Norwegian stove manufacturer believes in greensand

DISA 270 vertical moulding machine boosts capacity to 400 moulds an hour while cutting costs at Jøtul in Norway

DISA WM-1250 wire mesh blast cleaning machine for optimum cleaning of flat and thin-walled castings

Jøtul, a world leading supplier of cast iron stoves, hearths and fireplaces, wished to increase capacity and cut costs in order to reinforce its competitive position in world markets. A complete foundry project met all of the foundry's targets, including moulding speeds of 400 moulds per hour, with the replacement of a DISAMATIC 2070 MK1 by a DISA 270-A moulding machine, plus a major upgrade of the sand plant, shake-out, cooling and shotblast line.

Founded in 1853, the Jøtul foundry is based in Frederiksstad to the south of the Norwegian capital of Oslo. A world-leading manufacturer of cast iron stoves, hearths and fireplaces, the company markets its products in 34 countries on five continents under the motto 'warmth in every detail'.

The foundry employs 55 people in three shifts and has an annual output of 12,000 tonnes of uncored, grey iron castings ranging from 0.5 to 25kg.

Complete moulding line with DISA 270-A vertical moulding machine, automatic pattern changer unit and DISA WM-1250 wire mesh blast cleaning machine

Ambitious goals

'Our DISAMATIC 2070 MK1 had served us well for 25 years from 1981 until 2005, turning out a total of 19.5 million castings', Jostein Lunde, production and technical manager explains. 'Our sales were growing at a rate of 5% a year and we needed to increase our production capacity to keep up.'

Jøtul was looking for a solution that would deliver 400 moulds an hour, enabling the company to achieve a 50% capacity increase to cover needs for many years ahead. In addition, the solution had to deliver a significant reduction in cost per casting in order to take up the fight against emerging competitors in low-cost countries.

The foundry demanded at least 90% availability and lower manpower costs with a maximum of 10 or 11 people per shift to operate the line. In addition, even better castings quality, less scrap and 20% lower finishing costs would contribute significantly to the bottom line, while a simpler control system and minimum maintenance would ensure consistency and high availability. The project had to promise a payback period of no more than three years.

Complete foundry project

One of the unique features of Jøtul is that all production steps - melting, moulding and casting, machining, enamelling, painting, assembling, packing, pattern shop and development - take place in the same factory.

'For us, effective integration throughout the production process is of paramount importance', Jostein Lunde continues. 'And that is best achieved by opting for a complete solution for the foundry from a single supplier. Our extremely positive experience together with DISA as a service partner since 1981 meant that we approached them to find an overall solution that would satisfy our requirements for many years into the future.

'We finally agreed on a thorough upgrade of the entire foundry, the heart of which was to be the new DISA 270-A moulding machine. DISA assumed responsibility for the entire project so that we would only have to deal with one partner who was responsible for everything, including sub-suppliers.'

Installation during summer shut-down

The first step was to replace the existing shake-out and three shotblast machines as well as installing a new casting cooler and a new, complete control system that could integrate easily with all of the various components in the moulding line. This was achieved in just five weeks.

The next was to use the summer shut-down period in July and August 2005 to install the new DISA 270-A including an automatic pattern changer (APC) that ensures a pattern change in just 60 seconds, and a complete new sand mixer (SAM 16-160) with a sand multi controller (SMC). A number of other installations were also replaced and upgraded with the entire project taking just four weeks.

The design focus of the moulding machine is on casting accuracy, production capacity with speeds of 400 moulds an hour and user-friendly service and maintenance.

'We face three main challenges as far as casting quality is concerned,' Mr Lunde explains. 'These are the need for casting thicknesses between three and six mm, a perfect surface quality without pitting and the avoidance of tear-offs. The rigidity of the new moulding machine with its mismatch of 0.20mm or less has enabled us to meet these requirements to the full as well as reducing our grinding costs by more than 20%.'

Over 400 moulds an hour

'We have already achieved the required capacity increase with a steady speed of 410 moulds an hour in contrast to the 275 moulds an hour on the old machine. A scrap percentage of 2% or less as well as satisfactory yield and availability of up to 98% are well within our target range, and the new control system together with the new hydraulics and fewer moving parts have enabled user-friendly operation and maintenance well within the specified limits.'

