11-13 September / Eylül 2014
TÜYAP Fair, Convention & Congress Center, İstanbul
7th International Ankiros Foundry Congress
7. Uluslararası Ankiros Döküm Kongresi

«Advantages of Green Sand Molding Process Using Aeration Technology»

«Yaş Kalıplama Tekniğinde Havalandırma Teknolojisinin Faydaları»

Hiroyasu Makino
(Sintokogio, Evren İth. İhr.)

3.Oturum: Döküm Teknolojileri Demir - Çelik

3rd Session: Casting Technologies Iron - Steel

Oturum Başkanı/Session Chairman: Seyfi Değirmenci (Componenta Döküm. Tic. San. A.Ş.)

ADVANTAGES OF GREEN SAND MOLDING PROCESS USING AERATION TECHNOLOGY

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SINTOKOGIO, LTD., Japan

CONTENT

Mission of Sand Molding Technology

World casting production in 2012 exceeded 100 million tons.
Over 80 % of production was iron castings and made with sand molds.

1) Good sand filling

2) Good casting

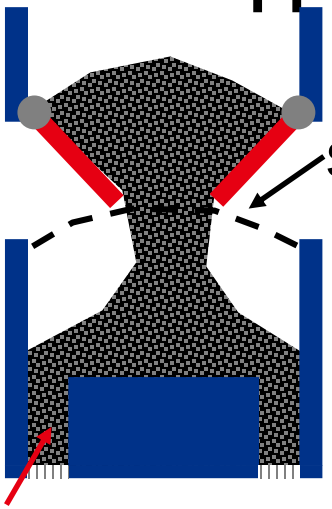
3) Environmentally-friendly

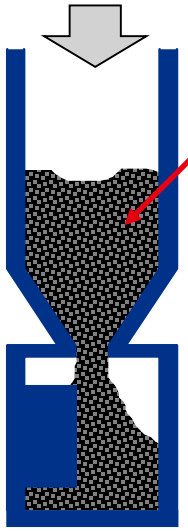
Aeration sand filling

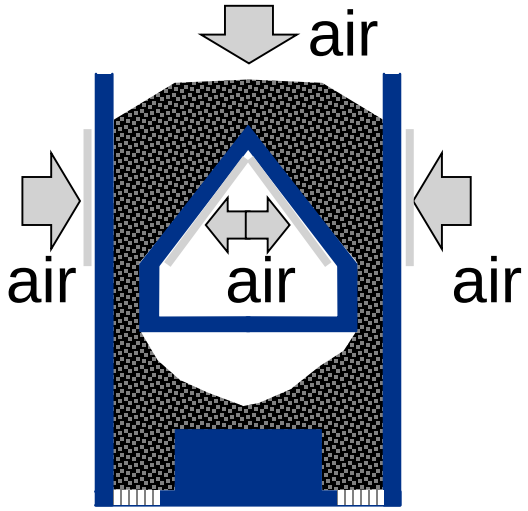
Image of Aeration Sand Filling

Comparison of Green Sand Molding Technology

air-flow + squeeze	blow + squeeze	aeration + squeeze
tight-flask	flask-less	tight-flask & flask-less
free fall (louver hopper)	**blow(0.3MPa)**	**aeration(0.1MPa)**





