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Critical Assessment of Green Sand Moulding Processes

Raghwendra Banchhor[1], S.K.Ganguly[2]

[1]Department of Mechanical Engineering, Bhilai Institute of Technology, Durg, India

***Abstract* -Although there are many new advanced technologies for metal casting, green sand casting remains one of the most widely used casting processes today due to the low cost of raw materials, a wide variety of castings with respect to size and composition, and the possibility of recycling the molding sand. The green sand casting process is one of the most versatile processes in manufacturing because it is used for most metals and alloys even with high melting temperatures such as iron, copper, and nickel. Understanding the conventional and modern green sand moulding method can help redesign for manufacturability and utilize processes for modernization of foundry; that meet specific requirements. The versatility of moulding is demonstrated by the number of molding processes currently available. This wide range of choices offers design engineers and component users' enormous flexibility in their metal forming needs. Each process offers distinct advantages and benefits when matched with the proper product application. This paper summarizes the process capability, advantages and limitations of various conventional and modern green sand molding processes.**

***Keywords* - Air flow-squeeze moulding, Casting, Flaskless moulding, Green sand, Tight flask moulding.**

I. INTRODUCTION

Fundamentally, a mold is produced by shaping a refractory material to form a cavity of desired shape such that molten metal can be poured into the cavity. The mold cavity needs to retain its shape until the metal has solidified and the casting is removed. This sounds easy to accomplish, but depending on the choice of metal, size and quantity of the casting certain characteristics are demanded of the mold.

When granular refractory materials, such as silica, olivine, chromite or zircon sands, are used, the mold must be:

- Strong enough to sustain the weight of the molten metal;
- Permeable**,** to permit any gases formed within the mold or mold cavity to escape into the atmosphere;
- Resistant to the erosive action of molten metal during pouring and the high heat of the metal until the casting is solid;
- Collapsible enough to permit the metal to contract without undue restraint during solidification;
- Able to cleanly strip away from the casting after the casting has sufficiently cooled;
- Economical, since large amounts of refractory material are used.
- The most common method used to make metal castings is green sand molding. In this process, granular refractory sand is coated with a mixture of bentonite clay, water and, in some cases, other additives. The additives help to harden and hold the mold shape to withstand the pressures of the molten metal. The green sand mixture is compacted by hand or through mechanical force around a pattern to create a mold.

Green sand moulding processes can be broken into following general categories as shown in **figure 1** and characteristics of each of it is reviewed in following paragraphs.

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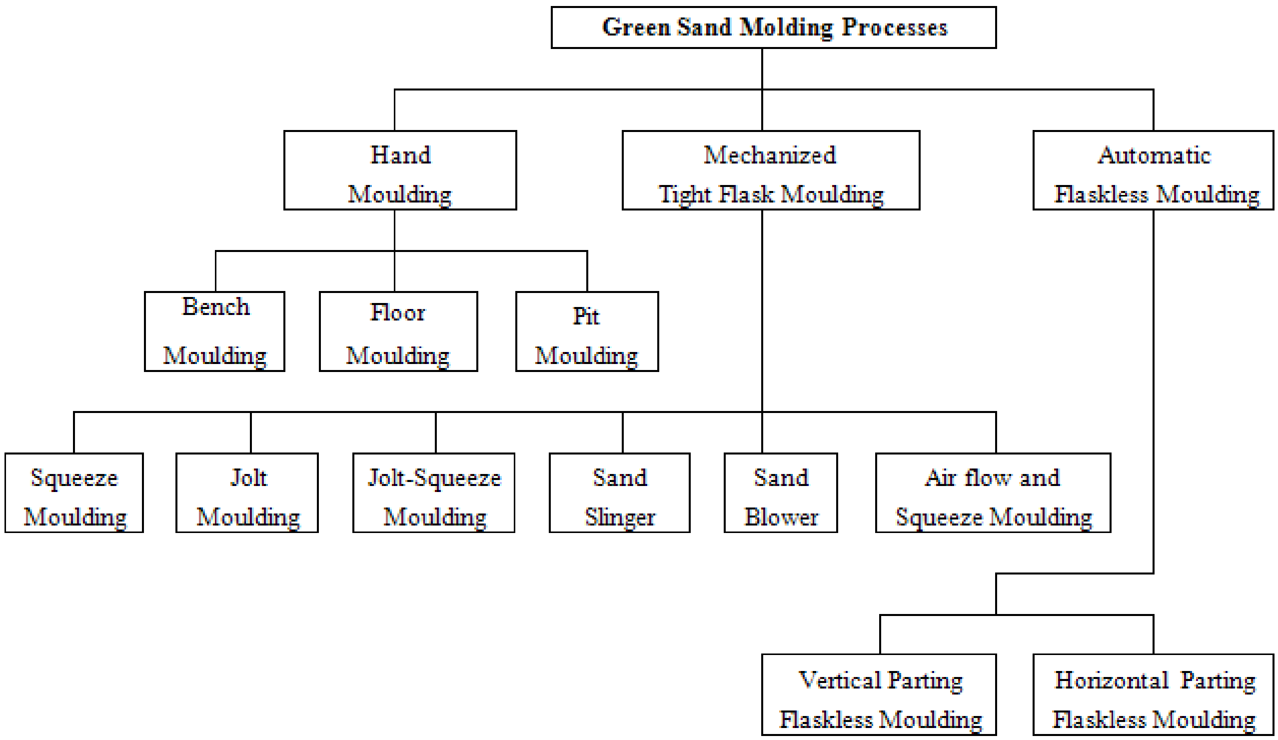