While the foundry workers at Jøtul were highly experienced in vertical moulding, training was necessary in order to ensure maximum benefit from the 25 years of technology advances embraced by the new DISA 270-A.

Training took place both at DISA in Denmark and during the installation process, ranging from adaptation of the existing DISAMATIC 2070 pattern plates to a detailed introduction to all of the new features as well as service and maintenance procedures.

Jøtul has also entered into a special DISA TOPS service agreement that ensures regular process status reports by DISA technicians, constant availability of spare parts and, if necessary, rapid response in the event of a problem that cannot be rectified by the foundry's own experts.

'Everything is working entirely according to plan, and we hope now that we are set for another 25 years of high-quality, trouble-free production,' Mr Lunde concludes.

DISA Industries A/S; tel: (+45) 4450 5050; fax: (+45) 4494 5225; e-mail: disa.industries@disagroup.com www.disagroup.com

DISA automatic pattern changer unit (APC) that allows a pattern change in just 60 seconds

Metal Prices

Ferro-alloys

Ferro Silicon
(per 1,000kilos) 75% loose in bulk (Mt) £725.00; 75% drums on pallets (Mt) £740.00; 75% bulk bags on pallets (Mt) £735.00.
Tennant Metallurgical Group Ltd

Ferro Silicon Briquettes
Gross 1.2kg, containing 1kg available Si, 56p per briquette (462 briquettes per pallet).
A&S

Ferro Molybdenum
Carbon free £41.20 to £43.00 per kg Mo contained.
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Ferro Vanadium
50/80% or 70/80%, £24.00 to £26.00 per kgV.
William Rowland

Ferro Titanium
67/72% content, £5.50 to £6.75 per kgTi.
William Rowland

Ferro Niobium
70%, £42.70 to £44.00 per kg Nb contained.
William Rowland

Ferro Tungsten
£19.00 to £21.00 per kgW.
William Rowland

Ferro Phosphorus
£425.00 to £500.00 per tonne
William Rowland

Electrolytic Manganese
99.9% minimum, £3,500.00 to £3,900.00 per tonne. 99.7% minimum, £3,150.00 to £3,400.00 per tonne.
William Rowland

Metallic Chromium
99% minimum Cr, £4,300.00 to £4,600.00 per tonne. 99.5% minimum Cr, £5,100.00 to £5,500.00 per tonne,
William Rowland

Ferro Manganese
(standard) 78%, £880.00 to £950.00 per tonne
William Rowland

Ferro Manganese Briquettes
Gross 1.80kg containing 1kg available Mn, 54p per briquette (960 briquettes per pallet).
A&S

Pig Iron
Basic, £225.00 to £235.00. Hermatite, £245.00 to £265.00. Nodular, £245.00 to £265.00
Hempel Metals

Non-ferrous metals

Aluminium Alloys
LM2 £1,345.00; LM4 £1,415.00; LM6 £1,557.50; LM24 £1,315.00 LM25 £1,557.50; LM27 £1,375.00

Copper
Cash, Grade A, US$7,360.00 to US$7,361.00
Calders Limited

Lead Refined Pig
Cash: US$3,958.00 to US$3,959.00 Three Months: US$3,850.00 to US$3,855.00 Settlement: US$3,959.00
Calders Limited

Zinc
Cash: US$3,095.00 to US$3,095.50 Three Months: US$3,095.00 to US$3,100.00 Settlement: US$3,095.50
Calders Limited

Tin
Cash: US$15,900.00 to US$15,950.00 Three Months: US$15,975.00 to US$16,000.00 Settlement: US$15,950.00
Calders Limited

Other metals

Magnesium Ingots
(10 tonne lots delivered) £1,800.00 to £1,900.00 per tonne
William Rowland

Antimony
99.65% min £2,910.00 per tonne
AMC

Nickel
US$32,300.00
Calders Limited

Flexibility with economy and recyclability

For reasons that include cost and environmental impact, greensand remains the basic moulding medium for foundries worldwide

The WFO Technical Forum organised by the WFO and VDG and run concurrently with GIFA 2007, included several papers that brought delegates up to date with developments in greensand technology.

In their paper, *'A new approach for the reduction of moulding sand emissions by 50%'* authors Y Paniaras, C Grefhorst and Dr O Podobed from S&B Industrial Minerals GmbH, Germany, spoke of how the environmental performance of foundries is rapidly gaining in importance an dhow it is also becoming a key competitive factor, alongside production efficiency and quality of castings.

