2. To watch the molds for a proper degree of dispersion.

3. To make sure that any sand lumps run through the grids or cooling drum and do not go along the shake-out and end up in the castings container.

4. To check that the castings are well separated from the gating system.

5. To make sure that no castings jam together on the shake-out grid and accumulate, blocking the passage of further incoming castings.

6. To avoid rough handling of the castings.

Sand Plant Operating Routine

The sand plant operator or the maintenance man are responsible for:

1. Testing the sand at the muller for every 3-5 charges (if no automatic sand controlling device is used), and once an hour if it is, for:
   - Compactability (or riddled density)
   - Moisture content

   independent of the routine laboratory test described in the section on molding sand.

2. Recording the compactability and moisture content figures.

3. Regular control that the bentonite and coal dust metering and feeding systems are clean and give the expected output flow (kg/sec.). Recalibrate them if necessary. The feeding speed depends on many factors such as degree of dispersion, air humidity, cleanliness, etc.

4. Making sure that the sand mixer is cleaned after every shift.

5. Regular adjustment of the ploughs, wheels, rollers, scrapers etc., in the sand mixer.
<table>
<thead>
<tr>
<th>Machine model</th>
<th>2013 A</th>
<th>2013 B</th>
<th>2070 A</th>
<th>2070 B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mold-face</td>
<td>Pneumatic Control Pressure (approx.).</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Squeeze Press.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>kp/cm²</td>
<td>psi</td>
<td>bar</td>
<td>psi</td>
<td>bar</td>
</tr>
<tr>
<td>6</td>
<td>85</td>
<td>0.9</td>
<td>12</td>
<td>1.1</td>
</tr>
<tr>
<td>8</td>
<td>114</td>
<td>1.2</td>
<td>17</td>
<td>1.5</td>
</tr>
<tr>
<td>10</td>
<td>142</td>
<td>1.5</td>
<td>22</td>
<td>1.9</td>
</tr>
<tr>
<td>12</td>
<td>170</td>
<td>1.9</td>
<td>26</td>
<td>2.3</td>
</tr>
</tbody>
</table>

Fig. 4.16 Squeeze pressure 10 kp/cm² on the mold face can be obtained by proper machine settings. The settings may vary slightly from machine to machine due to different transducing characteristics of the relief valve.
6. Cleaning of all sand deposits built up in return sand hoppers.

7. Regular check of sand disintegrators and aerators for correct operation.

8. Controlling that the magnetic separators are operationable and clean.

9. Cleaning the sand conveyors.

10. Checking the cup elevator shafts for sand built-up. Maintenance of the elevator cups.

HIGH DENSITY MOLDS WITHOUT EXCESSIVE PRESSURE

The manufacture of high density molds requires molding sand of high quality, but does not require an extremely high squeeze pressure. The blow pressure should be just high enough, but not higher than necessary, to provide uniform distribution of sand in the pattern cavities and over the "shadows". The subsequent squeeze pressure applied should be kept to the minimum necessary in order to obtain a stable mold.

Even if it is possible to produce an extremely hard mold, it is not correct to do so. When producing extremely hard molds, the green compression strength, the dry compression strength and the hot compression strength will gradually increase. This will result in more difficult shake-out and a decrease in permeability. Should the sand be compressed to too high a pressure and then suddenly released, there is a risk of extending the mold under these conditions. The effect of too high a squeeze pressure is that the molding sand from the area of plastic deformation passes into the area of elastic deformation. This is called "spring-back", an expression for the elasticity of the sand.

It may lead to dimensional inaccuracies of the castings, to concave parting lines and mold defects during pattern stripping. "Spring-back" also depends on the pattern geometry, and also varies over the whole parting line. Variations of the pattern height cause various compression, i.e. various compacting work at different spots on the pattern. All these problems can be avoided by running the machine with a squeeze pressure of $10 \pm 2 \text{ kp/cm}^2$ measured on the mold face.

The table in Fig. 4.16 shows the relation between squeeze pressure setting on the machine gauge and the resulting squeeze pressure measured on the mold surface. Increased addition of active bentonite to the mold sand can improve its resistance to the spring-back phenomenon by increasing the plasticity of the sand. The internal movements of the mold walls will then be better compensated for by a more plastic sand.

There is a general rule for new, untested pattern plates, saying that the initial squeeze pressure to be set on the molding machine should be 10 kp/cm$^2$, and the blow pressure 3 kp/cm$^2$.
<table>
<thead>
<tr>
<th>Production Settings</th>
<th>Value range</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Shot Pressure</td>
<td>2 - 4</td>
<td>bar</td>
</tr>
<tr>
<td>3 Squeeze Pressure</td>
<td>6 - 12 (on mold face)</td>
<td>kg/cm²</td>
</tr>
<tr>
<td>5 Mold Retaining Pressure</td>
<td>0 - 2</td>
<td>bar</td>
</tr>
<tr>
<td>6 Close-up &amp; Transport Pressure</td>
<td>0 - 2</td>
<td>bar</td>
</tr>
<tr>
<td>8 Pattern Spraying</td>
<td>0.6 - 1.5</td>
<td>positions</td>
</tr>
<tr>
<td>11 Mold Blow-off</td>
<td>Both, Stop</td>
<td>positions</td>
</tr>
<tr>
<td>12 Pattern Vibrators</td>
<td>Both, Stop</td>
<td>positions</td>
</tr>
<tr>
<td>14 Chamber Depth</td>
<td>Both, Stop</td>
<td>mm</td>
</tr>
<tr>
<td>15 Mold Close-up Point</td>
<td>Continuously</td>
<td></td>
</tr>
<tr>
<td>17 Core Setting Decelerator</td>
<td>1 - 7</td>
<td>positions</td>
</tr>
<tr>
<td>18 Core Setting Mode</td>
<td>No, Manual, Auto</td>
<td>positions</td>
</tr>
<tr>
<td>19 Pattern Temperature</td>
<td>0 - 60</td>
<td>degrees c.</td>
</tr>
</tbody>
</table>

Fig. 4.17 Production settings for DMM 2013 Mk3.
MOLDING MACHINE SETTINGS

Machine settings are the part of the "keyboard" to "play" on in order to utilize fully the advantages of the DISAMATIC molding machines. The settings are determining not only the way the parts and subassemblies of the molding machine will work, but also how the materials supplied to the machine will be applied for producing a high quality mold. The molding sand of high quality must be introduced into the chamber under the proper pressure and within a determined time. It has to fill the deepest pockets of properly parting fluid sprayed and perhaps heated patterns. The air cushion must be evacuated and the sand homogeneous in the chamber. The subsequent squeeze, core transport and core setting depends very much upon the machine settings. So does the mould close-up and transport as well as the in-mold cooling of the castings. The factors mentioned is only a part of the parameters to be set on the molding machine in order to ensure the proper quality of the castings.

PRODUCTION SETTINGS FOR DMM 2013

The tables on fig. 4.17, 4.18, and 4.19 show the parameters influencing the molding process to be set on the 2013 DMM models. The selection of the settings vary of course from model to model.

Later in the section there is a short description of the role of each setting and a guideline concerning its influence on the molding process. For description and location of the setting devices on the molding machine refer to the respective "Instructions for Use".

1. Shot Pressure

Shot pressure is one of the most important settings, since the majority of the sand compaction work should be done during the shot.

The squeeze has to deliver just enough of energy to increase the density of the precompacted sand during the shot. During the shot the sand has to be introduced into the deepest pockets of the patterns and the air present in the chamber must in the same time be evacuated through the chamber plate venting system and the pattern plate vents installed to avoid the air cushion effect.

The usual setting, applicable for the majority of the patterns, stays between 2.5 and 3.5 bars, however changing the shot time (setting no. 2) adjustment of the shot pressure is often necessary.

The shot pressure setting depends on pattern geometry, sand flowability, pattern venting condition and the depth of the chamber.

2. Shot Time Optimization

The utilization of the blow effect can sometimes be improved by varying the time of the shot. As it can be imagined, the filling sequence of the molding chamber and hereby also the pattern pockets depends on the mold thickness and how turbulent the sand flow is and how much air there is entrapped in the jet of the sand being blown in. Some pattern geometries
### DMM 2013 Mk4 A/B

<table>
<thead>
<tr>
<th>Production Setting</th>
<th>Value Range</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shot Pressure</td>
<td>2 - 4</td>
<td>bar</td>
</tr>
<tr>
<td>Shot Time Optimization</td>
<td>0 - 9.9 (norm. 0.9)</td>
<td>sec</td>
</tr>
<tr>
<td>Squeeze Pressure</td>
<td>6 - 12 (on mold face)</td>
<td>kg/cm²</td>
</tr>
<tr>
<td>Squeeze Time Extension</td>
<td>0 - 9.9 (norm. 0.2)</td>
<td>sec</td>
</tr>
<tr>
<td>Mold Retaining Pressure</td>
<td>0 - 2</td>
<td>bar</td>
</tr>
<tr>
<td>Close-up &amp; Transport Pressure</td>
<td>0.6 - 1.2</td>
<td>bar</td>
</tr>
<tr>
<td>Pattern Spraying Interval</td>
<td>every 1 - 99</td>
<td>molds</td>
</tr>
<tr>
<td>Pattern Spraying</td>
<td>Both, Stop</td>
<td>positions</td>
</tr>
<tr>
<td>Core Setting Pressure</td>
<td>3 - 5</td>
<td>bar</td>
</tr>
<tr>
<td>Pattern Stripping Acceleration</td>
<td>1 - 4</td>
<td>steps</td>
</tr>
<tr>
<td>Mold Blow-off</td>
<td>Both, Stop</td>
<td>positions</td>
</tr>
<tr>
<td>Pattern Vibrators</td>
<td>Both, Stop</td>
<td>positions</td>
</tr>
<tr>
<td>Manual Core Setting Side</td>
<td>Left, Right, Both</td>
<td>positions</td>
</tr>
<tr>
<td>Chamber Depth</td>
<td>225 - 470</td>
<td>mm</td>
</tr>
<tr>
<td>Mold Close-up Point</td>
<td>Continuously</td>
<td></td>
</tr>
<tr>
<td>Core Setting Decelerator</td>
<td>1 - 7</td>
<td>positions</td>
</tr>
<tr>
<td>Core Setting Mode</td>
<td>No, Manual, Auto</td>
<td>positions</td>
</tr>
<tr>
<td>Pattern Temperature</td>
<td>0 - 60</td>
<td>deg. cent</td>
</tr>
</tbody>
</table>

**Fig. 4.18** Production settings for DMM 2013 Mk4 A/B.
are more vulnerable on the turbulent sand flow than the others. It is a strictly empirical job to optimize the shot time. It is however a proven fact that the majority of the castings molded in 200 mm thick molds can run with the shot time of 0.9 sec.

This setting influences cycle time of the machine.

3. Squeeze Pressure

This pressure is measured on the mold face and must not exceed 12 kg/cm². As the largest part of the sand packing work should be done during the blow, the well balanced proportion between the blow and the squeeze will result in a minimized squeeze pressure.

On the operator panel the squeeze pressure is set by adjusting a pneumatic valve controlling the squeeze. The table on fig. 4.16 shows the correlation between the setting of the pneumatic valve and the actual squeeze pressure on the mold face. Besides of the shot settings and sand quality, the squeeze pressure setting depends on the pattern geometry, squeeze holding time (see setting no. 4).

This setting influences cycle time of the machine.

4. Squeeze Holding Time Extension

This setting \( T_{PH} \) is the duration of the holding of the squeezed mold under the preset pressure, before start of the pattern stripping operation (see fig. 4.20). This feature ensures that the sand grains, being squeezed, will have enough of time to displace to their new positions in the compressed sand packing. It can improve the stability of the sand mold when molding deep patterns with complicated shapes. The majority of the patterns being molded, however, do not require this feature and therefore the standard setting is 0.

This setting influences the cycle time of the machine.

5. Mold Retaining Pressure

The role of this setting is to ensure proper holding force of the mold retainers before the PP stripping operation can start. The retainers have a double function:

a) to maintain the mold string pressed together, also when the ram does not retain them anymore.

b) to prevent the mold pull-back when stripping the ram pattern.