Figure 1. Classification of green sand moulding processes

II. Hand Moulding

In hand molding process, all the molding operation, are performed manually using hand tools. The loose pattern is placed on a mould board and surrounded with suitable-sized flask. Molding requires ramming of sand around the pattern. As the sand is packed, it develops strength and become rigid within the flask. Both cope and drag is moulded in the same way .With cope and drag halves of the mould made and pattern withdrawn , core are set into the mould cavity to form the internal surfaces of the casting. With core set, the cope and drag are closed and clamped together to prevent it from floating when the metal is poured.

A. Bench moulding

In bench moulding, moulding is carried out on a bench of convenient height. Moulder makes the mould by hand hammering while standing. Small and light moulds are prepared on benches.

B. Floor moulding

Moulding work is carried out on foundry floor when required mold size is large and moulding can not be carried out on a bench. Medium weight casting moulds are compacted using pneumatic hammer on the floor.

C. Pit moulding

Very big casting which can not be made in flask is moulded in pits dug on the floor. The mould has its drag part in the pit and a separate cope is rammed above the pit

III. Mechanized Tight Flask Moulding

In tight-flask moulding a flask is necessary for each mould. The flask has the following functions:

- It serves as a frame for holding the mould during the moulding process
- It serves as a container for transporting the mould during the moulding process, pouring and cooling

- It supports the mould during solidification
- It includes the guide elements which guarantee a precise match between the two mould halves.

The object in molding is to produce accurate parts able to withstand lifting and handling and to contain the liquid metal pressures in casting. Machine molding enables moulds to be produced in quantity at high rates. Excluding the simplest types of hand operated pattern draw machine, the principal feature of machine molding is the use of power operated mechanisms for mould compaction; this mechanization can extend in varying degrees to pattern withdrawal and mould part manipulation.

Sand molding machines have the following advantages:

- Eliminate labor cost.
- Offer high quality casting by improving the application and distribution of forces.
- Manipulate the mold in a carefully controlled fashion.
- Increase the rate of production.
- Mould-wash can be used to increase surface finish and refractoriness of mould
- internal and external chills can be used to control directional solidification
- Facing and baking sand can be used
- Combination of sand system can be used
- There exist a change to repair the broken mould

Molding machine may be classified as follow on the basis of method of compaction:

1. Squeeze moulding
2. Jolt moulding
3. Jolt-squeeze moulding
4. Slingers
5. Blowers
6. Air flow and squeeze

Combination of number 1 to 6 above

A. Squeeze moulding

In squeezing, pressure is applied to the upper surface of the molding material through a squeeze head as illustrated in **figure 2.** Moulding by squeezing alone will become less effective for a given pressure as the depth of the mold increases. Furthermore, there will be a differential in the degree of packing from the squeeze head to the pattern .There is a limit to the flask depth that maybe moulded by squeezing which is dependent of squeeze machine capacity, pattern contour, molding sand etc.