Legislation at European and national level is setting ambitious targets for emissions, waste disposal and working conditions, Workers, the local community, shareholders and customers of foundries are also becoming increasingly sensitive on these issues.

Environmental, health and safety considerations have driven greensand systems for decades. One of the first developments was to combine the carbonaceous lustrous carbon formers and bentonite in a single blend, thereby reducing the explosion and self-ignition hazards of the carbonaceous component, while creating a homogeneous, quality controlled mix that also improved casting efficiency.

Another development, on the side of carbonaceous component, has been the emergence of components that maximise the performance of these organic products, while on the other hand minimising their negative environmental impact. Products such as IKO's Antrapur, Polycarbon and Priocarbon are typical of this progress.

In order to achieve further environmental improvement another breakthrough change is needed. For example, the authors asked 'instead of improving the carbonaceous component, why not remove it altogether'? This idea obviously challenges the common perception about greensand systems and requires a rethink of the basic processes that take place in greensand casting.

EU funding

Instrumental in this research has been an EU-funded project bringing together foundries, equipment manufacturers and raw material suppliers. The Go-Apic project (2000-2004) was successfully completed, with a practical demonstration that emission reductions can be achieved (World Foundry Congress, Istanbul 2004).

Following the EU project, IKO continued the product development with the aim to reduce further the emissions, while improving the mould shakeout characteristics. This has been achieved by the product Envibond, which has been introduced with success in foundries across Europe.

Envibond comprises bentonite and other minerals and can replace a traditional blend either partially or fully, depending on the types of castings and the configuration of the casting line. Its composition ensures firstly that the surface of the mould is highly compacted and secondly that wetting of the mould by liquid metal is reduced. The reduction of mould porosity and mould surface wetting contribute to the achievement of a smooth casting surface.

Emission generation

Emissions are generated in the mould by two sources - the carbonaceous component added to the sand and the organic binders coming from the cores, the main emission reduction effect of Envibond being through the reduction of the carbonaceous component. A secondary affect is the filtering of the organic binder emissions.

When introducing Envibond in a foundry, it is important to start with recording the current emission levels measured on-site and through pilot casting, and reviewing the sand system. Ideally, the foundry should be running on a single blend system, Envibond should then be introduced in parallel to the existing blend, starting with a small addition and building up to the maximum possible replacement. This way, the authors claimed, the product introduction takes place without imposing a risk to the casting process and quality.

Practical experience over the last 18 months with the material in foundries has shown that it can be applied 100%. In other words, it can replace completely the traditional lustrous carbon-based solution. BTEX emission reduction of 50% has been achieved, the casting quality in the foundries where Envibond has been introduced remaining unchanged, even though shakeout does need further improvement. Its consumption is generally lower than the traditional blends.

Importantly, there is a clear improvement in the workplace, the foundry looks cleaner with no smoke visible during casting and a lighter coloured moulding sand.

Cost-benefits

As each foundry has it own customised blend and would need its own customised Envibond, a universally applicable comparison of costs and benefits is difficult to make. As a general rule, however, the benefits of lower consumption, lower waste disposal costs and lower emission control costs will generate savings in the foundry.

The value of the product becomes higher in cases where foundries operate close to emission limits, while the unquantifiable benefit of having a cleaner foundry can be seen as a bonus.

The next generation has already been developed and tested in the labs of IKO and the pilot casting facility of TU Freiberg. Furthermore, the emission performance of bentonite-bonded sand systems is further researched at the University of Krakow, with testing developed for the quantification of emissions at any foundry before and after Envibond and ongoing tests on the impact of further additives on emission reduction.

The main innovation of the next generation of the material will lie in having a significantly improved shakeout, at the level of traditional blends. This will enable it to be used on a much broader range of castings, bringing environmental benefits, while maintaining the quality and production efficiency as normal blends.

Research from Japan

'Two-phase flow analysis of aeration sand filling for greensand moulding machines' was considered by Prof WU Junjiao, Dr LI Hongliang, Dr LI Wenzhen from Tsinghua University, Beijing, and Dr Hiroyasu Makino, Minoru Hirata and Takashi Hanai from Sintokogio Ltd, Japan.