The standard setting is approx. 1 bar and can be used for the vast majority of the jobs. Very intricate patterns, especially the insufficiently vented ones can require some higher retaining pressure. See fig. 4.21.

6. Close-up and Transport Pressure

This setting is the pressure against the mold string, which must be obtained during the mold closing operation (operation no. 4). The same pressure is applied by the ram when re-indexing the mold string after the close-up. This is called mold transport pressure.

The setting is generally the same for the most jobs and stays between

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<table>
<thead>
<tr>
<th>Production Setting</th>
<th>Value range</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Shot Pressure</td>
<td>2 - 4</td>
<td>bar</td>
</tr>
<tr>
<td>2 Shot Time Optimization</td>
<td>0 - 9.9</td>
<td>sec.</td>
</tr>
<tr>
<td>3 Squeeze Pressure</td>
<td>6 - 12 (on mold face)</td>
<td>kg/cm²</td>
</tr>
<tr>
<td>4 Squeeze Time Extension</td>
<td>0 - 9.9 (norm. 0.2)</td>
<td>sec.</td>
</tr>
<tr>
<td>5 Mold Retaining Pressure</td>
<td>0 - 2</td>
<td>bar</td>
</tr>
<tr>
<td>6 Close-up &amp; Transport Pressure</td>
<td>0.6 - 1.2</td>
<td>bar</td>
</tr>
<tr>
<td>7 Pattern Spraying Interval</td>
<td>every 1 - 99</td>
<td>molds</td>
</tr>
<tr>
<td>8 Pattern Spraying</td>
<td>PP, SP, Both, Stop</td>
<td>positions</td>
</tr>
<tr>
<td>9 Core Setting Pressure</td>
<td>3 - 5</td>
<td>bar</td>
</tr>
<tr>
<td>10 Pattern Stripping Acceleration</td>
<td>1 - 4</td>
<td>steps</td>
</tr>
<tr>
<td>11 Mold Blow-off</td>
<td>PP, SP, Both, Stop</td>
<td>positions</td>
</tr>
<tr>
<td>12 Pattern Vibrators</td>
<td>PP, SP, Both, Stop</td>
<td>positions</td>
</tr>
<tr>
<td>13 Manual Core Setting Side</td>
<td>Left, Right, Both</td>
<td>positions</td>
</tr>
<tr>
<td>14 Chamber Depth</td>
<td>225 - 470</td>
<td>mm</td>
</tr>
<tr>
<td>15 Mold Close-up Point</td>
<td>Continuously</td>
<td></td>
</tr>
<tr>
<td>16 Minimum Cycle Time</td>
<td>0 - 99</td>
<td>sec.</td>
</tr>
<tr>
<td>17 Core Setting Decelerator</td>
<td>1 - 7</td>
<td>positions</td>
</tr>
<tr>
<td>18 Core Setting Mode</td>
<td>No, Manual, Auto</td>
<td>positions</td>
</tr>
<tr>
<td>19 Pattern Temperature</td>
<td>0 - 60</td>
<td>deg. cent</td>
</tr>
<tr>
<td>20 Core Setting Holding Time</td>
<td>0 - 9.9</td>
<td>sec.</td>
</tr>
</tbody>
</table>

Fig. 4.19 Production settings for DMM 2013 PLC A/B
0.6 – 1 bar, however patterns where extremely high ferrostatic pressures are involved may require some higher pressure setting. It must be born in mind that too high transport pressure can cause mold deformation across the parting line and in an extreme case mold crushing. Here, the molding sand quality has decisive importance.

7. Pattern Spraying Frequency
This setting determines whether the pattern plates will be sprayed before each molding operation or less frequently.

The frequency of spraying depends on pattern material, pattern geometry and molding sand condition, especially bentonite/water ratio, bentonite quality, content of inactive fines and temperature.

8. Pattern Spraying
This setting selects either running with or without spraying the patterns with the parting agent. It also determines whether the agent should be dispensed on PP, SP or Both.

9. Core Setting Pressure
This setting defines the pressure with which the core will be inserted into the mold. For the cores or core packages with inconsistent dimensions, it is necessary to apply tighter crush fits on the locators between the core and the mold. In this case it is often necessary to increase the pressure of the core setting.

In most cases, however, the standard setting of approx. 4.5 bar is used. This setting influences cycle time of the machine.

10. Pattern Stripping Acceleration
This setting defines the increase of the velocity of the retracting patterns during the stripping. There are 4 steps, where step 1 indicates minimum acceleration. Most of the patterns are run on the maximum setting (step 4). Sometimes, the pattern venting is insufficient, pattern draft has to be very small or there are very high green sand clogs in the mold impression. In these cases, it is recommendable to decrease the stripping acceleration. The quality of the molding sand has decisive importance for the stripping acceleration as well. This setting influences cycle time of the machine.

11. Mold Blow-off
This setting is made by a switch, selecting whether the blow-off is necessary or not and whether it should be done on the PP- or the SP-side. This switch is normally set on blowing-off both pattern impressions.

12. Pattern Vibrators
This setting selects, whether the vibration of the patterns during the stripping is necessary. The usual selection is position 3 (PP and SP vibrators on). For very simple patterns, however, the vibrators can be switched off, which decreases the noise inconvenience.
Fig. 4.20 The diagram shows the concept of the squeeze pressure ($P_{SO}$), and the squeeze holding time ($T_{SO}$) settings.

![Diagram of squeeze pressure and time](image1)

Fig. 4.21 Operation 4 consists of two stages. Fast mold transport out of chamber and slow mold close-up.

![Diagram of mold transport and close-up velocities](image2)
13. **Manual Core Setting Side**

This setting has three options:

- Pos. 1. Automatic opening of left-hand sliding door.
- Pos. 2. Automatic opening of both sliding doors (used for two-operators manual core setting).
- Pos. 3. Automatic opening of right-hand sliding door.

14. **Chamber Depth**

This setting defines the depth of the chamber (distance between the heater plates of the machine immediately before the squeeze) calculated for each set of the patterns in accordance with the rules described in the appropriate section about the pattern height limitation in the present book.

This setting influences cycle time of the machine.

15. **Mold Close-up Point**

This setting defines at which distance from the front of the molding chamber the new produced mold will get in touch with the mold string.

The mold close-up is set by the machine automatically, considering the actual mold thickness, the thickness of the PP pattern plate and optimum production capacity. However, if a temporary correction of the close-up point should be necessary (for example, a sudden change of molding sand consistency), a readjusting can be caused by the machine by pressing the close-up point adjusting switch.

16. **Minimum Cycle Time**

By setting 0 on the timer defining the cycle time, the machine will run with a time which is a sum of the time of all six basic operations. If, however, a longer cycle time than the "natural" one is desired, the minimum necessary time can be determined by this setting. The reasons for a longer cycle time can be for example too long pouring related to the "natural" cycle time, a longer in-mold cooling time necessary etc.

This setting influences cycle time of the machine.

17. **Core Setting Decelerator**

Core setter mask delivery point at the end of the core setting stroke must coincide with the face of the mold, where the core is to be set. There is a hydraulic bumper decelerating the core setter stroke just before the core delivery.

The bumper has seven settings depending on the PP pattern plate thickness and the core mask thickness (see instruction for use).

18. **Core Setting Mode**

This setting concerns selection of the way of the core inserting. There are three options:
a) no core setting  
b) manual core setting  
c) automatic core setting.

19. Pattern Temperature

The purpose of the pattern heating is to avoid sticker defects due to the sand moisture condensing on a cold pattern surface. The usual setting is 5°C (41°F) above the usual sand temperature. This value must be higher, if bigger variations of the sand temperature are expected during the shift. Excessively heated plate, however, can cause unnecessary drying of the mold cavity during the squeezing and transport of the molds. This in turn will be fatal for the casting quality. Since the maximum recommendable sand temperature is approx. 40°C (104°F), it should not be necessary to heat the patterns to a higher temperature than 45°C (113°F).

**Note:** Using resin patterns it can be dangerous to exceed 60°C (140°F).

20. Core Setting Holding Time

This setting extends the time, the core setting pressure is exercised on the mold. The time can be necessary in a case when the deviations of the core locator dimensions from the nominal are large and it is necessary to increase the crush fit between the core and the mold. The extended holding time will ensure that the sand grains, being pressed, will manage to displace to their new positions in the sand packing. However, for the vast majority of the cored jobs a light crush fit is applied and therefore it is sufficient to run with the setting "0" (no extra holding time).