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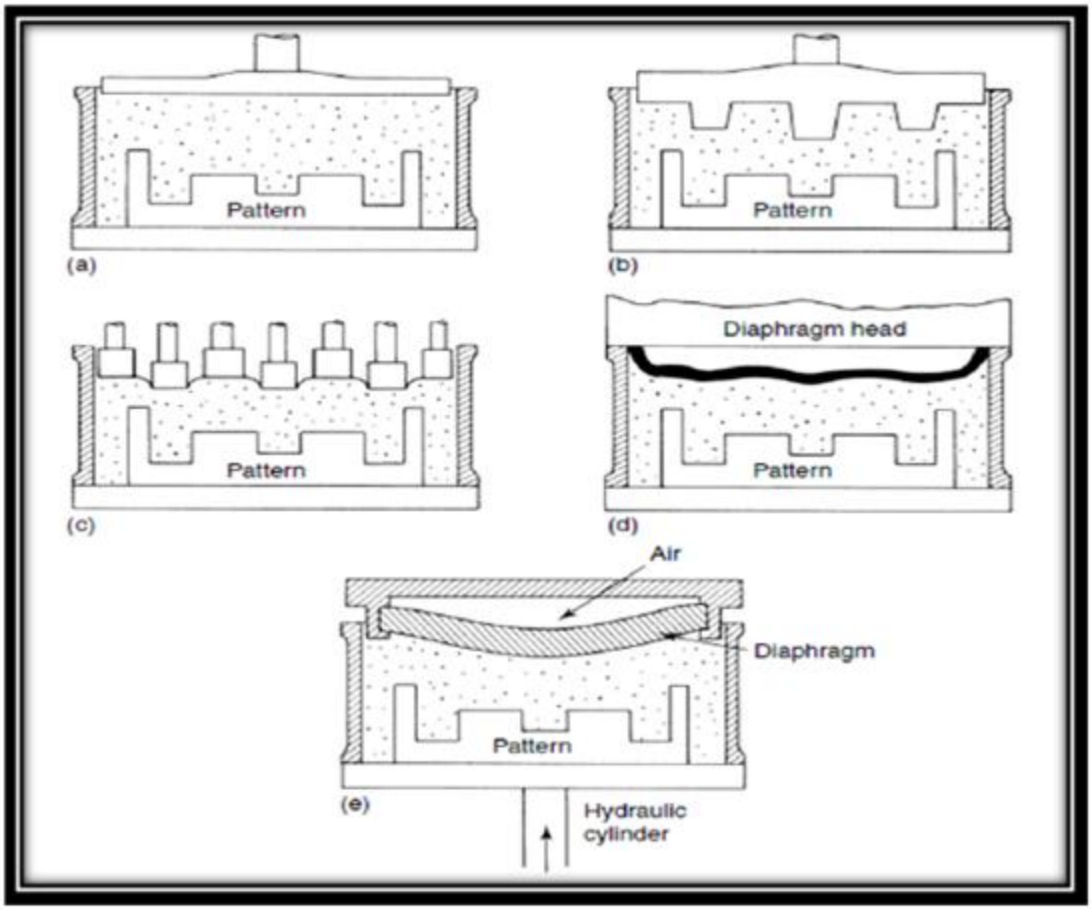

Figure2: Designs of squeeze head for mold making (a) conventional squeeze, (b) profile squeeze head, (c) equalizing piston squeeze, (d) diaphragm squeeze, (e) high pressure hydra-pneumatic squeeze.[1]

B. Jolt moulding

The work table with pattern, flask and sand is raised by pneumatically operated piston and allowed to fall against the base of the machine under the influence of gravity. Packing of the moulding sand is caused by work done by the kinetic energy of falling sand.

In this type sand packing the maximum molding force is applied at the pattern surface. The mold is hardest at the pattern surface

C. Jolt-squeeze moulding

Jolt-squeeze machines utilize a combination of jolting and squeezing to pack the moulding sand. A combination of the beneficial compaction effects of squeezing and jolting on sand density is obtained.