The authors began by saying that castings produced using sand moulds continue to increase in production, especially for iron casting production where the greensand mould remains a major foundry technology. Requirements for lighter automobiles have produced greater needs for near net shape iron castings and to meet such needs, it is necessary to develop an effective method to predict and control an optimal pattern plate layout and moulding conditions.

The greensand moulding process can be classified into two types - flask-less and tight-flask. The former is a process where greensand is blown from the sand tank into the moulding chamber with compressed air of 0.3-0.5MPa and then squeezed under high pressure. The latter is an airflow squeeze method which has been popular since the mid 1980s.

This process comprises the following steps. First the greensand is measured into the hopper and transferred into the filling frame and flask by gravity. Compressed air is then introduced onto the greensand and finally the moulding sand is compacted with multiple squeeze heads. These conventional filling methods can suffer from inhomogeneous sand density and inadequate sand filling into a small pocket, etc.

Aeration process developed

Recently, a new type of greensand moulding machine employing an 'aeration' sand filling process has been developed to solve such problems. This process is a new key technology for recent moulding machines, being characterised by sand being filled with lower air pressure than the conventional blow filling process. The aerated sand filling results in uniform sand density and high quality moulds through the subsequent squeezing process.

In this study the authors designed and built a mathematical model for the blow filling and the aeration filling process based on a two-phase continuous model through two-dimensional computer simulation.

In the mathematical model for the aeration filling and blow filling processes, the Euler two-phase model was taken as the basis of design. In this model, both gas phase and solid phase have been assumed as continuum, they have been treated as airflow and sand flow respectively.

In the governing equations of the mathematical model, the continuity equations and momentum equations of gas phase and solid phase have been treated separately. All of the sand particles are considered to be identical and are characterised by a mean diameter and a mean density.

To describe the collision between different sand particles, a typical kinetic theory model for multiphase flow was built based on the Gidaspow. The mass and momentum balance equations for the gas and solid phases are solved in the computer code. In these equations, the dependent variables are the gas volume fraction, the solid volume fraction, the gas density, the velocity vectors of the gas and sand flow.

Continuity equation of the gas phase:

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

Equation 1

Momentum equation of the gas phase:

$$\frac{\partial}{\partial t}(\alpha_g \rho_g V_g) + \nabla \cdot (\alpha_g \rho_g V_g V_g) = \beta (V_g - V_s) + \nabla \cdot \tau_g \qquad \text{Equation 2}$$

As the gravity force of air is very small compared with the stress of air, it is neglected.

Continuity equation of the solid phase:

$$\frac{\partial}{\partial t}(\alpha_s \rho_s) + \nabla \cdot (\alpha_s \rho_s V_s) = 0 \qquad \text{Equation 3}$$

Momentum equation of the solid phase:

$$\frac{\partial}{\partial t}(\alpha_s \rho_s V_s) + \nabla \cdot (\alpha_s \rho_s V_s V_s) = \beta (V_s - V_g) + \nabla \cdot \tau_s + \alpha_s \rho_s g \qquad \text{Equation 4}$$

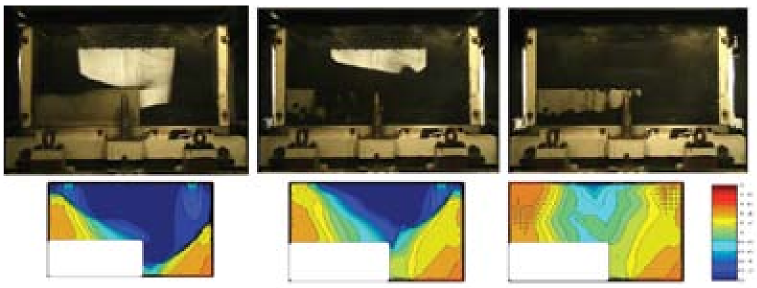
where ∇ is the Hamilton Operator, α_g is the volume fraction of gas phase, α_s is the volume fraction of solid phase, namely, $\alpha_g + \alpha_s = 1$. ρ_g is the density of gas phase, ρ_s is the density of pure sand particle, V_g is the velocity vector of gas flow, V_s is the velocity vector of sand flow, β is the drag coefficient, τ_g is the stress tensor of gas flow, τ_s is the stress tensor of solid phase, g is the gravity acceleration.