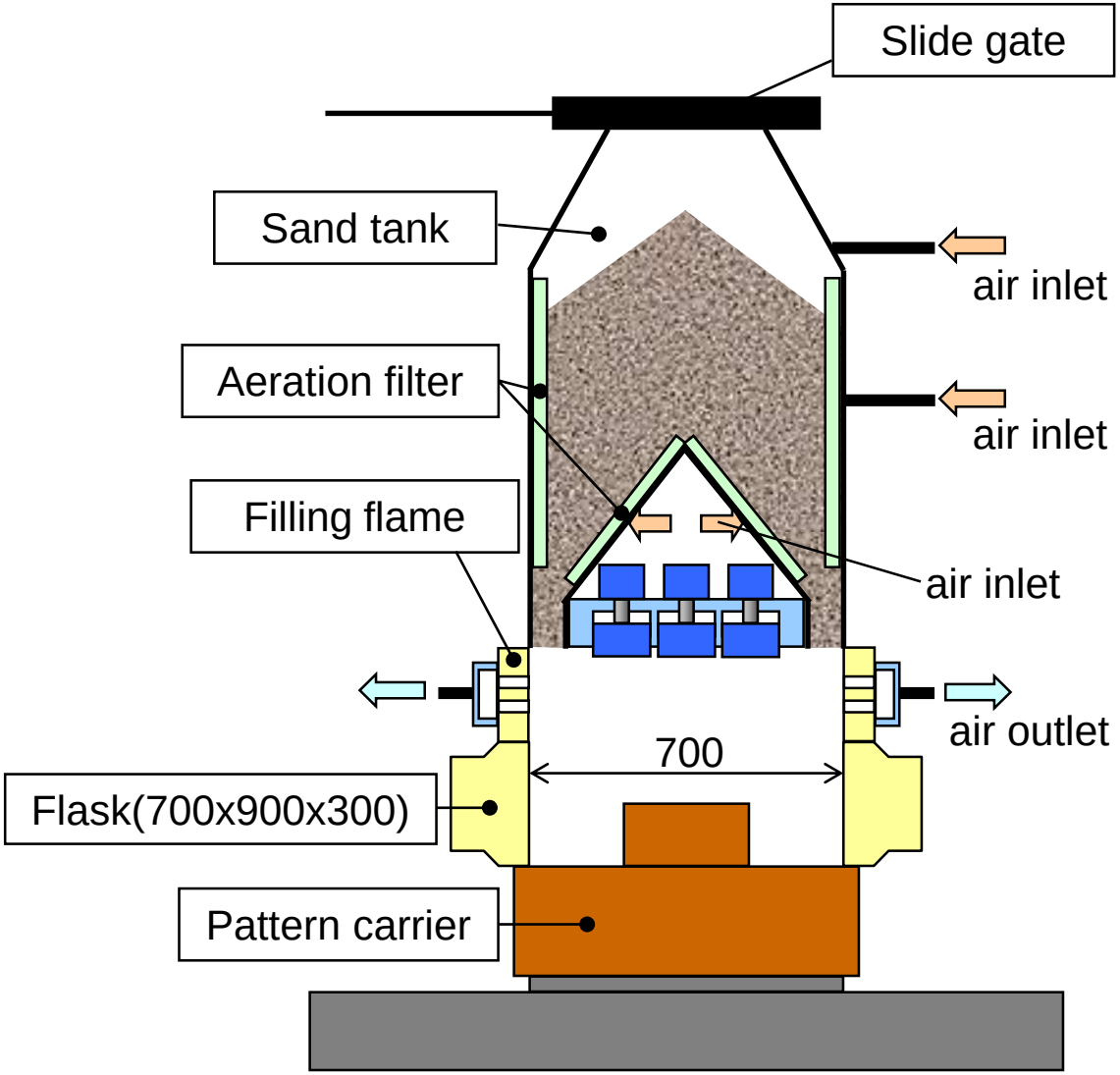


smooth fill and uniform density

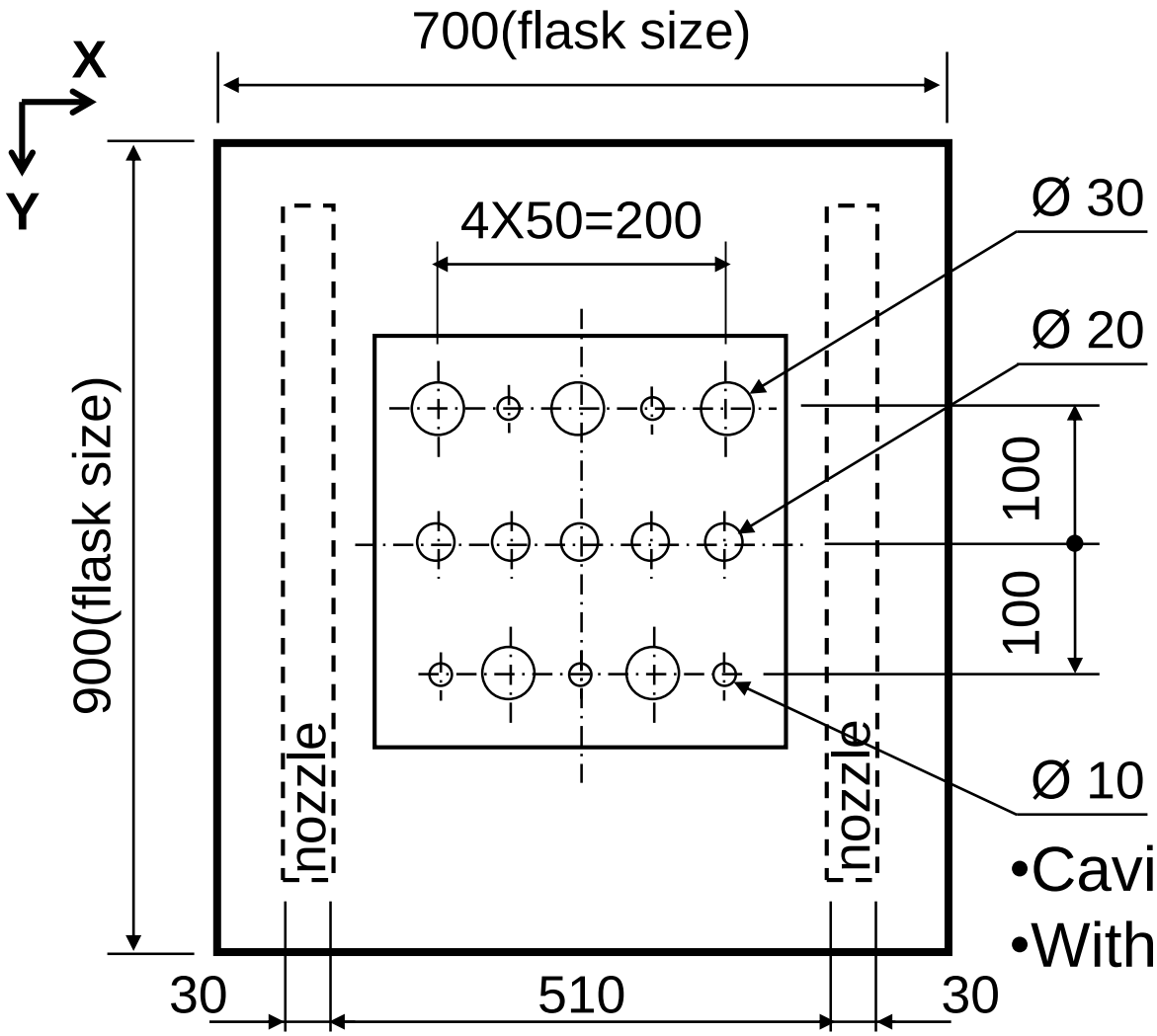
Conventional Molding | **Developed**

Comparison Movie of Aeration, Blow and Gravity Sand Filling Process

Actual Production Molding Machine



Test Pattern for Sand Filling Experiment