**This setting influences cycle time of the machine.**
<table>
<thead>
<tr>
<th>No.</th>
<th>Production Setting</th>
<th>Value Range</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Shot Time Correction</td>
<td>-1 +1</td>
<td>sec.</td>
</tr>
<tr>
<td>2</td>
<td>Shot Pressure Start Level</td>
<td>0 - 4</td>
<td>bar</td>
</tr>
<tr>
<td>3</td>
<td>Shot Pressure End Level</td>
<td>0 - 4</td>
<td>bar</td>
</tr>
<tr>
<td>4</td>
<td>Squeeze Pressure</td>
<td>2 - 12</td>
<td>kp/cm²</td>
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<tr>
<td>5</td>
<td>Squeeze Speed</td>
<td>0 - 9</td>
<td>steps</td>
</tr>
<tr>
<td>6</td>
<td>Squeeze Holding Time</td>
<td>0 - 9</td>
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</tr>
<tr>
<td>7</td>
<td>Close-up Pressure</td>
<td>0 - 1</td>
<td>bar</td>
</tr>
<tr>
<td>8</td>
<td>Mold Stripping with air (No=0 PP=1 SP=2 PP+SP=3)</td>
<td>0 - 3</td>
<td>steps</td>
</tr>
<tr>
<td>9</td>
<td>PP Chamber Position Correction</td>
<td>-999 - 999</td>
<td>mm</td>
</tr>
<tr>
<td>10</td>
<td>SP Chamber Position Correction</td>
<td>-999 - 999</td>
<td>mm</td>
</tr>
<tr>
<td>11</td>
<td>PP Strip Acceleration</td>
<td>0 - 9</td>
<td>steps</td>
</tr>
<tr>
<td>12</td>
<td>PP Strip Distance</td>
<td>0 - 350</td>
<td>mm</td>
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<tr>
<td>13</td>
<td>SP Strip Acceleration</td>
<td>0 - 9</td>
<td>steps</td>
</tr>
<tr>
<td>14</td>
<td>SP Strip Distance</td>
<td>0 - 250</td>
<td>mm</td>
</tr>
<tr>
<td>15</td>
<td>PP Pattern Temperature</td>
<td>1 - 99</td>
<td>°C</td>
</tr>
<tr>
<td>16</td>
<td>SP Pattern Temperature</td>
<td>1 - 99</td>
<td>°C</td>
</tr>
<tr>
<td>17</td>
<td>PP Pattern Thickness (B)</td>
<td>25 - 350</td>
<td>mm</td>
</tr>
<tr>
<td>18</td>
<td>PP Pattern Height (Q)</td>
<td>0 - 325</td>
<td>mm</td>
</tr>
<tr>
<td>19</td>
<td>SP Pattern Thickness (A)</td>
<td>25 - 250</td>
<td>mm</td>
</tr>
<tr>
<td>20</td>
<td>SP Pattern Height (P)</td>
<td>0 - 225</td>
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<td>21</td>
<td>Core Mask Thickness (M)</td>
<td>125 - 245</td>
<td>mm</td>
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<td>22</td>
<td>Core Inserting Force</td>
<td>0 - 9</td>
<td>steps</td>
</tr>
<tr>
<td>23</td>
<td>Level for Acceptable Vacuum</td>
<td>24 - 99</td>
<td>%</td>
</tr>
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<td>24</td>
<td>Max. Vacuum Level without Cores in Mask</td>
<td>0 - value of no.23 %</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>Distance between Lift. Table and Core Mask</td>
<td>0 - 499</td>
<td>mm</td>
</tr>
<tr>
<td>26</td>
<td>PP Spray Position 1</td>
<td>0 - 2000</td>
<td>mm</td>
</tr>
<tr>
<td>27</td>
<td>PP Spray Position 2</td>
<td>0 - 2000</td>
<td>mm</td>
</tr>
<tr>
<td>28</td>
<td>PP Spray Time</td>
<td>0 - 0.99</td>
<td>sec.</td>
</tr>
<tr>
<td>29</td>
<td>PP Spray Frequency</td>
<td>every 1 - 99</td>
<td>cycle</td>
</tr>
<tr>
<td>30</td>
<td>SP Spray Time</td>
<td>0 - 0.99</td>
<td>sec.</td>
</tr>
<tr>
<td>31</td>
<td>SP Spray Frequency</td>
<td>every 1 - 99</td>
<td>cycle</td>
</tr>
<tr>
<td>32</td>
<td>Sand Level in Sand Hopper</td>
<td>0 - 9</td>
<td>steps</td>
</tr>
<tr>
<td>41</td>
<td>In-Mold Cooling Time</td>
<td>0 - 999</td>
<td>min.</td>
</tr>
<tr>
<td>42</td>
<td>Manual Coresetting (No=0) (PP=1) (SP=2)</td>
<td>0 - 2</td>
<td>steps</td>
</tr>
<tr>
<td>43</td>
<td>CBS (No=0 with operator=1 jig=2)</td>
<td>0 - 2</td>
<td>steps</td>
</tr>
<tr>
<td>45</td>
<td>Core Retainer Active (No=0 Yes=1)</td>
<td>0 - 1</td>
<td>steps</td>
</tr>
<tr>
<td>46</td>
<td>Operation 3A Selected (No=0 Yes=1)</td>
<td>0 - 1</td>
<td>steps</td>
</tr>
<tr>
<td>48</td>
<td>Sand Aeration Pressure</td>
<td>0 - 4</td>
<td>bar</td>
</tr>
<tr>
<td>54</td>
<td>Pouring Cup Position, longitudinal</td>
<td>-50 +50</td>
<td>mm</td>
</tr>
<tr>
<td>55</td>
<td>Pouring Cup Position, transversal</td>
<td>-500 +500</td>
<td>mm</td>
</tr>
<tr>
<td>57</td>
<td>Stop after PP Pattern Change (No=0 Yes=1)</td>
<td>0 - 1</td>
<td>steps</td>
</tr>
<tr>
<td>59</td>
<td>Vacuum during Shot PP (No=0 Yes=1 Ext.=2)</td>
<td>0 - 2</td>
<td>steps</td>
</tr>
<tr>
<td>60</td>
<td>Delay between Vacuum and Shot, PP</td>
<td>0 - 9</td>
<td>steps</td>
</tr>
<tr>
<td>61</td>
<td>Coremask Cross Movement with Cores, 1.speed</td>
<td>0 - 9</td>
<td>steps</td>
</tr>
<tr>
<td>62</td>
<td>Coremask Cross Movement with Cores, 2.speed</td>
<td>0 - 9</td>
<td>steps</td>
</tr>
<tr>
<td>63</td>
<td>CBS Stripping Speed</td>
<td>0 - 9</td>
<td>steps</td>
</tr>
<tr>
<td>64</td>
<td>CBS Stripping Distance</td>
<td>0 - 255</td>
<td>mm</td>
</tr>
<tr>
<td>65</td>
<td>Water Dosage Factor</td>
<td>0 - 255</td>
<td>pulses</td>
</tr>
<tr>
<td>66</td>
<td>Core Jig Height</td>
<td>0 - 700</td>
<td>mm</td>
</tr>
<tr>
<td>67</td>
<td>Vacuum during Shot SP (No=0 Yes=1 Ext.=2)</td>
<td>0 - 2</td>
<td>steps</td>
</tr>
<tr>
<td>68</td>
<td>Delay between Vacuum and Shot, SP</td>
<td>0 - 9</td>
<td>steps</td>
</tr>
<tr>
<td>69</td>
<td>Strip Distance with Strip Air, PP</td>
<td>0 - 350</td>
<td>mm</td>
</tr>
<tr>
<td>70</td>
<td>Strip Distance with Strip Air, SP</td>
<td>0 - 250</td>
<td>mm</td>
</tr>
<tr>
<td>71</td>
<td>Reduction of Bracket Speed with Cores in Mask</td>
<td>0 - 9</td>
<td>steps</td>
</tr>
<tr>
<td>72</td>
<td>Reduction of Rotation Speed with Cores in Mask</td>
<td>0 - 9</td>
<td>steps</td>
</tr>
<tr>
<td></td>
<td>Mold Support Pressures</td>
<td>0 - 4</td>
<td>bar</td>
</tr>
</tbody>
</table>

Fig. 4.22 Production Settings for DMS 2120/2130.
PRODUCTION SETTINGS FOR DMS 2120/2130

Table on Fig. 4.22 shows the most essential production machine settings for the DISAMATIC 2120/2130 models. For each setting the value range is indicated. The quality of the molds and thereby the casting quality depends very strongly on the settings. Therefore they must be chosen carefully and with conscience. The machine design ensures certain standard settings being automatically introduced by the computer, but for each single job the standard settings must be reviewed since they do not take individual requirements into account.

Below follows a short description of each setting. For description and location of the setting devices on the molding machine refer to the respective "INSTRUCTIONS FOR USE".

1. Shot Time Correction

The machine calculates the optimal shot time on the basis of the calculated chamber depth. This shot time does not consider factors such as pattern geometry, shot pressure, sand flowability, vacuum characteristics, pattern venting, sand fluidizing. The shot time can be increased or decreased and is related to the shot pressure (setting 2 & 3). The shot time consists of two factors: T₁ - based on the chamber depth and T₂ - adjustable component (see fig. 4.23).

This setting influences the cycle time of the molding machine.

2. Shot Pressure Start Level

3. Shot Pressure End Level

Shot pressure start and end level shot on DMS 2120/2130 is divided into two stages, P₁ and P₂, in order to optimize the sand density and uniformity of the mold before squeezing (see fig. 4.23). The two shot pressures must be set related to the geometry of the pattern. Sand flowability and fluidizing pressure as well as vacuum/venting characteristics, shot pressure level settings are dependent on shot time correction and chamber depth corrections.

4. Squeeze Pressure (Pₛｑ)

This pressure is measured on the mold face. It is recommendable to keep the squeeze pressure at the minimum, moving most of the compressing work done on the sand at the shooting stage. The recommendable range is between 6 - 12 kp/cm² depending on sand quality, pattern geometry, shot settings, squeeze speed, and squeeze time. The range of the squeeze pressure is different for different DMS 2120/2130 sizes (see fig. 4.20):

\[2120/2130/A : 0 - 14.8 \text{ kp/cm}^2\]
\[2120/2130/B : 0 - 15.1 \text{ kp/cm}^2\]
\[2120/2130/C : 0 - 12.7 \text{ kp/cm}^2\]

This setting influences the cycle time of the molding machine.
Fig. 4.23 The second part of the shot time ($T_2$) is adjustable.

Fig. 4.24 Schematic illustration of the mold stripping with the air.
5. Squeeze Speed ($V_{SQ}$)

This setting is the speed of movement of the PP and SP toward each other during the squeeze (see fig. 4.20). In some circumstances (deep pattern pockets) it can be beneficial to squeeze slower for obtaining more uniform sand compaction. The speed is highest by setting 9. The setting depends on the pattern geometry, flowability of the sand, chamber and pattern venting characteristics.

This setting influences the cycle time of the molding machine.

6. Squeeze Pressure Holding Time ($T_{SQ}$)

This time is the duration of holding of the preset squeeze pressure before the pattern stripping operation starts. This ensures that during the squeezing the sand grains can displace to their new positions in the compressed sand packing (see fig. 4.20). It improves the sand distribution during the squeeze. By setting 0, the PP and SP plates are squeezing the mold in the chamber until the preset squeeze pressure has been obtained and then the pressure is relieved. The table shows the holding time increment obtained by different settings.

This setting influences the cycle time of the molding machine.

7. Close-up Pressure

The pressure against the mold string, which must be obtained during the mold closing operation, before the mold retainers can be activated (see fig. 4.21). The close-up pressure is basically the same for the majority of the items produced, but can be increased for extremely high ferrostatic pressures in the mold, an extremely utilized pattern plate area, etc.

8. Mold Stripping with Air

The setting concerns selection of the compressed air flow through the pattern plate for the stripping assistance (fig. 4.24).

The stripping air pressure can be adjusted on valves PN 139 and PN 140. The stripping air can be specially useful when molding with intricate patterns with short stripping distance (setting No. 12 & 14) and high stripping acceleration (setting No. 11 & 13).

9. PP Chamber Position Correction

10. SP Chamber Position Correction.

The position of the plates in the chamber, calculated by the computer on the basis of the pattern heights and pattern plates thicknesses can be corrected by these settings (fig. 4.25). The true chamber depth and thereby the mold thickness can be increased, which can be beneficial for blowing the sand into extremely intricate patterns or patterns with deep pockets. The chamber depth calculated on the base of the pattern geometry does not always comply with the minimum sand/metal ratio limit. By changing the plate position in the chamber, the sand-to-iron ratio in the mold can be adjusted.

This setting influences the cycle time of the molding machine.
Fig. 4.25 The SP and PP can be moved from their calculated (nominal) position.

Fig. 4.26 The stripping pattern plate moves at first more slowly (slope $\alpha_1$), and after obtaining the preset stripping speed limits, accelerates (slope $\alpha_2$).
11. **PP Strip Acceleration.**

13. **SP Strip Acceleration.**

Accelration of the retracting plates during pattern stripping until the preset stripping distance (setting 12 & 14) is obtained. After the preset distance has been obtained, the maximum retracting speed will be applied (fig. 4.26). The highest acceleration (9) can seldom be used, but be aware of the fact that this setting influences the cycle time of the molding machine. The strip acceleration must be determined in conjunction with the stripping air (setting 8) and depends among other things on pattern venting characteristics, pattern draft, height of green sand cores, molding sand quality.

12. **PP Strip Distance**

14. **SP Strip Distance**

This is the part of the ram stroke which will be undertaken with the reduced acceleration when stripping the pattern, before the acceleration will increase again to the maximum value (fig. 4.26). The strip distance is to be determined in connection with the stripping air (setting 8) and depends on pattern venting, draft, complexity of the pattern shape, molding sand quality, etc.

This setting influences the cycle time of the molding machine.

15. **PP Pattern Temperature.**

16. **SP Pattern Temperature**

The temperature of the pattern plates. The usual setting is 5°C (9°F) above the temperature of the molding sand. Since the maximum recommendable sand temperature is approx. 40°C (104°F), it should not be necessary to heat the plates to a higher temperature than 45°C (113°F).

**NOTE:** Using resin patterns it is not recommendable to exceed 60°C (140°F).

17. **PP Pattern Thickness**

19. **SP Pattern Thickness**

Thickness of the plates (see also "PATTERNS AND CORES", the section "Utilization of the mold thickness") is used for calculating and automatic setting the chamber depth before squeezing.

18. **PP Pattern Height**

20. **SP Pattern Height**

Height of the patterns themselves is used for calculating and automatic setting the chamber depth before squeezing (see also settings No. 17 and 19), as well as centering the pattern tops symmetrically in relation to the blowing slot.

Settings No. 17, 18, 19, and 20 must be introduced into the machine very accurately and carefully. Any erratic values, smaller than the
Fig. 4.27 The core inserting force is indicated by a pressure switch.

Fig. 4.28 Setting No. 24 must be chosen slightly above the value shown by vacuum transducer with the cores held in the mask and setting No. 23 slightly below the value shown by the vacuum transducer after the cores are set into the mold. The vacuum transducer reading is available on the VDU screen by displaying MENU item No. 7.
real pattern thicknesses and heights can cause damage of the patterns
due to too small safety distance between the patterns after the
squeezing. The optimum geometrical chamber depth is calculated by the
computer in accordance with the formula shown in the section about
chamber depth of the present book. It is, however, necessary to
control if the calculated geometrical chamber depth fulfils the
minimum sand/metal ratio condition.

This setting influences cycle time of the molding machine.

21. Core Mask Thickness

This setting is necessary to determine the mold delivery point of
the mold to ensure that during the core setting stroke the mask can
reach the face of the last produced mold. The mask thickness is mea-
ured from back to the parting line of the mask.