Experimental and calculated results

Based on the actual machine, two-dimensional computer simulation is conducted under the following conditions. The simulation area is 700mm wide and 400mm height, the test block being placed on the pattern plate.

The experimental and calculated results are shown in the figures, the aeration pressure being 0.15MPa. Different colours distinguish the contour figures of the sand filled density.

When sand particles are filled into the flask under low-pressure air, they move downward. Then the left sand flow reaches the top of the pattern block first, after that, it moves laterally. By comparing the experimental results with the calculated ones, it can be seen that they are in agreement.



0.3 0.6 0.9sec (g/cm3)

Comparison of aeration sand filling behavior between observed and calculated results.

The authors concluded by saying that the validity of the mathematical model is clarified through the comparison of aeration sand filling between calculated results and observed ones obtained on an actual production moulding machine. This study has provided new and valuable information on the behavior of aeration sand filling.

Compaction characteristics

The quality of the moulding sand and the resulting mould has a crucial influence on casting quality, such as dimensional accuracy and surface finish. Dr Ing Regina Lenz from the Institut für Gießereitechnik GmbH, Düsseldorf discussed '3D simulation of the compaction of clay-bonded moulding sands', claiming strength created by the compaction process and, therefore, the density of the mould has the greatest influence on quality in this regard. These quality factors resulting from the compaction process are, in turn, directly dependent on the moulding equipment parameters.

It is necessary to adjust these equipment parameters specifically to the pattern geometry in each case so as to achieve optimum compaction. Non-optimally adjusted parameters lead to inhomogeneous or inadequately compacted moulds, culminating in defective castings and thus scrap as a result of dimensional inaccuracies or mould fracture.

Where new cast parts are concerned, such optimally adjusted parameters have to be determined by trial and error in a very time-intensive series of tests. This process of parameter determination significantly prolongs the period of time until final release for production and, hence, until the start of quantity production.

Within the scope of a research project, the IfG has looked at the use of a commercially available, explicit FEM code for simulating the compaction of clay-bonded moulding sands. Simulation helps to calculate the moulding as a function of the moulding sand and pattern before any patterns are fabricated. It is thus possible, for example, to shorten the start-up time for new quantity production, increase the process robustness and productivity, realise maximum plate utilisation, and reduce the scrap rate.

Computer-based simulation additionally makes it possible to analyse and visualise the compaction process itself as well as the dependency on the above-mentioned parameters.

Software selection

A leading international software program designed for the simulation of highly non-linear, dynamic performance requirements was selected,