Sand Filling Process

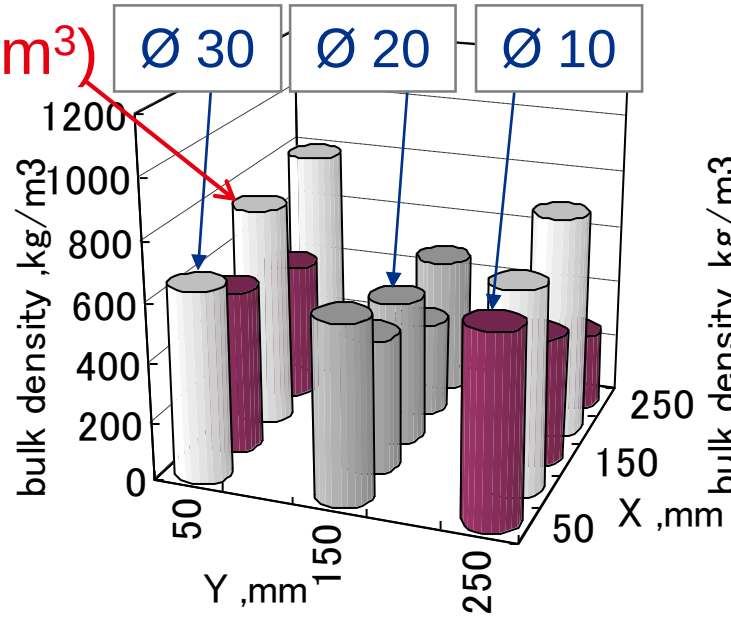
- Gravity free fall (Louver hopper)
- Blow (0.3MPa)
- Aeration (0.1MPa)

- Cavity(pocket) depth = 50mm
- With vent hole

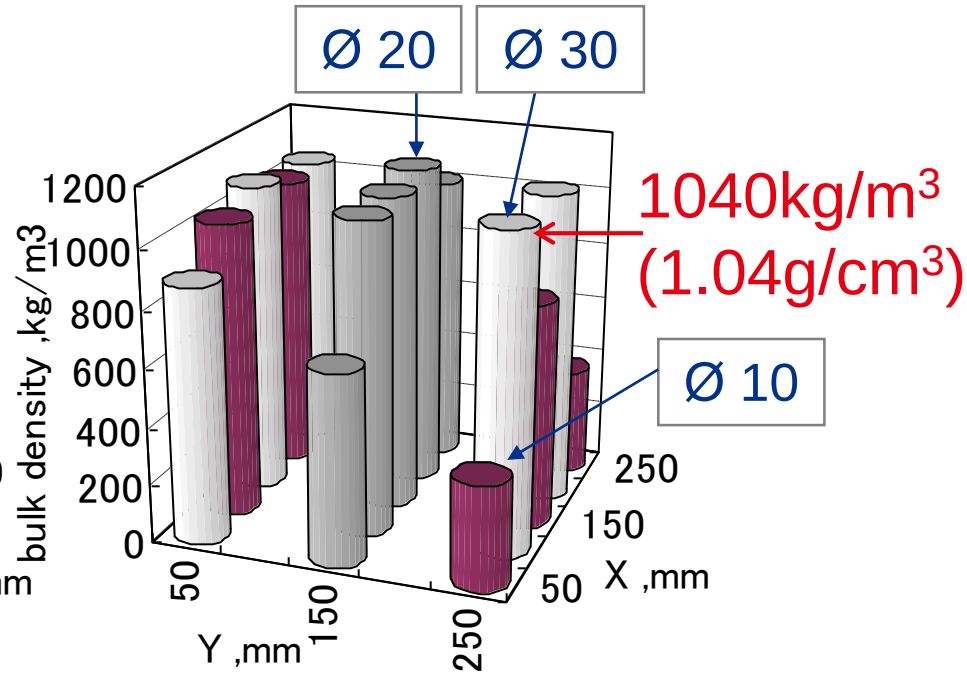
Experimental Results of Sand Filling for Small Pocket