Since the mask thickness affects the delivery point of the last pro-
duced mold, the core mask thickness setting must always be larger
than 0. Attention must be paid to the fact that the core mask thick-
ness setting must be smaller than the mold thickness for the actual
job, to ensure correct mold close-up operation.

22. Core Inserting Force

This setting defines the pressure with which the core will be pressed
into the mold during the core setting stroke (fig. 4.27).

The setting 0 gives the lowest pressure. The choice of the setting
will depend on the strength and geometry of the core, core weight,
the mold/core locator fit and core locator size deviation.

23. Level for Acceptable Vacuum

This setting defines the minimum vacuum expressed as percentage of
the atmospheric pressure (approx. 1 bar), with which the cores will
safely be held in the core setter mask. The acceptable vacuum level
is measured after that all the cores to be set are placed in the
mask. This setting is interconnected with setting No. 24, which de-
fines the maximum residual vacuum in the mask after delivering the
cores into the mold. Setting 24 must always be lower than setting 23
(see fig. 4.28).

The setting 23 depends on the core/mask suction area, core size, cen-
ter of gravity, location of the core, core sand permeability, etc.

Remember the main principles saying that the vacuum holes in the mask
must be so large that there is no vacuum drop through the mask and
suction area large enough to hold the cores already placed in the
mask, in spite of the rest of them not being placed there yet.

24. Maximum Vacuum Level Without Cores in the Mask

The max. vacuum in percent of the atmospheric pressure (approx. 1
bar) when there are no cores in the mask (see also setting No. 23).

After the accomplished core setting and cut-off of the vacuum, the
mask does not retract before the setting No. 24 is obtained (see
fig. 4.28).
Fig. 4.29 Distance core mask/lifting table.
Concept for a case with horizontal core jig.
25. **Distance Between Lifting Table and Core Mask**

This setting is defined as distance between reference position of the lifting table and the core mask during the core transferring.

For core transfer from circulating jigs with horizontally placed cores, the distance is measured from the jig's bottom side to the mask front side that touches the mold face at the end of the core setting stroke. (Fig. 4.29, see also setting no. 43, value 2).

26. **PP Spray Position 1.**

27. **PP Spray Position 2**

The settings define positions of the squeeze plate (PP) during operation 5, where the pattern plate will be sprayed with the parting agent first time (position 1) and second time (position 2). The position is measured from the datum called point zero, placed in the chamber of the machine.

The blow in position 1 covers normally the upper area of the plate. The position 2 blow sprays the lowest area of the plate. (See fig. 4.30).

The settings depend mainly on the shape of the patterns.

28. **PP Spray Time**

30. **SP Spray Time**

Definition is the time the spraying nozzles are activated.

As far as the setting No. 28 is concerned, only the position 2 spray time is adjustable. The spray time at the spray position 1 is constantly 50 msec. If the spray time for the PP is set at 0, then the spraying will be stopped also for the SP. The spray time depends mainly on the pattern geometry and pattern material.

29. **PP Spray Frequency**

31. **SP Spray Frequency**

This setting determines whether the pattern plates will be sprayed before each molding operation or less frequently.

By setting 0, there is no spraying at all. The frequency of spraying depends on pattern material, pattern geometry, and molding sand condition, especially bentonite/water ratio, inactive fines, and temperature.

32. **Sand Level in Sand Hopper**

This setting determines the required height of the sand heap in the hopper above the molding machine (fig. 4.31).

If there is too much sand over the blowing slot, it can be compacted.
Fig. 4.30 The spraying nozzles can be activated in two positions of the retracting PP.

Fig. 4.31 The sand heap height over the sand blowing slot is adjustable by setting the height of the sand probe in the hopper.
too hard under its own weight, and this will affect the flowability and thereby the amount of sand being transported down to the molding chamber during the blow operation. Usually the height of the heap should correspond to 1.5 mold, and therefore the setting depends mainly on the actual mold thickness.

41. **In-mold Cooling Time**

This setting is used to ensure that the casting produced will not be taken out too early. The production speed of the machine automatically decreases if there is a risk of a shorter in-mold cooling time than preset.

The setting depends on the metallurgical quality requirements of the casting, its modules of solidification, chemical composition, type of the out-mold cooling equipment, as well as other machine settings, such as mold thickness, length of the cooling conveyor. This program module is an option and requires the software modules 1 & 2 installed in the computer.

This setting influences the cycle time of the molding machine.

42. **Manual Core Setting**

This setting informs the system whether the manual core setting will be applied.

If manual core setting is selected, the molding machine will stop automatically to let the operator set the cores in the mask and push the button, restarting the system again.

There are following setting options:

0→No manual core setting
1→Manual setting in the PP pattern impression. The machine stops at the end of operation 6.
2→Manual setting in the SP pattern impression.

This setting influences the cycle time of the molding machine

43. **Combi Setter (CBS)**

The setting informs the system whether the automatic core setting will be applied.

There are following setting options:

0→No core setting with the CBS.
1→Core setting with cores placed in the mask by the operator, but inserted in the mold cavity by the CBS.
2→Core setting with the automatic core transfer from the circulating jigs to the mask by the lifting table and then inserted in the mold cavity by the CBS.

This setting influences the cycle time of the molding machine
**Fig. 4.32** Operation 3A and application of its elimination. The long protruding green sand cod collides with the upswinging SP (A). Elimination of operation 3A can remedy the trouble (B).

**Fig. 4.33** Three examples of longitudinal pouring cup position.
45. Core Retainer Active

This setting informs the system if the compressed air connection is necessary for the cores being held in the core mask by means of a pneumatic grip instead of or together with the vacuum. The air valve is activated either manually, by the operator when the cores are placed in the mask, or automatically during the core transfer onto the lifting table. The valve is deactivated again when the cores are inserted in the mold.

There are two setting options:

0—The air valve not activated
1—The air valve activated.

This setting influences the cycle time of the molding machine.

46. Operation 3A selected

If the mold has a too large projection on the SP side, it may be necessary to eliminate operation 3A (transport of the mold to the front of the molding chamber, when the mold is still clamped between the PP and the SP), so that the complete mold remains in the chamber. Otherwise the upswing SP may damage the protruding part of the mold (fig. 4.32).

There are two setting options:

0—Operation 3A eliminated
1—Operation 3A necessary

This setting influences the cycle time of the molding machine.

48. Sand Aeration Pressure

The sand aeration system increases the flowability of the sand in the sand hopper by creating an air emulsion acting as a lubricant when shooting the sand down through the blowing slot.

The pressure of the aerating air should not be lower than 1.5 bar to obtain sufficient aeration lubricating effect. The upper limit for this setting is determined by the setting no. 2: shot pressure start level, which may under no circumstances be lower than the aeration pressure. Otherwise these two pressures counteract each other.

The sand aeration pressure should be increased to approx. 3 bar after the finished shift when emptying the sand hopper.

54. Longitudinal Pouring Cup Position

This setting indicates location of the pouring cup related to the parting line (x). The information is used for positioning the auto-pour along the string of the molds to ensure central heating of the pouring cup by the jet of the poured metal.

When the cup is shifted towards the mold transporting direction, then x > 0 (plus). When the cup is shifted towards the molding machine, x < 0. Otherwise, x = 0 (center line of the cup is co-axial with the parting line, fig. 4.33).
Fig. 4.34 Three examples of transversal pouring cup position.

Fig. 4.35 The vacuum assistance is normally synchronized with the sand shot. However, there is a possibility of activating the vacuum slightly ahead of the shot in order to increase the pressure drop between both sides of the blowing slot.
55. Transversal Pouring Cup Position

This setting indicates location of the pouring cup related to the mold string center line. The information is used for positioning the auto-pour perpendicular to the mold string. The negative setting indicates the cup positioned to the left from the center line, and positive setting indicates the cup positioned to the right (looking towards the mold transport direction, fig. 4.34).

57. Stop After PP Pattern Change

This setting indicates whether it is necessary to stop the molding machine right after a new pattern plate has been placed on the PP during the pattern change. This can be practical if the operator has to introduce some manual adjustments, before the run of the new job can start.

0—Indicates no stop.
1—Indicates stop after PP pattern shift.

59. Vacuum During Shot, PP

67. Vacuum During Shot, SP

These settings indicate whether the vacuum assistance is necessary during the shot to get a better flow of the sand into the pocket of an intricated pattern (respectively for the PP and the SP, see fig. 4.35). The application of the vacuum can improve the mold quality in difficult areas of the pattern plate. The conditions are the right timing, sufficient venting of the pattern pockets, and optimum sand flowability (clay/water ratio, grain size, inactive fines content, etc.).

There are following options:

0—No vacuum during shot
1—Vacuum assisted shot
2—Vacuum assisted blow and squeezing.

60. Delay Between Vacuum and Shot, PP

68. Delay Between Vacuum and Shot, SP

This setting enables to activate the vacuum ahead of the start of the sand shot (see fig. 4.35).

There are basically three operations that have to occur during the vacuum aided sand shot, prior to the sand squeeze: sand aeration, vacuum activating, and the blow itself. The normal sequence is the aeration first and then the blow and vacuum simultaneously. In some cases, however, it can be an advantage to activate the vacuum slightly ahead of the shot, to empty the chamber of air before the blow starts, in order to increase the "pressure drop" between the blowing slot and the vents in the pattern plates. This delay of the blow has nine steps where:
Fig. 4.36 The curve of the slope $\alpha_1$ depicts the slow part of the core mask stripping until the preset stripping speed limit and distance are obtained.
0—No delay
1—0.1 sec. delay
.
9—0.9 sec. delay.

This setting influences the cycle time of the molding machine.

61. Coremask Cross Movement with Cores, 1st Speed

This is the speed of the coremask loaded with the cores during the first half of its movement perpendicular to the mold string. In some cases where the core is particularly heavy and/or the gravity center of the core is placed off the parting line of the mask, it can be an advantage to minimize the inertia force when the mask starts its movement towards the mold string (see also setting No. 62).

Setting "0" indicates the lowest speed.

This setting influences the cycle time of the molding machine.

62. Coremask Cross Movement with Cores, 2nd Speed

This setting indicates the speed of the coremask during the second half of the movement perpendicular to the mold string (see also setting No. 61). A core with the center of gravity shifted particularly long away from the parting line of the mask will be exposed to large inertia forces when decelerating behind the mold string. In these cases it can be an advantage to decrease the mask speed at this stage of the core setting movement.

Setting "0" indicates the lowest speed.

This setting influences the cycle time of the molding machine.

63. CBS Stripping Speed

This setting indicates the pull-away speed of the empty mask, just after the cores have been set into the mold. There are two possible forces during the mask retraction, that can require the slow-down (see fig. 4.36):

a) friction forces, when a heavy core or a core package rests on the bottom of the mask cavity with relatively large contact area. In this case, during the mask pull-away the core will always have a tendency of staying inside the mask, if the speed is too high.

b) retaining forces due to the rest vacuum (see also the setting No. 24) in the mask.

A lower mask retraction speed is necessary especially when the dimensional variation of the locators on the cores and/or molding sand properties variations are so large that the fit between the locators and their mold cavities changes constantly. In the case of a too loose fit, it is usually necessary to decrease the retracting speed of the mask.
Fig. 4.37 Duration of the stripping air flow can be extended beyond the stripping movement of the plates.

Fig. 4.38 There are four pressure settings on the mold side supports, depending on the location along the PMC and whether the thrust bars belong to the upper or the lower section of the bars.
Setting "0" means the lowest speed.

This setting influences the cycle time of the molding machine.

64. CBS Stripping Distance

This setting determines the length of the retracting stroke part of the mask, that should be carried out with the decreased speed (see also setting No. 63), before it increases to the normal speed (see fig. 4.36).

The stripping distance corresponds usually to the distance from the core delivery point to the point where the core has cleared the retracting mask. This applies only to the cases described under the setting No. 63, which means for the cores with large dimensional deviations and/or heavy cores resting with a large contact surface on the bottom of the mask cavity.

This setting influences the cycle time of the molding machine.