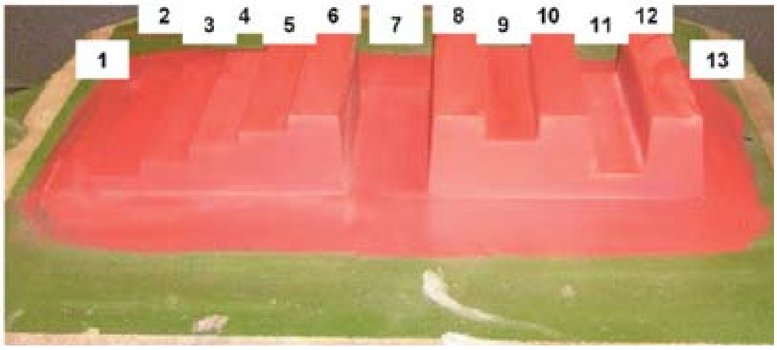


Fig. 1. Stepped wedge model with measuring points

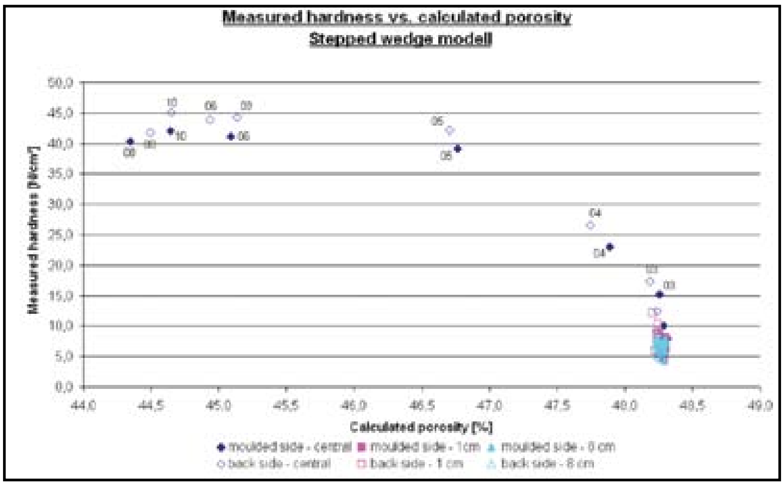


Fig. 2. Relationship between measured hardness and calculated porosity

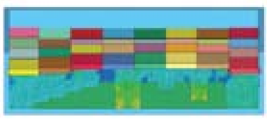


Fig. 3. Density distribution

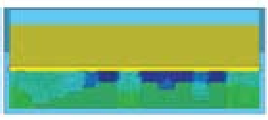


Fig. 4: Density distribution

Fig. 5. CT imaging of the multi-ram pressing single-ram pressing compacted mould

its main fields of application including crash simulation and associated problems.

One precondition when selecting the software was being able to calculate both static and dynamic processes. The programme should run in a stable manner even where major deformations are being simulated. An additional requirement included being able to describe the behaviour of the moulding sand under load realistically.

To do this, it had to be possible to simulate the relatively significant volume reduction of the moulding sand introduced loosely into the mould during the compaction process using a suitable material law.

To describe the moulding sand, a material model was used that was actually developed for calculating foam materials or foam-like structures. It was necessary to input a stress-strain curve in order to describe the material behaviour in the simulation. This can be derived directly from an experimentally determined load displacement curve.

The conduct of such testing involves relatively little work, a cylindrical test piece with a diameter of 50mm and a height of 100mm being used. The moulding sand is sifted into place, a ram then applying a load that is gradually increased. At the same time, the compaction (displacement of the ram) is recorded. This curve describes the compaction behaviour of the moulding sand when subjected to loading. It has to be determined specifically for each moulding sand.

The applied material model also takes into account the escape of the air and, thus, the volume reduction of the material, there being no explicit calculation of airflow. This material model is able to take account of a volume reduction as great as 70% without any problem.

Porosity calculated

During the simulation of the compaction process, the porosity of the individual elements (ratio of moulding sand and air) is calculated as a function of the applied load. Using this value as a basis, it is possible to predict the local mould hardness as a function of the moulding sand. Conducted tests and comparison with appropriate simulations have revealed very good consistency in this regard (figs. 1 and 2).

The suitability of the software used for simulating static compaction processes was demonstrated within the framework of the research project. It is possible to simulate the methods of 'single-ram pressing' and 'multi-ram pressing' in various directions (horizontally and vertically, top-down, bottom-up), as well as in combination with one another.

Fig. 3 shows the density distribution calculated for compaction by multi-ram pressing, and fig. 4 the density distribution resulting from compaction by single-ram pressing. Areas displayed in dark blue could be compacted very well, but red areas only very poorly. The results are plausible and meet expectations.

When compacting by means of the 'pressing' method, maximum compaction is to be found above the uppermost model points. Compaction by the multi-ram method leads, when applying the same overall load, to greater homogeneous compaction over the entire mould. Considerably less compaction is found in the pockets in both cases.

The simulation results were additionally verified by recording load-displacement curves at different points on the real mould during the compaction, for which purpose the calculated loads were compared with the ones measured. In this regard, too, it was possible to ascertain a good consistency.

Density distribution calculated

The density distribution after the compaction process was also determined with the aid of computer tomographic analyses on real moulds compacted by single-ram pressing. Very good consistency between test and simulation was found in this regard (fig. 5). General feasibility was demonstrated concerning the simulation of dynamic compaction processes, in which regard the results are also very promising.

By applying fully developed, commercially available software to a new field, it is already possible, based on the present status of the work, to calculate also real and, hence, complex moulds.

The research project was funded by the Land of North Rhine-Westphalia (PTJ-Az 0410MW 15).

For more information on the World Foundrymen Technical Forum visit: www.thewfo.com

Getting the best from greensand

Brian Clarke from Ridsdale & Co Ltd explains some sand tests and their importance to product quality.

Greensand moulding started some three or four thousand years ago with the pouring of metal into naturally shaped rock. This was improved upon by shaping simple sandstone moulds to make the required shape. The foundry industry then developed by using naturally bonded sands and patterns to enable the sand to produce a reasonable reproduction of the casting shape required.