730 kg/m^3
(0.73 g/cm^3)

Gravity free fall
(Louver hopper)



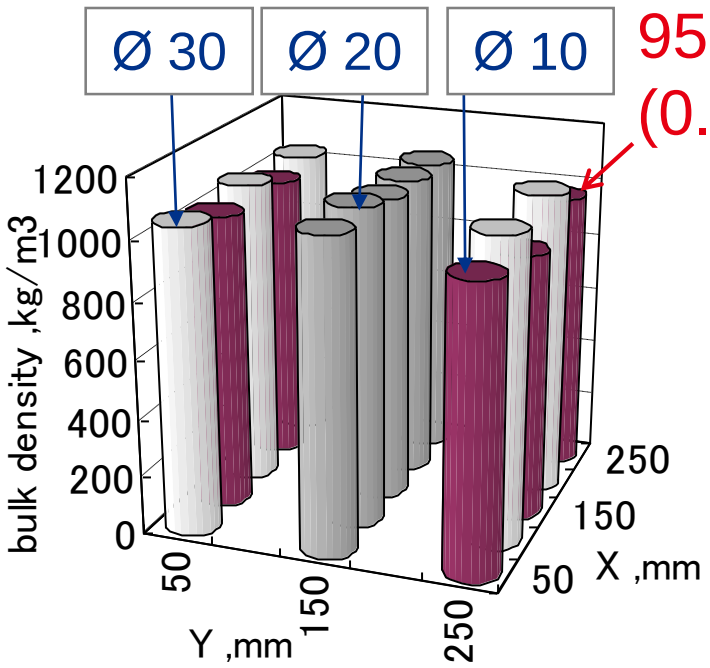
Blow : 0.3MPa



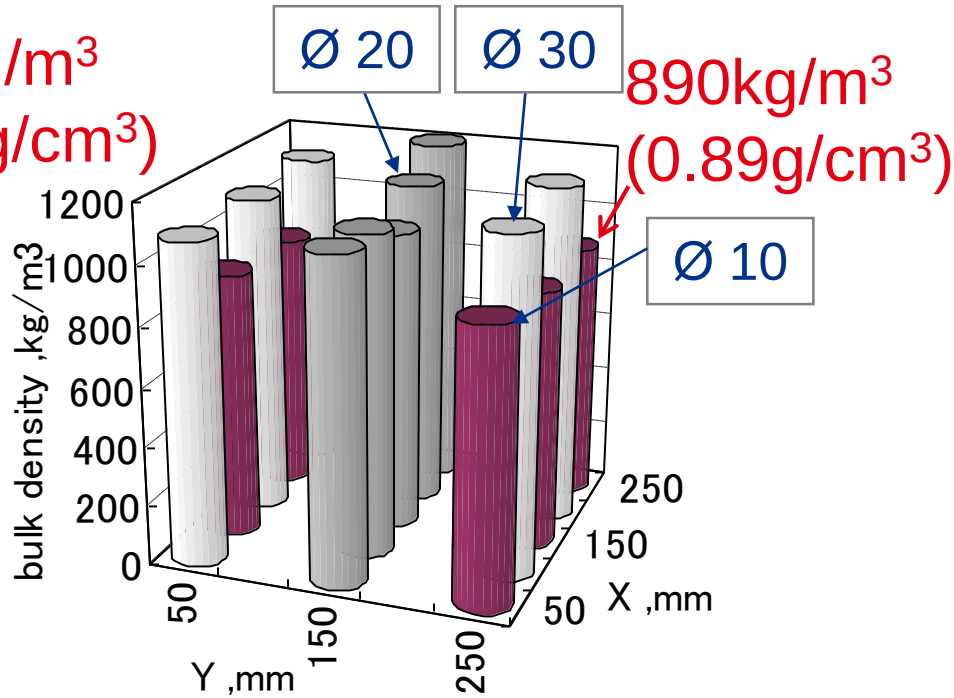
Bulk density : 1,000 kg/m^3 before molding at CB40%

Experimental Results of Sand Filling for Small Pocket

Aeration : 0.1MPa



Aeration : 0.15MPa



High pressure filling of green sand has an energy loss and an opposite effect for filling into the small pocket.

Computer Simulation of Sand Filling

- Mathematical model is based on euler two-phase continuous theory with Gidaspow's typical kinetic theory and Sinclair's viscosity theory.
- Air flow and sand flow is treated respectively

Air

Continuity equation for gas(air) phase

$$\frac{\partial}{\partial t}\left(\alpha_g \rho_g\right)+\nabla\cdot\left(\alpha_g \rho_g V_g\right)=0$$

Momentum equation for gas(air) phase

$$\frac{\partial}{\partial t}\left(\alpha_g \rho_g V_g\right)+\nabla\cdot\left(\alpha_g \rho_g V_g V_g\right)=\beta\left(V_g - V_s\right)+\nabla\cdot\tau_g$$

Sand

Continuity equation for solid(sand) phase

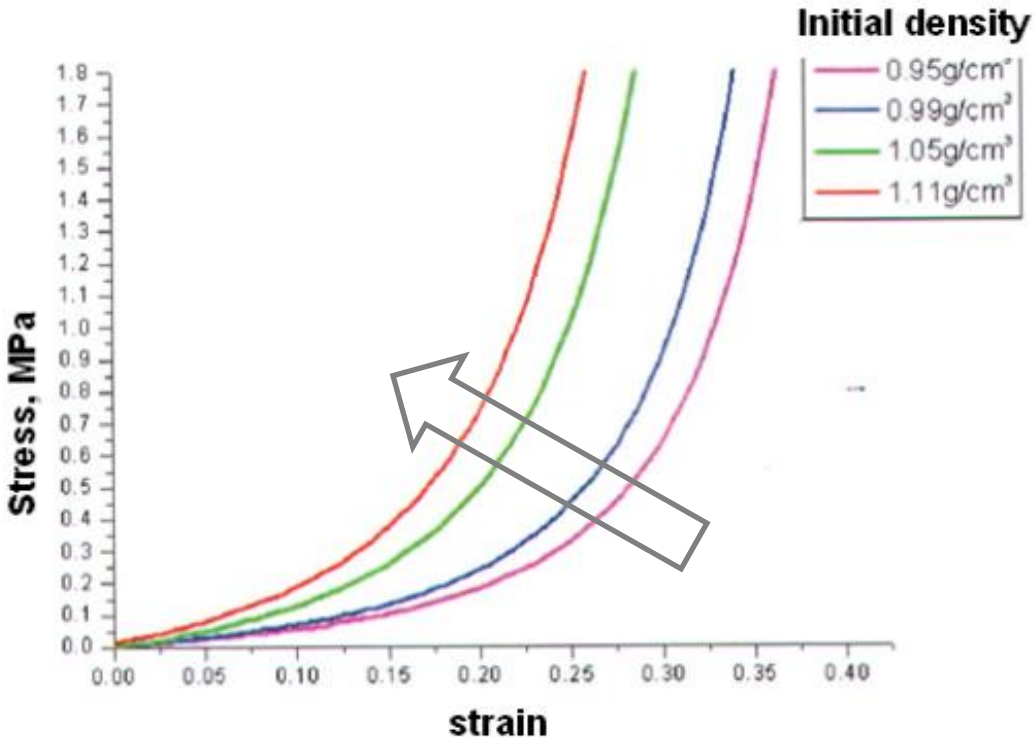
$$\frac{\partial}{\partial t}\left(\alpha_s \rho_s\right)+\nabla\cdot\left(\alpha_s \rho_s V_s\right)=0$$