65. Water Dosage Factor

This setting can be used for control of the water addition to the cooling drum or shake-out conveyor in the extension of the molding machine. The mold bookkeeping system in the computer of the machine informs the water dosing system whether the mold in question falling actually down off the mold cooling conveyor is a pourer or a non-poured one. On the basis of this information the water adding system triggers off a preset amount of water. The system does not take into account any additional water amount necessary due to elevated sand temperature caused by any stop of the molding line.

66. Core Jig Height (H)

This setting indicates the height of the core jigs used in case a run with circulating jigs on the TSC is selected (see fig. 4.29).

This information is used for the computer to calculate the lifting height of the lifting table during the core transfer to the core mask from the

a) horizontally circulating jigs
b) vertically circulating jigs

The core jig height is measured as the distance from the lower to the upper point of the jig.

69. Strip Distance with Strip Air, PP

70. Strip Distance with Strip Air, SP

This setting indicates the lapse of time it is necessary to assist the pattern stripping with the compressed air (see fig. 4.37).

The main purpose of the air injection between the mold impression and the stripping pattern is to equalize the pressure in order to get rid of the vacuum created by the retracting pattern. The strip distance depends on the pattern draft size, pattern venting condition, sand
ENCIRCLED NUMBERS REFER TO THE NUMBERS OF PRODUCTION SETTINGS.

\[ T_1 = \text{SHOT TIME BASED ON CHAMBER SIZE.} \]

\[ T_2 = \text{SHOT CORRECTION} \quad (1) \quad (\pm \text{VALUE}) \]

\[ T_{\text{SHOT}} = T_1 + (T_2) \]

\[ T_{\text{AIR}} \]

\[ T_{\text{SHOT}} \leq 1 \text{ SEC.} \Rightarrow T_{\text{AIR}} = T_{\text{SHOT}}/2 \]

\[ T_{\text{SHOT}} > 1 \text{ SEC.} \Rightarrow T_{\text{AIR}} = T_{\text{SHOT}} - 0.5 \text{ SEC.} \]

\[ P_1 \quad \text{SHOT PRESSURE START LEVEL} \quad (2) \]

\[ P_2 \quad \text{SHOT PRESSURE END LEVEL} \quad (3) \]

\[ P_{\text{FA}} \quad \text{SAND AERATION PRESSURE} \quad (28) \]

\[ P_{\text{SO}} \quad \text{SQUEEZE PRESSURE} \quad (4) \]

\[ T_{\text{SO}} \quad \text{SQUEEZE TIME} \quad (5) \]

PLEASE NOTE THAT THE DRAWING IS ONLY SCHEMATIC.
THIS MEANS THAT SCALING IS NOT CORRECT.

Fig. 4.39 Some of the machine setting functions synchronized in accordance with the six standard operations.
properties (especially the permeability), stripping distance (see setting No. 12 & 14) and stripping acceleration (see setting No. 11 & 13).

**Mold Support Pressures**

These settings ensure supporting of the sides of the thermally loaded molds. This support improves dimensional stability of the molds and, providing the proper sand quality, allows higher pattern plate utilization (see fig. 4.38).

The pressure in the lower sections of the support should be slightly larger than that in the upper sections, due to the higher ferrostatic pressure involved in the poured molds.

It applies to both planes that the pressure in the discharge zone of the supports can be slightly lower than that in the inlet zone (see fig. 4.38), where the metal is still liquid. This way the setting of the pressure in line B will be highest, and in line C lowest.

It is quite obvious that each pair of the thrust bars receives the same pressure on either side of the mold string. The general rule is to minimize the pressure so that a too high thrust does not increase the friction between the molds and the bars unnecessarily.

The maximum pressure is 4 bars, but the usual setting for the lowest row of the bars in the inlet zone will be 0.6 bar and in the discharge zone 0 bar. For the highest row the pressure can be decreased to 0.5 bar in the inlet zone and still kept at 0 bars in the discharge zone.

For thin section and less critical castings the pressures can be lower and be respectively 0.4 bar and 0.3 bar.

At the start-up of the machine the bars might be left without pressure until the start of the pouring.

When restarting with the full mold conveyor (f.ex. after a production stop) it might be necessary to exhaust all thrust bars for a short moment.

71. **Reduction of Bracket Speed with Cores in Mask**

Reduction factor reducing speed of longitudinal movements when the CBS returns from the core gate to position for cross movement.

The speed profile (MENU 2.3) should be adjusted with the grippers gripping an empty core mask and with a reduction factor of 9. Subsequently the factor is gradually reduced until it is possible to perform the movement without losing the cores.

Level adjustment from 0 to 9.

9 = no reduction of speed (maximum speed)

5 = reduction to 75% of maximum speed

0 = reduction to 44% of maximum speed

This setting influences the cycle time of the molding machine.
72. Reduction of Rotation Speed with Cores in Mask

Reduction factor reducing speed of rotary movements performed by the CBS with the core mask containing cores during core setting, i.e. during core setting from circulating core jigs, horizontal cores.

The speed profile (MENU 2.3) should be adjusted with the grippers gripping an empty core mask and with a reduction factor of 9. Subsequently the factor is gradually reduced until it is possible to perform the movement without losing the cores.

Level adjustment from 0 to 9.
9 = no reduction of speed (maximum speed)
5 = reduction to 75% of maximum speed
0 = reduction to 44% of maximum speed

<table>
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<tr>
<td>34 SP pattern no.</td>
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<tr>
<td>35 Core mask no.</td>
</tr>
<tr>
<td>36 Core jig no.</td>
</tr>
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<td>37 PF Pattern Volume</td>
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<tr>
<td>38 SP Pattern Volume</td>
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<tr>
<td>39 Core-sand Volume</td>
</tr>
<tr>
<td>40 Poured Metal, weight</td>
</tr>
<tr>
<td>47 SP Pattern Plate, Weight</td>
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<tr>
<td>49 Pouring Temperature</td>
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<tr>
<td>50 Max. Pouring Time</td>
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<tr>
<td>51 Pouring Rate</td>
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<tr>
<td>52 Pouring Parameter, Spare 1</td>
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<td>53 Pouring Parameter, Spare 2</td>
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<tr>
<td>56 Returned Metal, Weight</td>
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<td>58 Pattern/Casting type</td>
</tr>
</tbody>
</table>

Fig. 4.40 Informative settings for DMS 2120/2130.

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INFORMATIVE SETTINGS FOR DMS 2120/2130

The informative settings are the parameters having no direct influence on the molding process, but contain information to the operator with regard to the number of the tooling actually being used, sand consumption, iron consumption, casting being actually produced or pouring data, such as maximum pouring time, actual pouring rate etc. This information is transferred to the mold bookkeeping system in the computer during the production and can be seen on the VDU unit or be picked up by the central computer system of the foundry. The table on fig. 4.40 shows the informative parameters available and here a short description of each setting follows.

33. **PP Pattern No.**

The identification number of the PP pattern. This number must be coded in the PP pattern plate by means of a special coding system which can be read by the machine.

The code number is used by the machine for unambiguously finding the pattern plate data of the PP pattern.

See DISA publication.

34. **SP Pattern No.**

The identification number of the SP pattern. This number must be coded in the SP pattern plate by means of a special coding system which can be read by the machine.

The code number is used by the machine for unambiguously finding the pattern plate data of the SP pattern.

The method of number coding is described in DISA publication.

35. **Core Mask No.**

The identification number of the core mask. This number must be coded in the core mask by means of a special coding system which can be read by the machine.

The number is used by the machine to check that the core mask is the correct one for the pattern plate set.

The number is only important when core setting with CBS has been selected (see production setting no. 43).

See DISA publication.

36. **Core Jig No.**

Identification number of the core jig. This code number must be coded in the core jig by means of a special code system which can be read by the machine.

The number is used by the machine to check that the core jig does belong to the pattern plate set.
Fig. 4.41 Sketch describing pattern plate information settings.
The number is only important if core setting from the circulating core jig has been selected (see production setting no. 43).

See DISA publication.

37. PP Pattern Volume

Volume of pattern on PP pattern plate. The parameter is used when calculating the sand consumption which is the chamber size minus the two pattern volumes.

NOTE: If the pattern is negative (plate A on sketch), the volume entered must have a negative value. See sketch on fig. 4.41.

38. SP Pattern Volume

Volume of pattern of SP pattern plate. The parameter is used when calculating the sand consumption which is the chamber size minus the two pattern volumes.

NOTE: If the pattern is negative, the volume entered must have a negative value. See sketch on fig. 4.41.

39. Core Sand Volume

Amount of core sand in each mold. The parameter is used when calculating the total consumption of core sand.

NOTE: Parameters used as information to the operator with regard to sand consumption, iron consumption, etc. are transferred to the mold book-keeping during mold production and can be seen on the terminal or be collected by the computer system of the foundry.

40. Poured Metal Weight

Total weight of castings and inlet. The parameter is used when calculating the melt consumption.

See the note at the setting 39.

47. SP Pattern Plate Weight

Weight of SP pattern plate. The parameter is used to obtain optimum movement of SP.

Even though the setting range is very large, the max. SP pattern plate weight is 300 kgs.

49. Pouring Temperature

Desired pouring temperature. The parameter is not used by the machine itself, but can be used by the operator as information about the desired pouring temperature.

NOTE: Parameters used as information to the pouring devices are transferred to the mold book-keeping during mold production and can from here be read on the VDU.

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In this way the operator - by means of the mold book-keeping - is able to get information about each mold in the mold string, e.g. desired pouring temperature, desired pouring time, etc.

50. Max. Pouring Time
Desired, maximum pouring time. The parameter is not used by the machine itself, but can be used by the operator as information about the desired pouring time.

See note at setting no. 39.

51. Pouring Rate
Desired pouring speed. The parameter is not used by the machine itself but can be used by the operator as information about desired pouring rate.

See note at the setting no. 49.

52. Pouring Parameter, Spare 1
Available parameter which the foundry may use for their own information, e.g. customer number, iron type, etc.

See note at the setting no. 49.

53. Pouring Parameter, Spare 2
Function and adjusting area as setting no. 52.

56. Returned Metal Weight
The weight of the returned metal, i.e. gating system etc.

See note at the setting no. 39.

58. Pattern/Casting Type
Parameter which can be used to show pattern type, iron type (SG iron grey iron), or similar.

The parameter is not used by the machine itself but can be used by the operator for his own information.

See note at the setting no. 49.
### DMM 2070 Production Settings

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value Range</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>PP Pattern Height</td>
<td>25 - 382</td>
<td>mm</td>
</tr>
<tr>
<td>SP Pattern Height</td>
<td>25 - 312</td>
<td>mm</td>
</tr>
<tr>
<td>PP Plate Thickness</td>
<td>25 - 407</td>
<td>mm</td>
</tr>
<tr>
<td>SP Plate Thickness</td>
<td>25 - 337</td>
<td>mm</td>
</tr>
<tr>
<td>Shot Pressure</td>
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<td>bar</td>
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<tr>
<td>Shot Time Optimization</td>
<td>0.4 - 2.5</td>
<td>sec</td>
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<td>Squeeze Pressure</td>
<td>6 - 12 (on mold side)</td>
<td>kg/cm²</td>
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<td>Squeeze Speed Extension</td>
<td>1 - 30</td>
<td>positions</td>
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<tr>
<td>Mold Retaining Pressure</td>
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<td>bar</td>
</tr>
<tr>
<td>Close-up &amp; Transport Pressure</td>
<td>0 - 2</td>
<td>bar</td>
</tr>
<tr>
<td>Pattern Spraying Time &amp; Freq.</td>
<td>0.1, 0.15, 0.22, 0.39</td>
<td>sec.</td>
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<td>Pattern Spraying</td>
<td>On, Off</td>
<td>positions</td>
</tr>
<tr>
<td>Pattern Stripping Acceleration</td>
<td>PP, SP, Both, 1-9</td>
<td>positions</td>
</tr>
<tr>
<td>Mold Blow-off</td>
<td>On, Off</td>
<td>positions</td>
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<tr>
<td>Pattern Vibrators</td>
<td>On, Off</td>
<td>positions</td>
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<td>Core Mask Thickness</td>
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<td>Chamber Depth Correction</td>
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<td>Core Setting Shock Absorber</td>
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<td>Core Setting Mode</td>
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<tr>
<td>Strip Distance SP</td>
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</table>

Fig. 4.42 Production settings for DMM 2070.
PRODUCTION SETTINGS FOR DMM 2070

The tables shown on fig. 4.42 show the parameters influencing the molding process to be set on the 2070 DMM models. The selection of the settings vary of course from model to model.