Until the turn of the last century, or even later, very little advancement was made in the foundry industry on naturally bonded sands, because of lack of deposits of naturally bonded sands and more stringent requirements demanded by the engineers. Synthetic sands were introduced in the 1900s and today are widely used in a variety of forms, the most common being silica sands which occur from the breakdown of silica rock.

To prepare greensand moulds, the material must be thoroughly mixed and mulled to develop their green working properties and to make them suitable for moulding. The sand must be homogenised, particularly in the case of re-circulating moulding sand.

To develop the strength of a greensand mould the sand must be uniformly moistened, the water must be picked up by the fines, particularly by the bonding clay and any new additions of bentonite and carbonaceous material. The actual mulling energy must be transferred to the sand so that each individual grain starts moving against the neighbouring grain. The increased dispersion of the bonding clay during the mulling and the coating of the grains is reflected by the increase in the green strength.

Monitoring moisture

The most important working property of a clay-bonded greensand is the moisture requirement to create good moulding sand for the individual job. The permissible moisture content for moulding sand is very limited, as it must not be too wet or too dry in order to develop the correct degree of temper and optimum working properties.

Each sand has its individual moisture requirement and is not transferable to another sand. It cannot be defined by an absolute moisture percentage either. Water is the most important sand additive and in the early days this was controlled by the individual moulder using his experience.

The study of systematic sand testing began in 1921 by the American Foundrymen's Society and in 1924 they published recommended procedures for measuring moisture content, permeability, green strength and grain fineness. Even today their original methods still form the basis for testing clay-bonded sands.

With the introduction of boxless moulding lines, another very important test was introduced - the wet tensile test. Further tests came along and today greensand moulding lines are controlled at the sand mill using the compactability test, with further detailed checks being carried out in the sand laboratory on an hourly and daily basis.

Test interpretation

Permeability

Greensands in particular must be permeable to allow the gasses that develop during pouring (steam, expanding air, volatiles from the additives) to escape. The degree of permeability required for this purpose is often overestimated. Permeability also has an indirect significance in that it is a good measure for the grain fineness of the sand (the coarser the sand the higher the permeability). It also measures the influence of fines present in the sand.

If the permeability of the sand is high, this can result in rough surface finish. The permeability, therefore, is a simple and reliable method to test the effect of sand on the surface of the casting. In sand moulds without risers or other means of gas venting, permeability of the sand is more important than in moulds with a riser.

Green compression

The green compression test has been the accepted method of primary sand control in foundries for many years. The rate of clay addition is often predicted on this property alone, despite the fact that there are many other factors that can influence the test values.

Equipment is readily available to test greensand using AFS methods, originally in imperial units, but also extended to DIN (metric) units.

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www.basrid.co.uk

Choosing the best technology for the job

A new Künkel-Wagner moulding plant for the production of engine blocks and cylinder heads is now operating at Technocast SA de CV, Saltillo, Mexico.

Fig 1. The new moulding machine at Technocast SA de CV, designed for a production rate of 90 moulds per hour

Künkel-Wagner has supplied to Technocast SA de CV, Saltillo, Mexico (a joint venture between Cinfunsa, Mexico and Caterpillar, USA) a moulding plant for a new cylinder block foundry in northern Mexico. The foundry, commissioned in the middle of 2006, produces engine parts for Caterpillar construction machines.

Moulding machine

The moulding machine (fig. 1) has a flask size of 1,680x1,200x560/560mm, being designed for a production rate of 90 moulds per hour. Currently, the plant is being operated at 75 moulds per hour, as it still has to be fully integrated with the other foundry areas. Its production rate of up to 90 moulds per hour is very high, considering the flask size, which is why the high-performance Künkel-Wagner squeeze machine type HPM (patent eP(UK)0731742) has been selected.

Fig. 2 illustrates the sequence of the moulding machine, the horizontal passage of the half flasks through the moulding machine being performed on the moulding line roller conveyor. Cope and drag flasks are lifted simultaneously into the stationary filling and compaction stations respectively for sand filling mould compaction using AIRPRESSplus2000 technology. The flasks are then simultaneously lowered into the moulding line, pattern bolsters are lowered and the full flask-half goes to the turnover device. Return changeover of cope and drag flask patterns is by vertical pattern circulation below the moulding line (see also http://kuenkel-wagner.com/en/c._downloads.html.