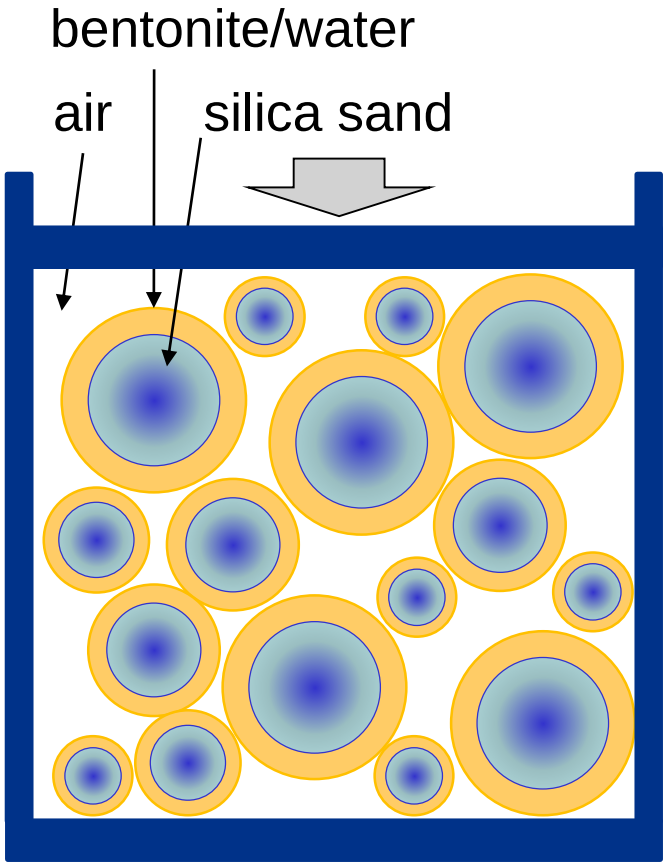
Momentum equation for solid(sand) phase

$$\frac{\partial}{\partial t}\left(\alpha_s \rho_s V_s\right)+\nabla\cdot\left(\alpha_s \rho_s V_s V_s\right)=\beta\left(V_s - V_g\right)+\nabla\cdot\tau_s+\alpha_s \rho_s g$$

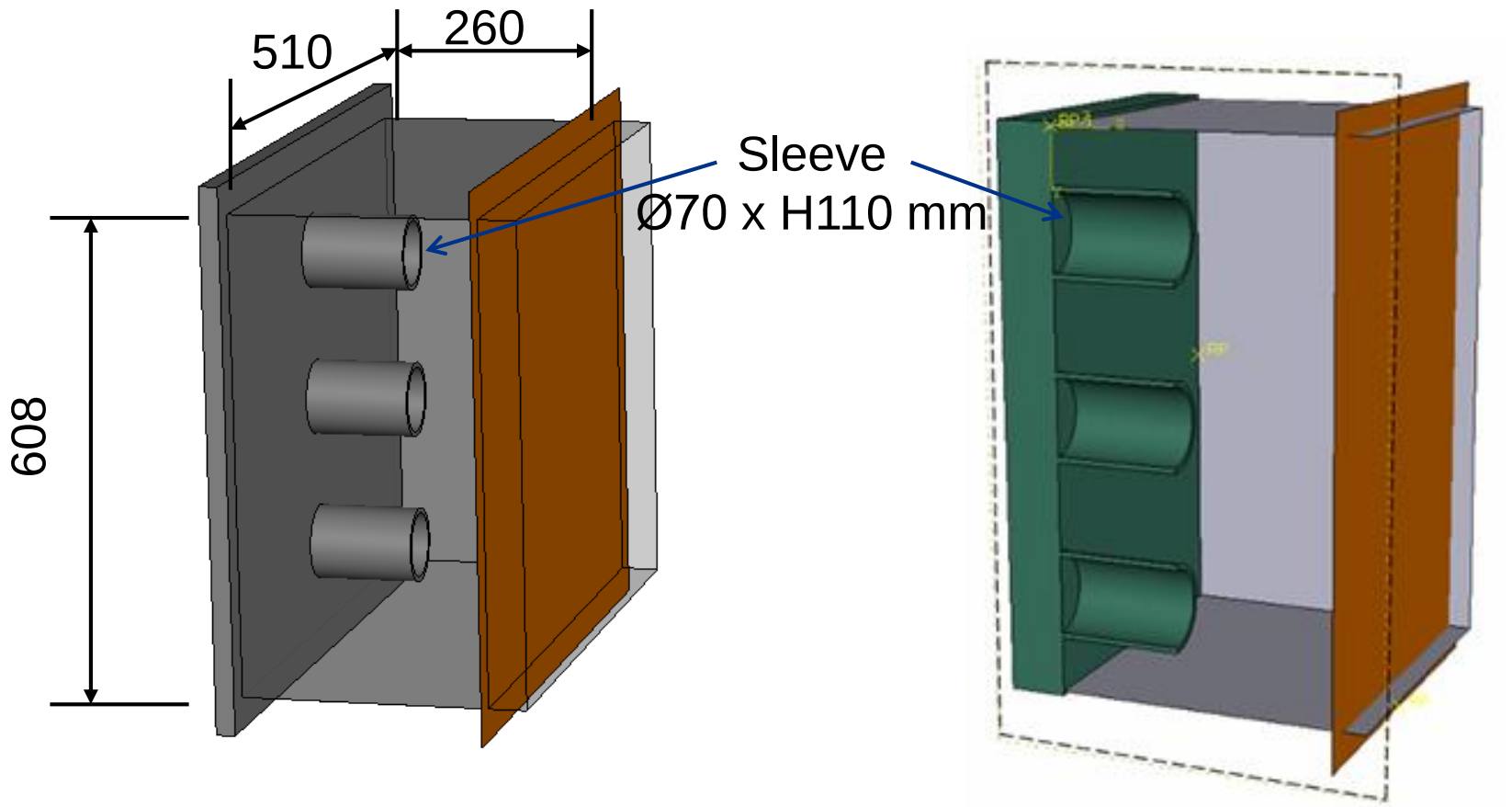
Computer Simulation for Squeeze

- Commercial FEM software ABAQUS is applied.
- The nonlinear elastic material model is used for squeeze simulation.