Using these techniques less extreme pressures are required, since an element of lateral thrust is achieved, giving high mould hardness even on deep vertical surfaces. Although many machines have been replaced by more sophisticated compaction systems, Jolt squeeze machine is still very popular.

D. Sand Slinger

This machine is used for filling and uniform ramming of the sand in the molds. This machine is particularly advantageous for large molds. Sand slinger consists of a heavy base, a bin or hopper to carry sand, a bucket elevator and a swinging arm which carries a belt conveyor and the sand impeller head. A bucket elevator consists of several numbers of buckets.

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Well-conditioned sand is filled in a bin. This sand is then fed to the bucket elevator. These buckets pour the sand onto the belt conveyor which carries it to the impeller head. This head can be positioned anywhere on the mold by swinging the arm. The head revolves at very high speed and throws a stream of sand into the flask at a great speed. This is called slinging. The force of sand ejection and striking into the flask is enough to pack the sand in the flask uniformly.

E. Air flow- squeeze molding (SEIATSU process)

Air flow-squeeze machines utilize a combination of compressed air flow through the moulding sand and squeezing to pack the moulding sand. The air is passed through the moulding sand from the back of the mould and towards the pattern **Figure 3**. Vents provided on the pattern plate or on the pattern itself facilitate the air flow simultaneously through all the components. The mould is then compacted by applying pressure in an arrangement that may use a squeeze plate, an elastic squeeze plate or a multi-ram press. [6], [7]

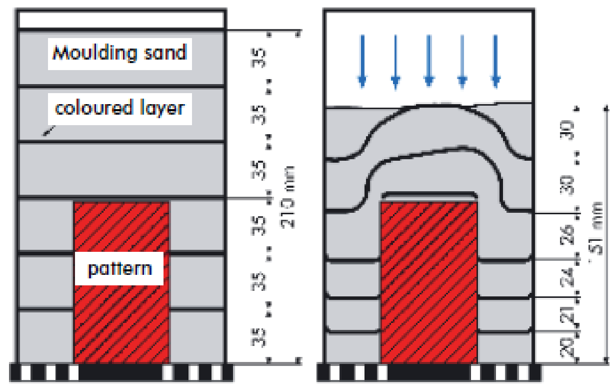


Figure 3.

The advantages of the process:

1) Uniformly high mould hardness: The moulds produced are uniformly hard resulting in the production of dimensionally accurate castings. The moulds produced by the SEIATSU air flow process are considerably harder than those produced by jolt squeezing **Figure 4.**