Later in the section there is a short description of the role of each setting and a guideline concerning its influence on the molding process. For description and location of the setting devices on the molding machine refer to the respective "INSTRUCTIONS FOR USE" or "SERVICE MANUAL".

1. **PP Pattern Height**

2. **SP Pattern Height**

   The height of the patterns is used for automatic calculation and setting the optimum chamber depth before the shot as well as centering the pattern tops symmetrically in relation to the blowing slot.

   These values must be set very carefully and accurately. Any erratic values smaller than the actual ones can cause the pattern crash due to too small safety distance between the patterns.

   The optimum geometrical chamber depth is calculated by the computer in accordance with the formula shown in the section about chamber depth of the present book. It is, however, necessary to control if the calculated geometrical chamber depth fulfils the minimum sand/metal ratio condition.

   This setting influences cycle time of the molding machine.

3. **PP Plate Thickness**

4. **SP Plate Thickness**

   Thickness of the plates is used for calculating and automatic setting the chamber depth before squeeze. These settings must be introduced very carefully. Any erratic values smaller than the actual ones can cause damage of the patterns due to a too small safety distance between them.

   This setting influences cycle time of the molding machine.

5. **Shot Pressure**

   Shot pressure is one of the most important settings, since the majority of the sand compaction work should be done during the shot.

   The squeeze has to deliver just enough of energy to increase the density of the precompacted sand during the shot. During the shot the sand has to be introduced into the deepest pockets of the patterns and the air present in the chamber must in the same time be evacuated through the chamber plate venting system and the pattern plate vents installed to avoid the air cushion effect.

   The usual setting, applicable for the majority of the patterns stays between 2.5 and 3.5 bars, however changing the shot time (setting no. 6) adjustment of the shot pressure is often necessary.
The shot pressure setting depends on pattern geometry, sand flowability, pattern venting condition and the depth of the chamber.

6. **Shot Time Optimalization**

The utilization of the blow effect can sometimes be improved by varying the time of the shot. As it can be imagined, the filling sequence of the molding chamber and hereby also the pattern pockets depends on the mold thickness, how turbulent the sand flow is and how much air there is entrapped in the jet of the sand being blown in. Some pattern geometries are more vulnerable on the turbulent sand flow than others. It is a strictly empirical job to optimize the shot time. The machine optimizes the shot time only from the chamber depth point of view.

This setting influences cycle time of the molding machine.

7. **Squeeze Pressure** \( (P_{Sp}) \)

This pressure is measured on the mold face. It is recommendable to keep the squeeze pressure to the minimum, moving the most of the compressing work done on the sand at the shooting stage. The recommendable range is 6 - 12 bar, depending on sand quality, pattern geometry, shot settings and squeeze speed.

The squeeze pressure on the operator panel is indicated as pneumatic pressure on the valve controlling the hydraulic pressure of the squeezing. The table on fig. 4.14 shows the correlation between the setting of the pneumatic pressure and the squeeze pressure on the mold face.

This setting influences cycle time of the molding machine.

8. **Squeeze Speed Extension**

This setting indicates the speed of the movement of the squeezing plates towards each other (see fig. 4.20), showing the squeeze speed down can be beneficial to the patterns with deep pockets. The lower the speed, the more time there is for the air evacuation and sand grains displacement during the squeeze. The vast majority of the patterns produced, however, will be molded with max. squeeze speed.

9. **Mold Retaining Pressure**

The role of this setting is to ensure proper holding force of the mold retainers before the PP stripping operation can start. The retainers have a double function:

a) to maintain the mold string pressed together also, when the ram does not retain them anymore.

b) to prevent the mold pull-back when stripping the ram pattern. The standard setting is approx. 1 bar and can be used for the vast majority of jobs. Very intricate patterns, especially the insufficiently vented ones can require some higher retaining pressure. See fig. 4.21.
10. **Close-up and Transport Pressure**

This setting is the pressure against the mold string, which must be obtained during the mold closing operation (operation no. 4), before the mold retainers can be activated. The same pressure is applied by the ram when reindexing the mold string after the close-up. This is called mold transport pressure.

The setting is generally the same for most jobs and stays between 0.5 – 1 bar, however, patterns where extremely high ferrostatic pressures are involved may require some higher pressure setting. It must be born in mind that too high transport pressure can cause mold deformation across the parting line and in an extreme case mold crushing. Here, the molding sand quality has decisive importance.

11. **Pattern Spraying Time & Frequency**

There is a possibility of choosing the pattern spray activation time. The options are 0.1, 0.15, 0.22, and 0.39 sec. The spraying time depends on the intricacy of the patterns, molding sand condition, and the plate moving speeds.

To some extent it is also possible to choose different spraying frequency. The option is every 1st, 2nd, 4th, and 8th cycles. The frequency of spraying depends on the pattern material, pattern geometry, and molding sand condition, especially bentonite quality, bentonite/water ratio, content of inactive fines and temperature.

12. **Pattern Spraying**

This setting is affected by a two-position switch. The option is spray off and spray on.

13. **Pattern Stripping Acceleration**

This setting defines the increase of the velocity of the retracting patterns during the speed. There are 9 steps, where step 1 indicates minimum acceleration. Most of the patterns are run on the maximum setting (step 9). Sometimes the pattern venting is insufficient, pattern draft has to be very small or there are very high green sand costs in the mold impression. In these cases it is recommendable to decrease the stripping acceleration. The quality of the molding sand has decisive importance for the stripping acceleration as well.

This setting influences cycle time of the machine.

14. **Mold Blow-Off**

This setting is made by a switch, selecting whether the blow-off is necessary or not. This switch is normally set on blowing-off both pattern impressions.

15. **Pattern Vibrators**

This setting selects whether the vibration of the patterns during the stripping is necessary. The usual selection is position 2 (PP and SP vibrators on). For very simple patterns, however, the vibrators can be switched off, which decreases the noise inconvenience.

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16. **Core Mask Thickness**

The core mask thickness together with the pattern heights and plate thickness is for the computer base for calculating, among other data, the mold delivery point, i.e. the point where the mask touches the mold face at the end of the core setting stroke.

If running without core setting, the mask thickness should always be set to 100 mm.

If running with the shifted core-setter shock absorber (see setting no. 18) for extra high cores, the adjustment should be mask thickness plus 40 mm.

17. **Chamber Depth Correction**

The position of the plates in the chamber before the squeeze, calculated by the computer on the base of the pattern heights and pattern plates thicknesses can be corrected by these settings. The true chamber depth and thereby the mold thickness can be increased, which can be beneficial or blowing the sand into extremely intricate patterns or patterns with deep pockets. The chamber depth calculated on the base of the pattern geometry does not always comply with the minimum sand/metal ratio limit. If a high metal weight requires a thicker mold, it can be accomplished by this setting.

This setting influences cycle time of the molding machine.

18. **Core Setting Shock Absorber**

The shock absorber placed on the core setter in front of the core mask console has two positions:

a) standard position, closest to the molding machine.

b) position 40 mm away from the molding machine.

The standard position is used for most cored jobs. The second position is an option, which makes it possible to make full use of the entire stroke (300 mm) of the air cylinder and hereby to be able to increase the height of the core protruding from the core mask by 40 mm.

This setting influences cycle time of the molding machine.

19. **Core Setting Mode**

This setting has three options:

- no core setting
- manual core setting
- automatic core setting

This setting influences cycle time of the molding machine.

20. **Pattern Temperature**

The purpose of the pattern heating is to avoid sticker defects due to the sand moisture condensing on a cold pattern surface. The usual
setting is 5°C (41°F) above the usual sand temperature. This value must be higher, if bigger variations of the sand temperature are expected during the shift. Excessively heated plate, however, can cause unnecessary drying of the mold cavity during the squeezing and transport of the molds. This in turn will be fatal for the casting quality. Since the maximum recommendable sand temperature is approx. 40°C (104°F), it should not be necessary to heat the patterns to a higher temperature than 45°C (113°F).

NOTE: Using resin patterns it can be dangerous to exceed the temperature of 60°C (140°F).

21. Core Mask Speed

Mask movements in both directions have adjustable speed.

- Speed of the movement along the mold string.

The normal setting is 3 bar. However, in the cases of particularly heavy cores or having the gravity center shifted extremely off the parting line of the mask, it can be an advantage to minimize the inertia force occurring when the mask and cores start their movement along the mold string.

Do not change this setting before you have made sure that the sucking holes, sucking areas, and the vacuum in the mask are sufficiently large.

This setting influences cycle time of the molding machine.

- Speed of the movement across the mold string.

The normal setting is 3 bar. However, a core or core package with the center of gravity shifted particularly far away from the parting line of the mask will be exposed to large inertia forces due to decelerating the mask behind the mold string. In such cases, it is an advantage to decrease the mask speed of this core setting movement.

Do not decrease the mask speed before you have made sure that the size of the sucking holes, the sucking areas and the vacuum in the mask are sufficiently large.

This setting influences cycle time of the molding machine.

22. Core Setting Force

This setting defines the pressure with which the core will be pressed into the mold cavity during the core setting stroke (fig. 4.27). The necessary force depends on dimensional consistence of the core or core package locators, the mold/core locator fit, core weight, strength and geometry of the core and molding sand plasticity and strength. The normal setting is approx. 3 bars and can be used for most jobs. The optimum core setting force must be determined experimentally.

23. Pneumatic Core Holder

If pneumatic core holders instead of or together with the vacuum are used for core retaining in the mask, there is a possibility of set-
ting the air pressure operating the holding devices (see the section about the core mask design). The normal air pressure will be approx. 3 bars.

24. Core Blow-Off

The pressure supplied to the core blow-off nozzles can be adjusted and the normal value is 2 bars.

25. Mold Transport Speed

This setting is used very rarely. Actually, only if some extra long time is necessary for the mold blow-off or more careful visual mold cavity inspection during mold conveying out of the chamber. The mold conveying speed can stepwise be decreased down to 1/16th of the normal speed.

This setting influences cycle time of the molding machine.

26. Operation 3A Eliminated

If the mold has a too large projection on the SP side, it may be necessary to eliminate operation 3A (transport of the mold to the front of the molding chamber, when the mold is still clamped between the PP and the SP), so that the complete mold remains in the chamber. Otherwise, the upswinging SP may damage the protruding part of the mold (fig. 4.32).

27. Strip Distance PP

28. Strip Distance SP

This is the part of the ram stroke which will be undertaken with the reduced acceleration when stripping the pattern, before the acceleration will increase again to the maximum value (fig. 4.26). Introducing the extended strip distance causes maintenance of the reduced stripping speed, until the pattern plate is completely free from the mold. A benefit of the extended stripping length will be obtained, when there are bad pattern venting conditions, too low pattern draft, and the molding sand is of bad quality.

This setting influences cycle time of the molding machine.
Fig. 4.43 Mold troubleshooting.
MOLD PRODUCTION TROUBLE SHOOTING

As is often the case, even the most dangerously looking molding problems can be solved relatively easily by simple means. In this section we will try to give some hints on how to get rid of some troubles which may occur when preparing a mold string for pouring. A troubleshooting cross-check table is shown in fig. 4.43. Some further explanations are given below in addition to table 4.43.