Geometrical Model of Flask-less Molding



A) Integrated geometrical model

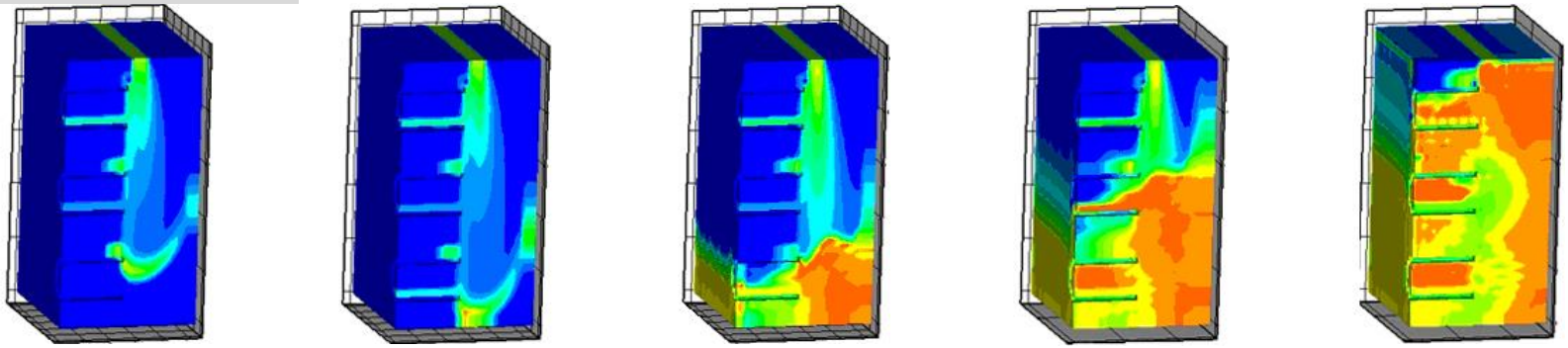
Flask size: 608x510x260mm

B) Symmetrical half part

Observing sand filling behavior

Simulation and Experimental Results for Aeration Sand Filling Process

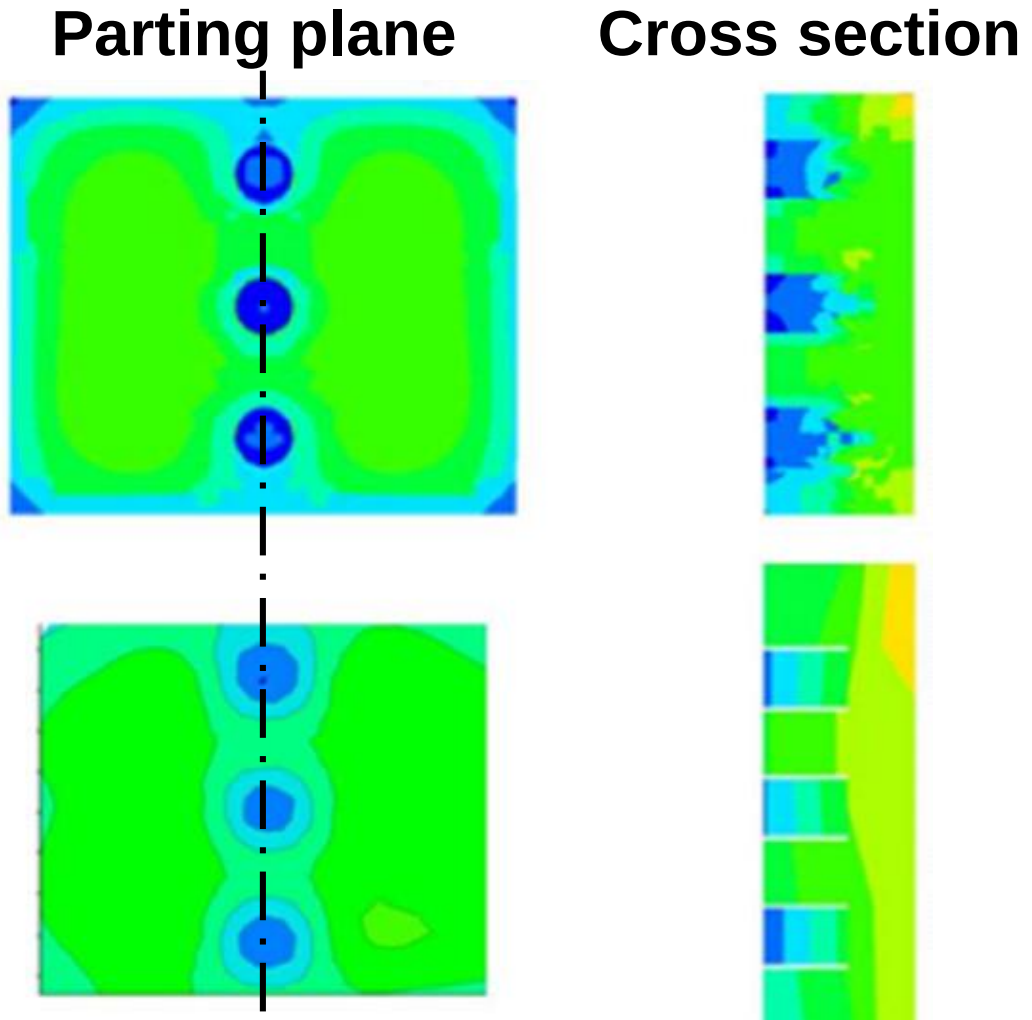
Simulation result



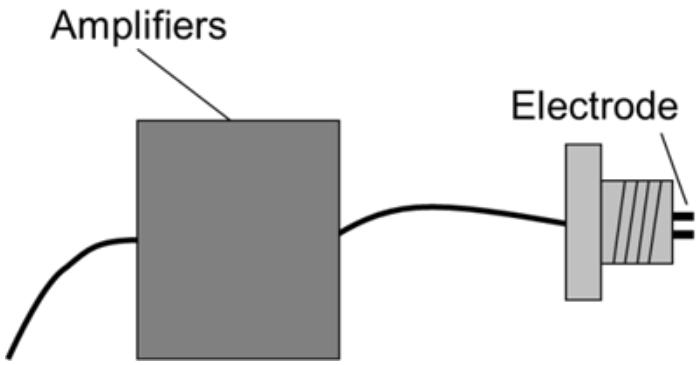
Experimental result

0.05s　　0.15s　　0.25s　　0.45s　　0.80s

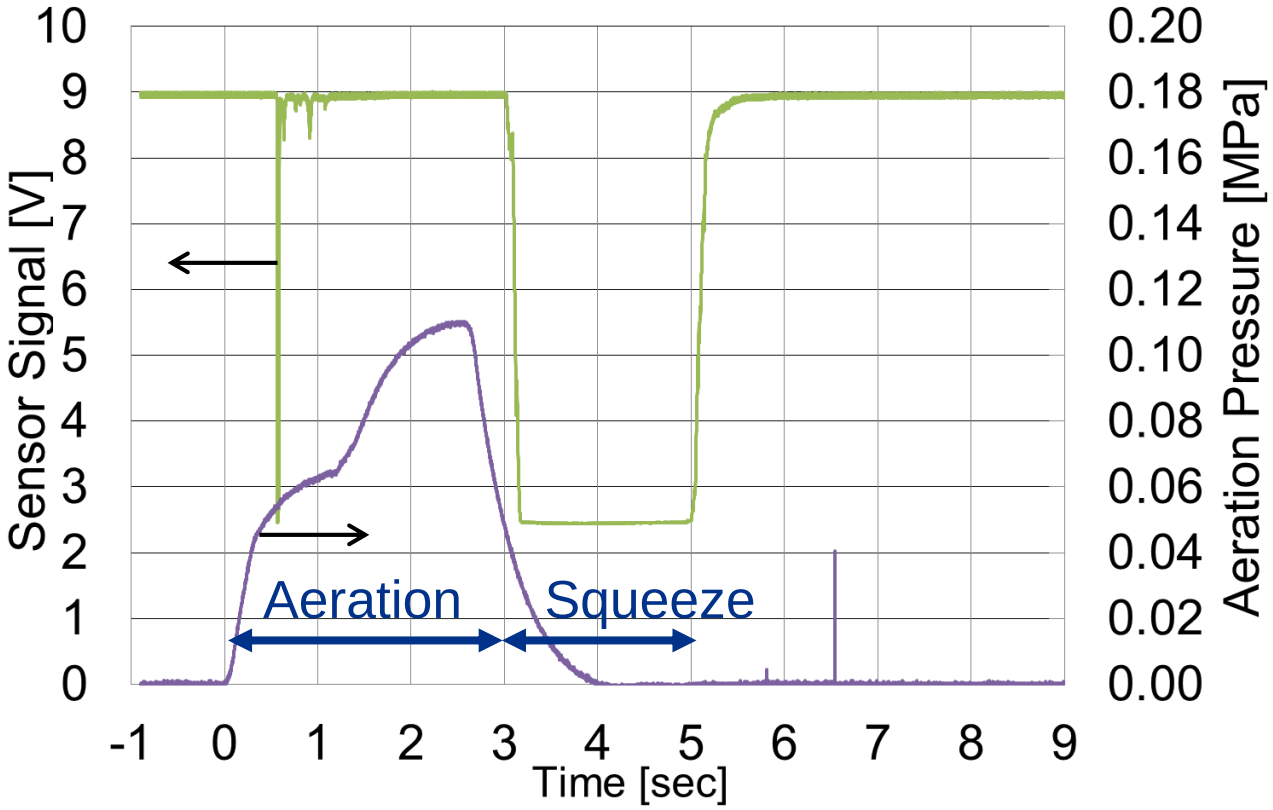
Simulation and Experimental Results for Squeeze Process