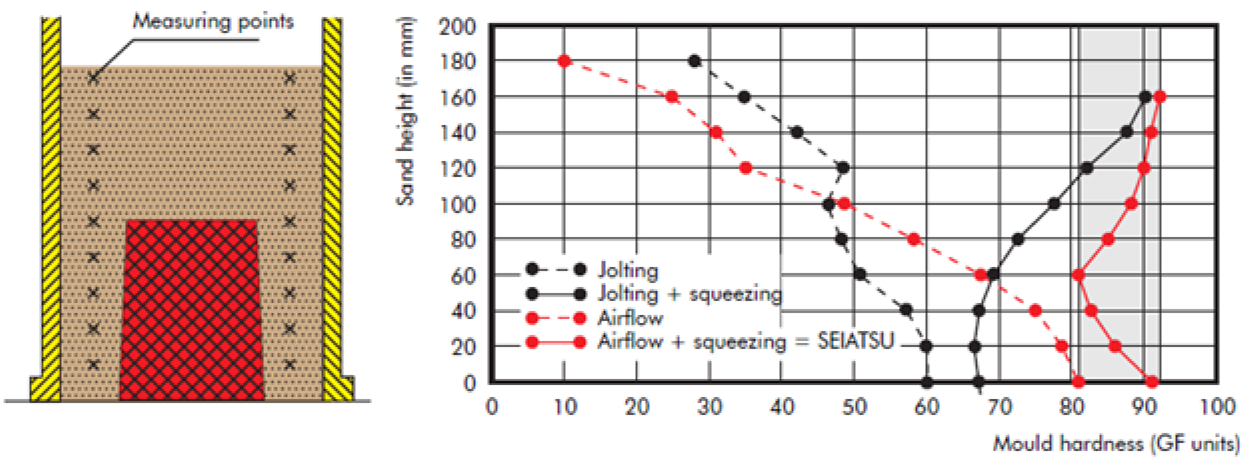


Figure 4

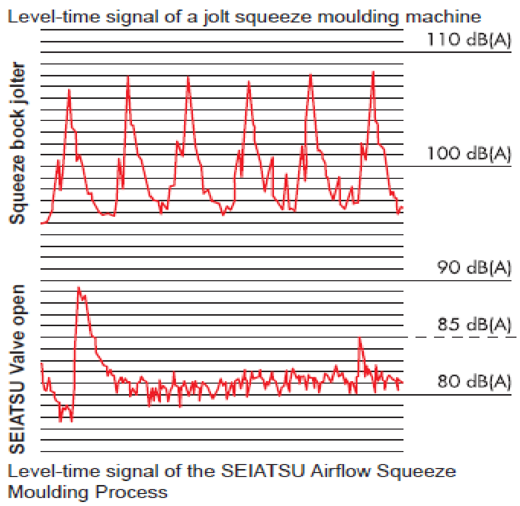
2) Fewer cores required: In many cases cores can be eliminated when moulding complicated pattern shapes and extreme cods.

3) Reduced pattern draft: Draft can be reduced to 0.5° when using the SEIATSU process, resulting in corresponding reductions in use of material and in machining costs.

*4) Improved utilization of the mould space:*The ability to reduce the distance between patterns from each other and the side of the mould results in improved utilization of the available space and hence more castings per mould.

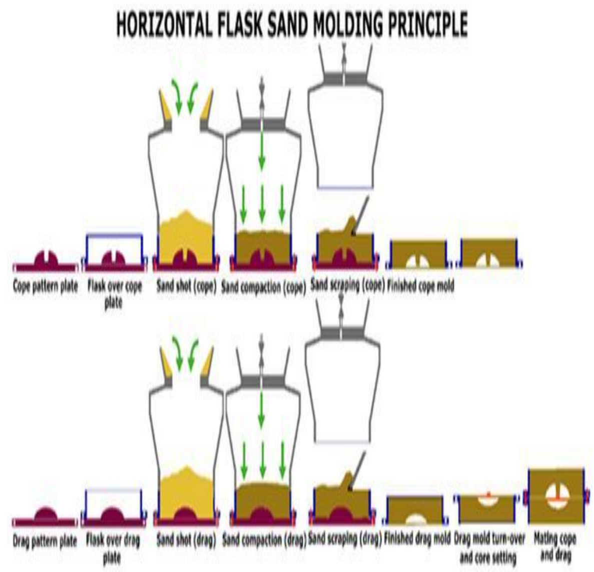
5) Reduction in fettling costs: The SEIATSU process achieves consistently high general and surface quality, and dimensional accuracy with almost no burrs, so that fettling requirements and machining costs are very considerably reduced.

6) Environmental advantages: Where the jolt squeeze process is replaced by the air flow system noise levels are brought down to 85 dB (A) as shown in graph below. This brings a major improvement in the working conditions in a foundry. The SEIATSU process does not produce shock loads so that the foundation requirements are simplified, the impact on the surroundings is reduced and there is less need for maintenance.



IV. Horizontal Tight Flask Automatic Molding Line

Increasing quality requirements made it necessary to increase the mold stability by applying steadily higher squeeze pressure and modern compaction methods for the sand in the flasks. In early fifties the high pressure molding was developed and applied in mechanical and later automatic flask lines. The first lines were using jolting and vibrations to pre-compact the sand in the flasks and compressed air powered pistons with hydraulic pressure of up to 140 bars to compact the molds. The subsequent mold handling including turn-over, assembling, pushing-out on a conveyor was accomplished either manually or automatically. In the late fifties hydraulically powered pistons or multi-piston systems were used for the sand compaction in the flasks. This method produced much more stable and accurate molds than it was possible manually or pneumatically. In the late sixties mold compaction by fast air pressure or gas pressure drop over the pre-compacted sand mold was developed (sand-impulse and gas-impact).