Mold Production
Shear- and Tear-off
Possible reasons:

- Poor molding sand strength properties.
- Too high content of inactive fines makes the sand brittle.
- Distorted pattern plates.
- Vertically shifted positioning of the plates due to excessive wear of guide pins or bushings.
- Counterdraft, scratches or wear on the patterns.
- Bad air evacuation from the deep pattern pockets causing vacuum creation during pattern stripping and thus tear-off. Use air vents.
- Pattern plates positioned inclined (see "Patterns and Cores") causing a counterdraft on the patterns.
- Bad core/mold fit can cause mold break-off during core setting.
- Incorrect core dimensions can be the reason for mold break-off.
- Too high squeeze pressure causes sand "spring-back" and thus tear-off.
- Sand build-up under the squeeze plate (scraper strip damaged).
- Non-parallelism of the pattern plates causes counterdraft on the patterns where, otherwise, the draft would have been correct.
- The pattern plate guide bushings/pins in the heater plates are out of alignment.
- Bottom plate worn.
- Misalignment between bottom plate and rail.
- Counterpressure plate's main bearings worn or out of alignment.
- Tierod and tierod bushings worn.
• Tierod stop collars misadjusted.
• Plugged chamber vents.
• Improperly adjusted guide blocks.

Mismatch
• Pattern plate distortion.
• Excessive wear on the guide pins/bushings of the plates.
• Misalignment between DMM and mold conveyor.
• Heater plates out of parallelism.
• Guide/bushing brackets on the heater plates misadjusted.
• Misalignment between bottom plate and rail.
• Counterpressure plate's main bearings worn or misadjusted.
• Tierods and tierod bushings worn.
• Tierod stop collars misadjusted.
• Guide bars improperly adjusted.
• Guide blocks improperly adjusted.

Soft Sand Codes
• Too high sand moisture content reduces flowability and causes poor sand compaction during the blowing operation.

• Poor air evacuation from the deep pattern pockets during sand blowing. Use air vents.
• Too high blow pressure.
• Too low squeeze pressure.
• Poor sand distribution during sand blowing operation. Chamber depth increase creates more space for the sand, which - blown into the chamber - can be better distributed over the deep pattern pockets.

• Plugged vents in chamber plates.

Stickers
• Poor strength properties of the molding sand.
• Too wet sand tends to stick to the pattern.
• Too high content of inactive fines makes sand sticky
- Water from too hot sand condenses on the colder pattern plates and causes stickers.
- Excessive wear, hits or scratches on the patterns.
- Too high squeeze pressure leads to sand "spring-back" and increases the risk of stickers.
- The pattern spray system must be adjusted and the proper spraying time interval chosen.
- Temperature of the patterns must exceed the temperature of the molding sand by approx. 5°C. This does not always apply to resin patterns.

Uneven Mold Hardness Distribution
- Low degree of sand lump dispersion and sand aeration.
- Insufficient air evacuation from the deep pattern pockets and from the the "shadows" under the patterns.
- Incorrect setting of blow pressure causes poor sand distribution before squeezing.
- Too low squeeze pressure.
- Too short sand blowing time causes too little sand supply in the top of the chamber resulting in a softer top part of the mold. On the other hand, too long a sand blow will increase the pre-squeeze compaction of the bottom part of the mold.
- A larger chamber depth gives the blow sand a possibility of better distribution.
- Plugged vents in chamber plates.

Dirt in the Mold Cavities
- The protecting pattern plate plastic strips and pouring cup wear plates cause creation of sand brims, which, if broken off, can contaminate the mold cavity.
- There must be room in the core locator of the mold for both the sand scratched off the mold and the core during core setting.
- Incorrect pattern blow-off instead of mold cleaning can cause mold cavity contamination.
- Sand mixed with excess sprayed separation fluid, as well as dry sand, will always be deposited in various places of the machine. Flakes of dirt can easily fall off and enter the mold cavity.

Non-parallelism of the Mold Sides
Any kind of non-parallelism of the mold sides is unacceptable. It can be caused by:
a) Distorted pattern plates.
b) The pattern plates do not make contact with heater plates over the whole surface.
c) Too long or too short sand blowing times.
d) Non-parallelism of the heater plates.
e) Excessive wear or misadjustment of the counterpressure plate bearings.
f) Stop collars and stop blocks.
g) Pressure pads and stop pads.

**Deformation on the Parting Line**
- Too low compression strength of the molding sand.
- Too low squeeze pressure.
- Too high transport pressure.
- Excessive pattern wear causes reduced transport surface between the molds.
- Misadjusted mold conveyor.
- Kiss point not adjusted (2013)

**Core Setting**

**Poor Core Retention in the Mask**
- Too loose a fit between the core and the mask. The suction forces are insufficient because of bad vacuum sealing.
- Too small vacuum holes in the mask.
- Uneven suction surface on the core.
- Changed core/mask fit because of core distortion or core out of dimension because of worn core box.
- Too rapid mask movement, creating extra inertial forces.
- Filter in vacuum unit needs cleaning.

**Poor Core Retention in the Mold**
- Poor green sand strength properties.
- Excessive wear of the pattern causing too tight mold/core fit.
- Incorrectly designed mold/core fit.
- Core jamming in the mask.
- Core out of dimension because of core box wear.

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• Poor core sand strength.
• Too high squeeze pressure.
• Misadjustment of coresetter shock absorber.

Core Crush
• All reasons for misalignment between the core mask and mold string will result in inaccurate core setting and thus core crush:
  • Pattern plates distortion.
  • Guide pins/bushings wear.
  • Poor contact between the pattern plates and the heater plates.
  • Core mask guide/bushings worn down.
  • Non-parallel heater plates.
  • Excessively worn patterns create incorrect mold/core fit.
  • Too tightly designed mold/core fit.
  • Core setter/DMM not adjusted mutually.
  • Misadjustment of mask guide brackets.
  • Too tight mask/core fit.
  • Core out of dimension.
  • Poor strength of the core sand.

Poor Core Mask Delivery
• Any defect causing inaccurate mask/mold contact (see troubleshooting table fig. 4.43) at the moment of the core delivery results in poor core setting. The actual mask/mold contact can be checked by covering the mask surface with pulverized chalk or similar and checking the chalk imprint on the mold surface after running a core setting cycle.
  • Core out of dimension.
  • Wrongly adjusted core setter shock absorber (for 2013) or incorrect core mask thickness, set on the 2070 DMM.
  • The core setter mask console is not perpendicular to the mold string.

Mold Transport
Mold Crush at Close-up
• Poor molding sand strength properties.
• Poor contact surface between the molds.
• Too low squeeze pressure.
• Misalignment between the molding machine and the mold conveyor.
• Incorrect ram speed profile.
• Misadjustment of kiss point.

Mold Crush at Mold String Transport
• Poor molding sand strength properties.
• Poor contact surface between molds.
• Misalignment between the molding machine and the mold conveyor.
• Misalignment between the bottom plate and the rails.
• Uneven mold conveyor.
• AMC forward pressure too low (DMM 2013 Mk3)
• Transport pressure too high.

Open Parting Lines
• Distorted pattern plates.
• The ram draws the mold back during pattern stripping, caused by vacuum creation in poorly vented pattern pockets.
• Misadjusted mold retainer or incorrect setting of retainer pressure.
• Too high stripping speed.
• Misalignment between DMM/mold conveyor.
• Uneven mold conveyor.
• Guide bars improperly adjusted.

Mold Sticks to the Rails
• Too high moisture content in the green sand. The water condenses at the high conveyor rails.
• Too much inactive fines in the molding sand causing excessive water demand.
• Too short a distance between the casting and the mold bottom.

COOLING THE CASTINGS
The cooling rate of the casting strongly affects its quality, such as:
• machinability
Fig. 4.44 Nomogram for cooling zone determination.
• hardness
• geometry
• dimensional tolerances
• mechanical defects

but also some production parameters:
• durability of the molding sand
• casting handling and transportability of the molds
• etc.

It is therefore necessary to be able to determine, or at least to be able to estimate the cooling rate necessary for a certain casting type. The cooling rate directly influences the length of the cooling conveyor, providing a specified mold thickness, production speed (molds/hour) and the required shake-out temperature.

To determine the cooling time of the casting, it is sufficient to determine the cooling time of its most compact section. The cooling time can be determined in two ways:

1. Experimentally, by measuring the cooling time and directly plotting a cooling curve of the casting in question.

2. From a knowledge of its maximum solidification module ($M_c$) - see the section on risering techniques ("Gating").

The second method is faster and cheaper, but not very accurate.

**Experimental Determination of Cooling Time**

The experimental method aims at building a cheap pattern (Fig. 4.45), molding a short string and installing thermo-couples in the parts of the casting where the cooling time is going to be measured (Fig. 4.46), connecting the thermo-couples to a plotter (Fig. 4.47). The cooling curves will automatically be depicted in temperature/cooling time coordinates (Fig. 4.48 and Fig. 4.49).

The method can also be applied successfully by means of simulated trials.

**Estimated Evaluation of Cooling Time**

The module of solidification is calculated for the most slowly solidifying part of the casting. Using the upper diagram from the cooling nomogram (Fig. 4.44) and applying the module ($M$) and the required shake-out temperature ($T$) as input, the cooling time ($t$) can be found as the required output.

The cooling time can be converted into the length of the cooling zone of the mold conveyor (AMC + SBC or PMC + SBC). The input is the mold thick-
Fig. 4.45 Crankshaft pattern plate with patterns of thermocouple cavities for experimental determination of the cooling time of the different parts of the casting.

Fig. 4.46 Thermocouples installed in the casting cavity.

Fig. 4.47 The thermocouples and their compensation cable connections.  Fig. 4.48 The plotter for depicting the cooling curves.
ness calculated as (see Fig. 4.50):

\[ \text{Mold thickness} = P + Q + S \]

and the production speed (molds/hour). When using the lower diagram of the nomogram on Fig. 4.44, the length of the cooling zone can be found.

For example, the universal knuckle joint mentioned in the section "Rising Technique" has the previously calculated solidification module (see "Gating", section about rising):

\[ M_c = \frac{D \times H}{2(D + 2H)} = 0.72 \text{ cm} \]

If the required shake-out temperature is about 720°C, the cooling time can for instance be determined from the upper diagram of the nomogram. It is approx. 16 min.

Assuming that the production speed is 250 molds/hour and the necessary mold thickness is 200 mm, a point coordinating these two figures can easily be found on the lower diagram of the same nomogram. A value for the required length of cooling zone can be found from the coordinate of the following position: a sloping line from the point previously mentioned, drawn downwards to cross an extrapolation of the cooling time figure. In the case of the universal knuckle joint, the length will be approx. 14 meters.

The opposite problem can also be solved: how quickly can you produce (molds/hour) a casting of the module

\[ M_c = 1.5 \text{ cm} \]

requiring a shake-out temperature of

700°C

with a mold thickness of

350 mm,

when a fully defined cooling zone length of 39 meters is available (for instance, the DISAMATIC line in the foundry was installed earlier).

The solution (approx. 100 molds/hour) can be found by means of the cooling nomogram (Fig. 4.44), when the dotted line is followed. This way of using the nomogram can help to solve certain economical tasks when the foundry wants to add a new product to its production program and needs some preliminary calculations.

If the cooling time for a specified casting is determined experimentally, the use of the cooling time diagram from the cooling nomogram is not necessary, but the rest of the cooling zone lengths determination remains unchanged.
Fig. 4.49 Cooling curves for different parts of the crankshaft plotted in a temperature/cooling time coordinate system.

Fig. 4.50 Fast method of mold thickness determination.
Note:

1. The molds may not be transferred from the mold conveyor (AMC/PMC) to the belt conveyor (SBC), before the castings have reached the solidification temperature (for iron marked $T_1$ on Fig. 4.44).

2. Any calculated cooling time should be confirmed by a test.

QUALITY ASSURANCE

All previously mentioned reasoning and measures suit one purpose and one only: to produce castings of the highest possible quality as cheaply as possible. The all-important purpose of quality assurance is to indicate rejection and to prevent its occurrence.

There is no shortage of literature on the organisation of quality assurance systems in casting manufacturing. It is quite tempting to speak about well-organized foundry quality assurance, but management models are far beyond the framework of this present section. It will therefore be reduced to basic guidelines.

Fig. 4.51 shows a CASTING REJECTION SHEET used at the first stage of quality assurance analysis. The castings are tested as soon as they are produced, on some specified day. The defect diagnosis will be made on the basis of this record, and the proper decision on the process improvement will be taken.

In general, quality improvement consists of the following stages:

1. Examination of the defective castings.

2. Classification of the defects according to the main process branches (an example of the process division is shown on Fig. 4.52).