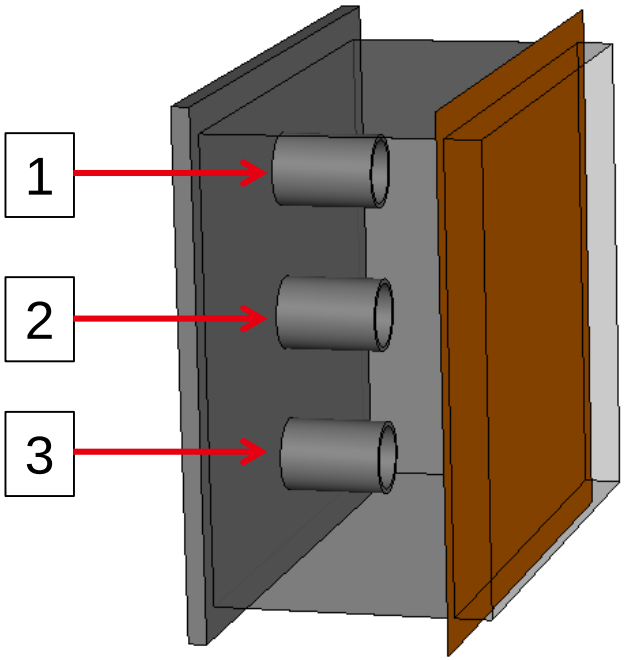
SAND DETECTION SENSOR FOR SAND FILLING



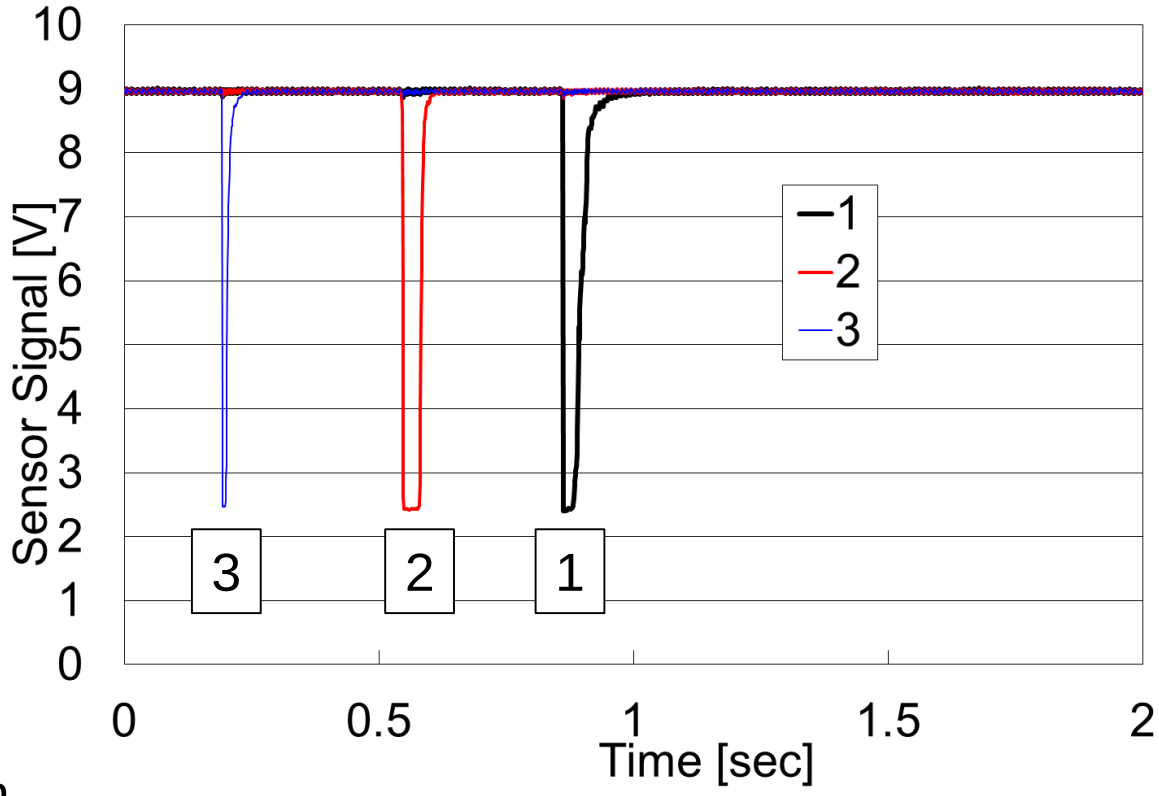
Schematic Illustration of Sensor



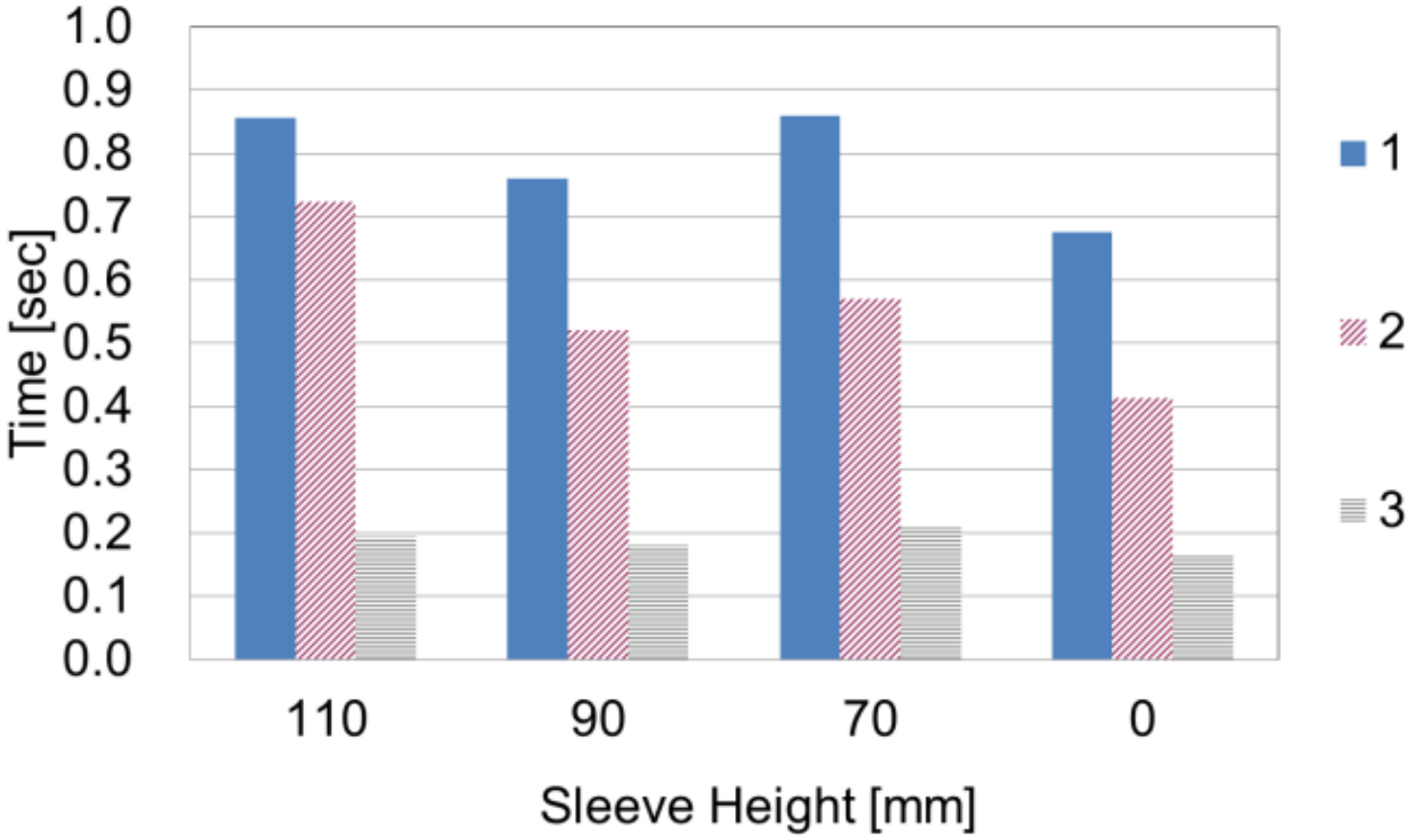
SAND DETECTION SENSOR FOR SAND FILLING



Sleeve : Ø70 x H70 mm



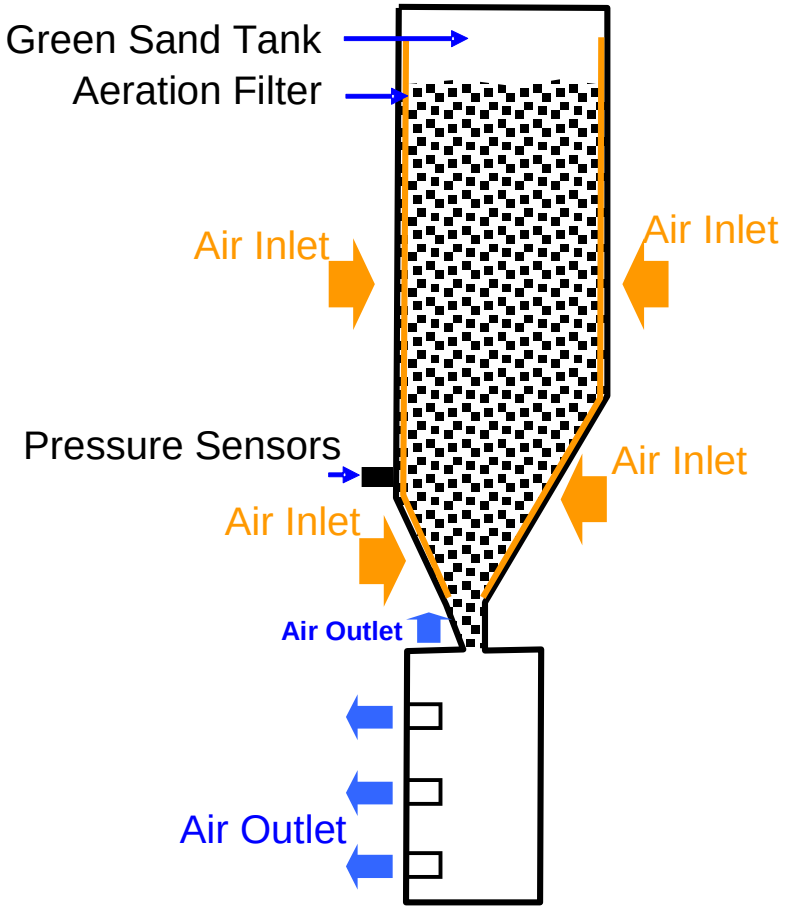
SAND DETECTION SENSOR FOR SAND FILLING



The behavior of aeration sand filling is not much affected by pattern shape.