Today there are many manufacturers of the automatic horizontal flask molding lines. The major disadvantages of these systems is

- High spare parts consumption due to multitude of movable parts,
- Need of storing, transporting and maintaining the flasks, and
- Productivity limited to approximately 90–120 molds per hour.

V. Automatic Flaskless Molding

In flaskless moulding, no flask is used for supporting the moulding sand; the mould itself is made sufficiently strong to bear the liquid metal pressure.

A. Vertical Parting Flaskless Moulding (DISAMATIC)

In 1957, Vagn Aage Jeppesen - professor at the Danish Technical University claimed a patent for a device producing flaskless molds of sand mixtures with vertical parting lines for casting metal parts. In 1962, Dansk Industri Syndikat A/S (DISA-DISAMATIC) invented a flask-less molding process by using vertically parted and poured molds. **DISAMATIC** is an automatic production line used for fast manufacturing of sand molds for sand casting. This process is commonly used to mass manufacture of metal castings for the automotive and machine industry The first line could produce up to 240 complete sand molds per hour.

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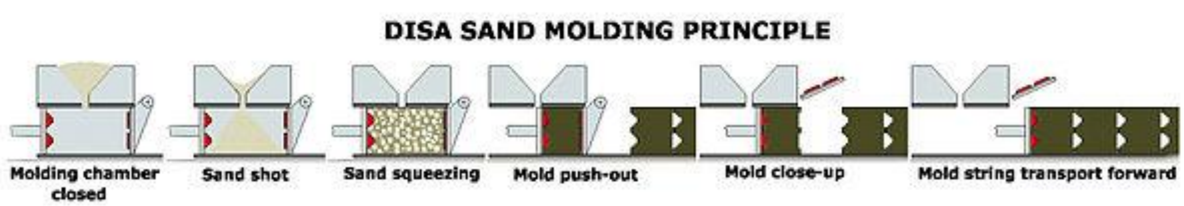
Today molding lines can achieve a molding rate of 550 sand molds per hour and requires only one monitoring operator.

DISAMATIC consists of a molding machine and mold transporting conveyor (figure 7) A molding sand mixture, usually green sand or bentonite, is blown into a rectangular steel chamber using compressed air. The molding sand is then squeezed against two patterns, which are on the two ends of the chamber. After squeezing, one of the chamber plates swings open and the opposite plate pushes the finished mold onto a conveyor. Finally, any cores are automatically set into the mold cavity while the next mold is being prepared. The cycle repeats until a chain of finished molds butt up to each other on the conveyor.

The molds are then filled with molten metal and placed on a cooling conveyor, which moves at the same pace as the fabrication conveyor. At the end of the conveyor the solidified castings are separated from the molds and processed further, while the sand is directed to the sand preparation plant for reconditioning and reuse in the next cycles of the DISAMATIC molding process.

1) Advantages: The DISAMATIC sand molding process has several advantages comparing to other molding processes.

- It does not use flasks, which avoids a need of their transporting, storing and maintaining.
- No repair expenditure on flasks
- By adopting aeration sand filling technology, energy saving and noise reduction have been achieved
- Stable pattern draw is secured by automatic pattern spray
- Since sand is introduced into the sealed chamber, waste sand and dust are greatly reduced.
- Variation of mold quality generated by hand molding is eliminated by automated molding
- It is fully automatic and requires only one monitoring operator, which reduces labor costs.
- Molding sand consumption can be minimized due to variable mold
- thickness that can be adjusted to the necessary minimum.
- A modern DISAMATIC molding line can mold at the rate of 550 sand molds per hour (one complete mold in 6.5 seconds).
- Maximum mismatch of two halves of the castings does not exceed 0.1 mm.
- Total uptime exceeds 98%.
- Possible mold sizes range from 400 x 500 to 850 x 1200 millimeters.
- Working environment is far more superior because of jolt-less molding.
- Reduced operator exposure to safety risks or service-related problems.
- A DISAMATIC line can be completed with automatic casting and sand cooling drums, robotized devices for extracting castings from the molds and automatic casting cleaning and abrasive blasting machines placed inline.
- In such automatic production lines there is no need of any human manual labor until the castings are completely finished and ready for dispatch