3. Finer classification of the defects according to process areas.

4. Listing possible causes of the defect (if the cause cannot be determined unequivocally) in descending order of probability.

5. To ensure that the scrap diagnosis will be transformed into the right decision by a change in the production process and carrying it through correctly.

The first three items mentioned vary considerably depending on the type of castings, alloys used, requirements of the user, the foundry's own organization and management etc. Some remarks on the last two items will therefore be given.

Recording Casting Defects

Every single foundry has its own casting defect occurrence model, or in other words, the frequency of appearance of certain casting defects depends on the local conditions in each foundry such as production program, materials used, production equipment, manpower, etc. Therefore,
Fig. 4.51 Example of casting quality recording form.
the way of recording the casting defects may vary from one foundry to another. DISA will, however, recommend its own model of casting defect recording.

The main steps toward a well-organized quality control are:

1. To establish the casting selection and rejection criteria based on the requirements of the customers.

2. To establish a proper control organization consisting of the right personnel and equipment.

3. To determine casting sampling and quality classification rules.

4. To secure accurate casting diagnostics and recording methods for the examined samples and hold regular discussions amongst the staff (scrap meetings) about the causes of defects.

5. To determine which process changes to be undertaken and to introduce changes one at a time.

6. To record carefully the course of the production after the changed condition.

Fig. 4.53 shows an example of the casting defect improvement graph. The casting defect discovered was metal penetration on the casting surface. After some consideration during the "scrap meeting", three most likely reasons were established:

Directly:

- too high moisture content in the molding sand,
- too open sand structure caused by too low fines content (APS-clay content).

Indirectly:

- too high pouring temperature.

In the next step, respective changes were introduced to the process and new results observed and recorded.

Scrap recording covering longer periods of time must be carried out for better definition of the responsibility for action and for more efficient allocation of the technical control staff. A weekly, monthly or yearly scrap summary based on the previously mentioned classification of the production process, divided into branches and areas should be made. An example of the yearly scrap recording forms divided in accordance with the graph from Fig. 4.52 is shown on Fig. 4.54.

Casting Defects

Much literature is available on the subject of casting defects and their remedies. For this as well as many other reasons, the defects described
Fig. 4.52 Example of the foundry process division into branches and areas.

Fig. 4.53 Graph of the casting quality improvement process.
Fig. 4.54 Example of yearly scrap recording forms, classified according to the branches and areas of the production process.
Fig. 4.55 Metal penetration caused by explosive vapor development in the hot corner of the casting.

Fig. 4.56 Metal penetration caused by too high a flow rate of the metal jet entering the casting cavity through the encircled lowest ingate. Cause: too large ingate area in relation to the ferrostatic height.

Fig. 4.57 Too high pouring speed through the ingates results in sand erosion defects.
in the present section do not cover the whole area but concentrate on the most likely and troublesome of them.

They can be listed as follows:

1. Surface defects:
   a) Metal penetration
   b) Sand erosion
   c) Misrun

2. Porosities:
   a) Microshrinkage
   b) Macroshrinkage

3. Inclusions:
   a) Sand inclusion
   b) Slag inclusion.

Re 1a)

By definition metal penetration is described as any kind of sand burn-on on the surface of the casing, where the molten metal for one reason or another forces its way into the sand grain structure of the casting/mold interface. Fig. 4.55 shows a typical penetration defect caused by excessive moisture content in the molding sand, resulting in violent vapor development in a hot corner of the casting. The vapor bubbles from the sand next to the hot casting were pressed into the molten metal forcing equivalent metal portions to penetrate the spaces between the sand grains.

Result: rough surface of the casting.

Another type of penetration is shown in Fig. 4.56. The lowest ingate area (encircled) was calculated to be too large in relation to the ferrostatic pressure height above the gate, resulting in too high flow rate through the ingate. The metal jet could easily penetrate the sand structure in the lowest part of the casing, causing a rough casting surface.

Re 1b)

Sand erosion defects are normally defined as superficial marks on the casting, which are caused by sand grain displacement brought about by a high-speed metal jet filling the casting cavity. Fig. 4.57 illustrates a typical sand erosion defect.

Re 1c)

Misrun occurs when the metal viscosity is too low in relation to the geometry of the gating area and the casting cavity volume. The initial stage of misrun appears as a shiny spot on the part of the casting where the last, coldest metal was concentrated before solidification (Fig. 4.58). In extreme cases, the metal will never come to fill the mold completely, causing discontinued castings (Fig. 4.59).
Fig. 4.58 Shiny spot - sign of the beginning stage of misrun.

Fig. 4.59 Incomplete casting - a product of misrun.

Fig. 4.60 Typical microshrinkage defect (A). Distinctive dendrite shape (B). Magnified 32x.
The most usual reason for misrun is too low a pouring temperature or too long pouring time. Incorrect metal distribution caused by incorrect location of the gates can also be the cause of misrun defects.

Re 2a)

Molten metal entrapped between branches of dendritically solidifying metal shrinks during solidification, and as with other shrinking material it needs a fresh supply. If there is no access for the fresh metal at the moment of interdendritic solidification, a microporosity will be created (Fig. 4.60). As it is almost impossible to supply fresh metal to the interdendritic spaces, the best way to correct the defect is either to adjust the metal composition, thus decreasing the interval of solidification (difference between the temperature at the start and at the end of the solidification) or to pour at a lower temperature. Sometimes a change of ingate location can cause a better heat distribution and remedy the problem.

Re 2b)

The expansion and the contraction of the solidifying metal makes it necessary to feed the freezing casting. An insufficient feeding (risering) of very thick sections of the casting, which naturally solidify latest, will cause shrinkage defects. The shrinkage tendency depends on pouring temperature, metal composition, mold stability etc. A typical macroshrinkage on the top of the casting is shown on Fig. 4.61.

Re 3a) and 3b)

Slag or sand trapped in the molten metal will sooner or later result in inclusions. It is normally very difficult to distinguish between the sand and slag inclusions, even if they are due to different causes. A sand inclusion example is shown in Fig. 4.62 and a slag inclusion in Fig. 4.63.

Casting Defect Troubleshooting

The most likely casting defects previously mentioned, and their possible causes, are marked in the table Fig. 4.64. The table must be treated as a guideline only, as only the most typical reasons of defects are listed.

Metal Penetration

Possible causes:

- excessive pouring temperature,
- excessive pouring rate,
- ingate(s) located too close to critical area of the casting cavity,
- excessive pouring time,
- excessive moisture content,
- poor sand compaction,
- excessive content of inactive fines makes mold cavity surface too weak,
Fig. 4.61 Typical macroshrinkage pit, also called top shrinkage.

Fig. 4.62 Sand inclusion.

Fig. 4.63 Slag inclusion.
- insufficient content of inactive fines makes the sand structure too open,
- too coarse molding or core sand,
- insufficient active bentonite content makes the mold cavity surface too weak,
- insufficient fresh sand addition does not suppress the inactive fines sufficiently, thus demanding a higher moisture content,
- too hot molding sand has deteriorated strength properties.

Remedies:
- Pour colder
- Decrease ingate areas, recalculate them according to the respective ferrostatic height pressures.
- Move away or remove the ingate from the most exposed location of the cavity.
- Decrease the pouring time and thereby the time of exposure on the casting cavity to the hot metal jet.
- Increase blow and squeeze pressures.
- Adjust the content of inactive fines.
- Add some finer sand as new sand during recycling.
- Adjust the active bentonite content.
- Increase the new sand addition.
- Install a molding sand cooler.
- Increase the sand/metal ratio, increase the production rate (molds/hour) (short time of sand burning by the castings).

Sand Erosion
Possible causes:
- too high pouring rate through the eroding ingate
- incorrectly located ingate
- excessive pouring time
- too dry sand
- too loose core and molding sand structure
- excessive sand temperature
Fig. 4.64 Table showing the most likely casting defects and their most probable causes.
Remedies:

- Decrease the area of the eroding ingate
- Remove the ingate causing trouble.
- Decrease the pouring time and thereby the time of exposure of the casting cavity wall or the core to the destructive action of the metal jet.
- Increase the moisture content.
- Increase the sand compaction by using higher blow and squeeze pressures.
- Install a sand cooler, increase sand/metal ratio, increase the production rate (molds/hour).

Misrun
Possible causes:

- too low pouring temperature
- poor pouring practice
- incorrect gating area
- improper ingate distribution
- excessive pouring time
- too low sand compaction causing deformation of the mold at the parting line and thereby reduction of ingate heights and subsequent reduction of ingate area.

Remedies:

- Pour hotter.
- Fill the gating system more quickly and keep the pouring cup full. Hit the cup centrally with the metal jet.
- Recalculate the gating areas. The areas are too small.
- Move one of the ingates to a location where it will inject some fresh hot metal into the coldest place in the latest stage of pouring.
- Decrease the compactability of the sand by reducing the moisture content, and increase the blow and squeeze pressures.

Microshrinkage
Possible causes:

- too high pouring temperature making the solidification interval too long and the metal expansion too large
in the case of iron too high an amount of inoculant,
too low carbon equivalent,
too high phosphorous content,
too high a percentage of alloying additions (Cr, Mo, etc.)

• uneven metal and heat distribution in the casting

• insufficient risering

• contaminated scrap.

Remedies:

• Pour colder.

• Decrease or change the type of inoculant,
  increase carbon content,
  lower phosphorous content,
  decrease alloying additions.

• Provide better metal distribution by distribution of ingates and higher
  ferrostatic pressure on the castings.

• Increase the riser or/and the riser neck.

• Better scrap composition and control (less steel scrap).

Macroshrinkage
Possible causes:

• too hot metal

• the metal level in the pouring cup sinks during pouring

• too high inoculant addition increasing the amount of eutectic cells

• too low carbon equivalent

• too high phosphorous content

• excessive alloying addition (Cr, Mo, etc.)

• too long pouring time due to too small gating areas

• uneven metal distribution

• insufficient risering

• poor sand compaction decreasing mold rigidity

• contaminated scrap.
Remedies:

- Pour colder to decrease the temperature range of freezing.
- Keep the pouring cup full during the entire pouring process to increase the ferrostatic pressure on the castings and for better pressurizing of the riser.
- Decrease inoculant addition or change type of inoculant.
- Increase the carbon content.
- Decrease the phosphorous content.
- Decrease the addition of alloying elements.
- Adjust the gating areas.
- Provide better metal distribution by distributing the ingates.
- Increase the riser and riser neck, supply more hot iron to the riser, increase the "notch" in the riser.
- Increase compressibility and blow and squeeze pressure.
- Better scrap composition and control (less steel scrap).

**Sand Inclusion**

Possible causes:

- The gating system is not kept full, so sand particles can float to the surface
- Incorrectly sized gating area makes it impossible to keep the gating system continuously filled with metal
- Incorrectly located ingates wash the sand from the mold and keep the gating system continuously filled with metal
- Incorrectly located ingates wash the sand from the mold or core wall
- Poor sand compaction
- Too high content of inactive fines makes the sand brittle and weak
- Sand tear-off or cracks during molding or on the cores
- Friable sand edges
- Poor mold and core mask blow-off.

Remedies:

- Reinstruc the pouring personnel.
- Recalculate the gating system.
• Remove or move the ingates from the location causing the trouble.

• Increase the moisture content in order to obtain better compactability. Increase blow and squeeze pressure.

• Add more new sand for better suppression of inactive fines.

• Control the molding operation, the patterns and the core quality.

• Increase sand friability by increasing active bentonite content, introduce fillets at sharp sand corners on the pattern and the core box, increase core sand strength.

• Improve the blow-off system or correct the direction of the blow-off nozzles.

**Slag Inclusion**

Possible causes:

• Poor slag skimming.

• Bad pouring practice by not keeping the gating system full and allowing the slag particles to float to the surface.

• Excessive inoculation or wrong inoculant.

• Incorrect gating area makes it impossible to keep the pouring cup full during the entire pouring process.

• Contaminated steel scrap.

Remedies:

• Improve skimming practice.

• Reinstruct the pouring personnel.

• Decrease inoculant addition or change the inoculant.

• Recalculate the gating system.

• Install a slag trap.

• Better scrap control.