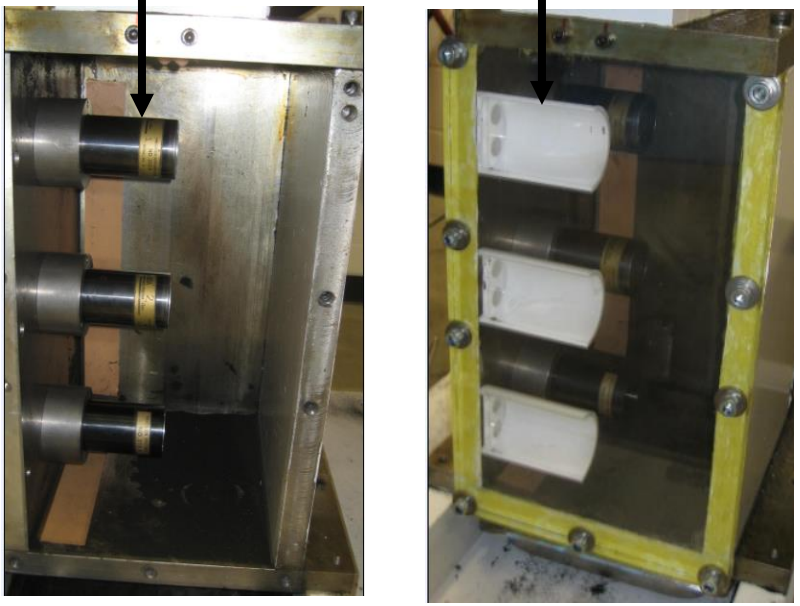
CONTENT

Schematic Illustration of Fundamental Aeration Sand Filling



AFS Specimen Tubes

Half-Section Sleeve
Ø60mm x H120mm



Measured Properties of Green Sand

AFS Test	Aeration Filling			Gravity Filling		
Compactability (%)	**30** *(0.2)*	**35** *(0.2)*	**40** *(1.0)*	**30** *(1.0)*	**35** *(1.5)*	**40** *(1.0)*
Bulk Density (g/cc)	**0.99** *(0.01)*	**0.99** *(0.01)*	**0.89** *(0.02)*	**0.98** *(0.02)*	**0.89** *(0.01)*	**0.88** *(0.04)*
Moisture content (%)	**2.5** *(0.02)*	**2.5** *(0.01)*	**2.5** *(0.01)*	**1.9** *(0.14)*	**2.5** *(0.05)*	**2.7** *(0.10)*
Specimen weight (g)	**160** *(1.0)*	**158** *(1.0)*	**158** *(0.5)*	**158** *(1.0)*	**158** *(1.5)*	**152** *(0.5)*
Permeability (#)	**220** *(1.0)*	**223** *(1.5)*	**228** *(1.2)*	**228** *(2.0)*	**233** *(1.0)*	**261** *(1.0)*
Splitting Strength (psi)	**3.4** *(0.12)*	**5.4** *(0.20)*	**5.1** *(0.10)*	**3.9** *(0.05)*	**5.4** *(0.10)*	**5.0** *(0.09)*
Compression Strength (psi)	**17** *(1.2)*	**24** *(1.0)*	**25** *(1.2)*	**21** *(0.2)*	**24** *(0.5)*	**24** *(0.1)*
Mold Hardness (#)	**93** *(1.5)*	**94** *(1.0)*	**97** *(0.5)*	**92** *(1.0)*	**94** *(1.2)*	**96** *(1.1)*
Friability (%)	**9** *(1.0)*	**7** *(0.5)*	**5** *(0.2)*	**31** *(3.0)*	**17** *(2.0)*	**10** *(1.0)*

Note : italicized number in parenthesis indicates standard deviations

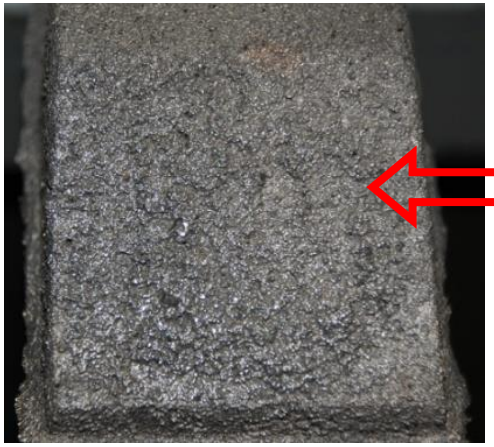
AFS Friability Test

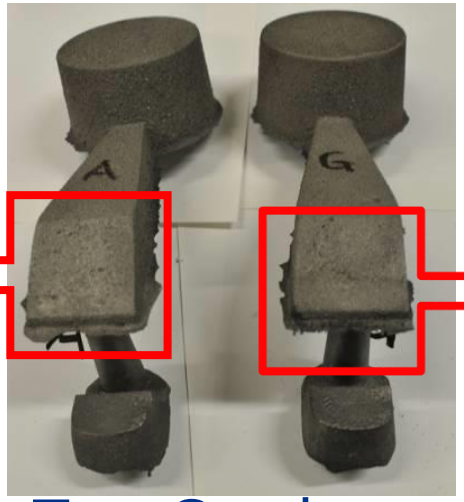
Measures the abrasion characteristics of the sand

Comparison of Casting Surface

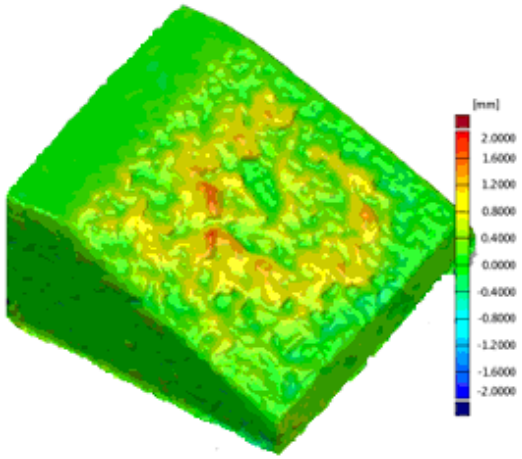
Aeration Wedge Section

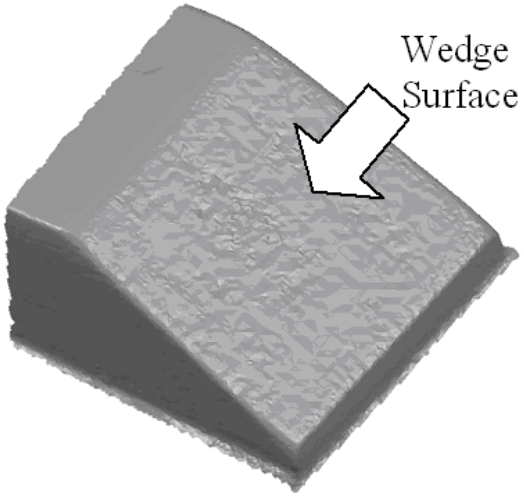
Gravity Wedge Section

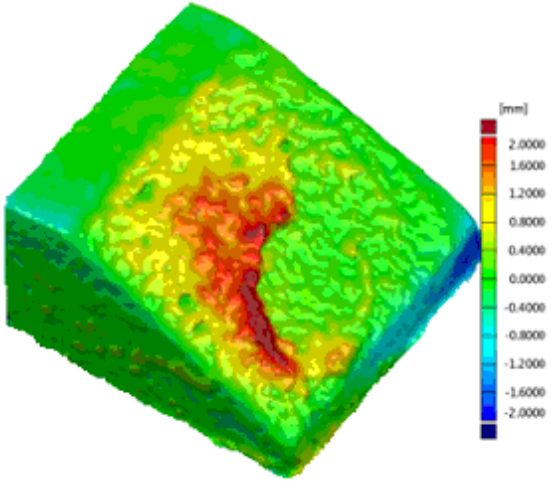




Test Castings







Advantages of Aeration Technology Achieved Missions

1) Good sand filling

- especially for small pocket

2) Good casting

- because of low friability and strong mold

3) Environmentally-friendly

- low air & energy consumption, low noise

because of low air pressure

Molding Machine Using Aeration Technology

1) tight flask

2) flask-less
- two station

3) flask-less
- single station

4) flask-less
- small flask size (450x350)

CONCLUSION

Aeration sand filling technology in green sand molding process is evaluated from the view of sand filling process and mold properties after sand filling. The results are summarized as follows.

1) Aeration sand filling and squeeze are numerically simulated. The calculated result is in agreement with the experimental results. Through these experiment and simulation, aeration sand filling is effective for sleeve pattern and can make highly strong and uniformly dense mold by lower air consumption.
2) The sand detection sensor can evaluate sand filling behavior. The behavior of aeration sand filling is not much affected by pattern shape.
3) Friability by aeration sand filling is lower than that of conventional gravity sand filling, especially in case of lower compactability. Therefore, aerated green sand mold can reduce casting defects caused by green sand property.

ACKNOWLEDGMENT

The authors gratefully acknowledge to

Prof. WU Junjiao at Tsinghua University, China
for computer simulation of sand molding.

Dr. Hartmut Polzin at TU Bergakademie Freiberg, Germany
for developing sand detection sensor.

Dr. Sam Ramrattan at Western Michigan University, USA
for fundamental testing of aerated green sand.

Teşekkür ederim!!

Thank you very much for your attention!!