2) Disadvantages:

- Only for mass production of light weight casting
- Can be used for simpler casting
- Need sophisticated machine
- Skilled operator is required
- Less utilization of the pattern plate due to edge distance
- Core setting can be problematic
- Internal and external chills can be used
- Mould-wash cannot be used
- Different sand system for facing and baking cannot be used
- Combination of sand system in single mould is not possible
- Risk of collapsing of mould during transport and pouring
- There is no chance to repair the damaged mould
- Freedom of use of open risers is limited
- Feeding aids such as anti-piping compound and exothermic powder can not be used

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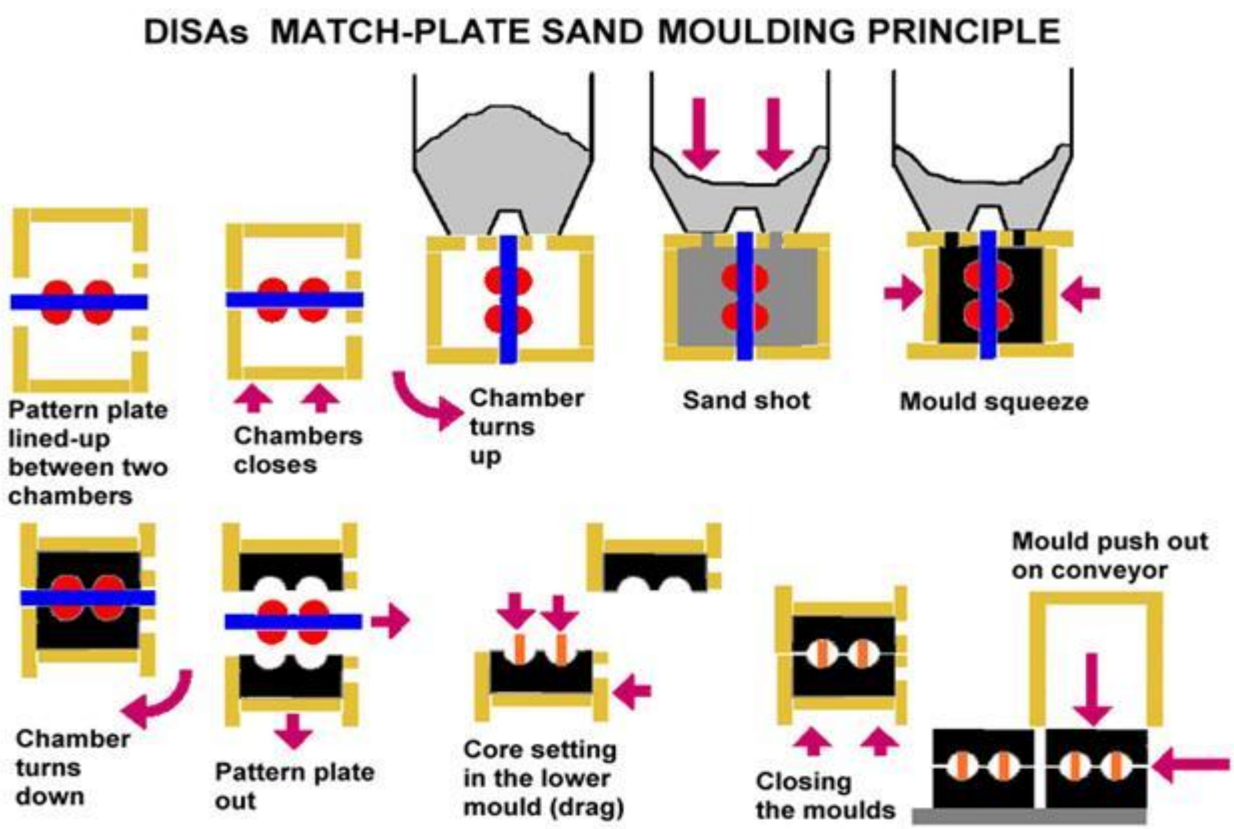
B. Horizontal Parting Flaskless Moulding

The principle of the matchplate, meaning pattern plates with two patterns on each side of the same plate, was developed and patented in 1910, fostering the perspectives for future sand molding improvements. However, first in the early sixties the American company Hunter Automated Machinery Corporation launched its first automatic flaskless, horizontal molding line applying the matchplate technology.

The method alike to the DISA's vertical moulding is flaskless, however horizontal. The matchplate molding technology is today used widely. DISA MATCH is intended for small and medium-sized jobbing foundries, which due to their small runs are obliged to make extremely frequent changes of pattern plates. It covers an area of demand in which the use of a DISAMATIC would not be economic. At the same time, it allows foundries to invest in a machine which can be installed on a flat foundation deck, with only very small pits. Apart from the avoidance of extensive foundation work, other cost savings are available, such as expenditure on flasks and the significantly reduced associated costs of hydraulic plant. [9], [10]

1) Advantages:

- Inexpensive pattern tooling,
- Easiness of changing the molding tooling,
- Suitability for manufacturing castings in short series so typical for the jobbing foundries.
- By adopting aeration sand filling technology, energy saving and noise reduction have been achieved
- Stable pattern draw is secured by automatic pattern spray
- Since sand is introduced into the sealed flasks, waste sand and dust are greatly reduced.
- Machine can be used immediately after setting, piping and wiring.
- Variation of mold quality generated by hand molding can be eliminated by automated molding
- Working environment is far more superior because of jolt-less molding.



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VI. Conclusion

Green sand processes are the most cost-effective of all metal forming operations; these processes readily lend themselves to automated systems for high-volume work as well as short runs and prototype work; The properties of green sand are adjustable within a wide range, making it possible to use this process with all types of green sand molding equipment and for a majority of alloys poured. Each process of green sand moulding offers distinct advantages and limitations when matched with product application.

When reviewing these processes and determining which best suits specific needs, appropriate method can be chosen considering the following:

- Required quality of the casting surface
- Required dimensional accuracy of the casting
- Number of castings required per order
- Type of pattern and core box equipment needed
- Cost of making the moulds
- How the selected process will affect the design of the casting
- Noise level
- Shock level
- Maintenance need

Hand moulding is essentially a choice for jobbing industry. In present scenario the use of tight-flask moulding machines should only be considered when larger mould dimensions are required than are currently offered by suppliers of flaskless technology.

REFERENCES

[1] Serope Kalpakjian and Steven R. Schmid , " Manufacturing Engineering and Technology ", 4th edition , Pearson,New Delhi,2013
[2] Richard W heine,carl R loper,Pilip C Rosenthal,"Principle of metal casting,tata McGrahill,New Delhi,
[3] Rao T.V."Metal casting principle and practice", New age publication, New Delhi 2010.
[4] B.Ravi ,"Metal Casting computer aided design and and analysis" PHI,Learning New Delhi 2011
[5] *CASTING SOURCE DIRECTORY,"* Guide to Casting and Molding Processes" ENGINEERED CASTING SOLUTIONS, 2006
[6] Heinrich Wagner Sinto, "SEIATSU Air-Flow Squeeze Moulding Process" Maschinenfabrik Gmbh Sintokogio Group, Bad Laasphe, Germany, Vo 1000,06.2011
[7] Heinrich Wagner Sinto, "Seiatsu Moulding Machine HSP" Maschinenfabrik Gmbh Sintokogio Group, Bad Laasphe, Germany, Vo 1000,06.2011
[8] Hiroyasu Makino, Shuichi Tsuzuki and Minoru Hirata, "Development of new molding process using aeration sand filling and practical use of green sand molding machine", International Foundry Research 65 (2013) No. 4 Toyokawa, Aichi, Japan,6 March 2013
[9] DISA MATCH article by Michael Colditz, "State of the art in the manufacture of flaskless, horizontally parted moulds"18/06/2012
[10] Features of FDNX, 6th International Ankiros Foundry Congress 2012 Istanbul, 13-15 September 2012