Mould compaction technology

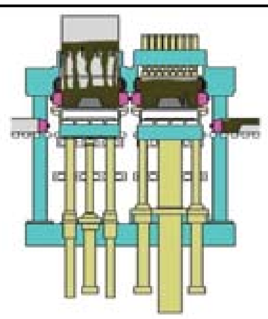
Mould compaction with the AIRPRESSplus2000 technology comprises a specific pre-compaction by airflow and the following final compaction by squeezing with a controlled, active multi-piston squeeze head. Fig. 3 gives a schematic view of the machine set-up for this technology.

Main features of moulding machines operating with this technology include:

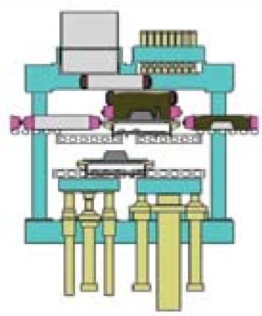
- The special, rapid acting AIRPRESS valves that produce the air pulse.
- The AIRPRESS frame and the cavity below the multi-piston squeeze head which together constitute the moulding chamber.
- The multi-piston squeeze head that is equipped as standard with at least two completely separate squeeze circuits. Due to the particular arrangement on the pattern plate, the multi-piston squeeze head of the Technocast moulding machine is equipped with three separate squeeze circuits
- The pattern bolster is equipped with a nozzle strip for the evacuation of the air during airflow.
- An air reservoir that has been adapted to the size of the moulding chamber to accumulate compressed air with an operating pressure of five to seven bar.

The standard moulding plant is equipped with a S7 Siemens control system and a WinCC visualisation system that is used for operation and visualisation. Fig. 4 shows the first screen of the visualisation system and the moulding plant layout.

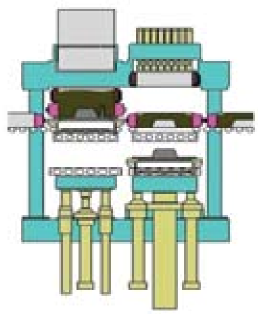
Starting from the bottom left hand side to the right hand side is seen the HPM moulding



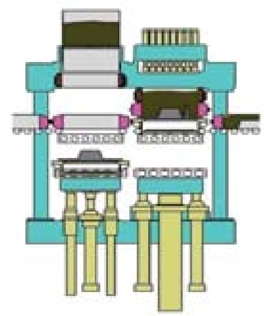
a) Cope and drag flask are filled at the same time and compaction according to the AIRPRESSplus2000 technology takes place.



c) Further transport of a moulded flask half to the turnover device and return changing of cope and drag patterns by vertical pattern circulation below the moulding line.



b) Simultaneous lowering of cope and drag flask into the moulding line. Lowering of pattern bolsters.



d) Cope and drag flask are lifted at the same time for sand filling and for mould compaction according to the AIRPRESSplus2000 technology

Fig 2. Sequence of motions of the moulding machine

machine; the moulding line with turnover device and sand cutting device arranged crosswise to the indexing motion; automatic downgate drilling device and automatic vent drilling device; separate core setting lines for drag flask and cope flask with two further vent drilling devices, automatic core setter, locations for the automatic coating and drying of the mould surface in selective areas, second turnover device for the cope flask; flask closing device; pouring line with automatic pouring furnace; three cooling lines for the in-flask cooling.

At the top right is the punch-out device to eject engine block flasks in jackets with a transfer device for the transport of the jackets into the sand parcel cooler, consisting of four double cooling lines.

Guaranteed constant cooling time

The main features of the moulding plant include the special requirements regarding the control of a pre-set cooling time of the castings. For example, shakeout of the cylinder heads must take place exactly after two hours, engine blocks have a cooling time of five hours for example. Deviation from the pre-set cooling time has a negative influence on the casting quality, and is therefore not allowed.

To solve this problem, the design and the control system of the moulding plant has been engineered in such a way that the cooling area and the two shake-out areas for the cylinder heads and the engine blocks can operate completely separately and independent of the condition of the moulding machine, the core setting line and the pouring area. That is why shakeout of the castings can always be performed after the pre-set cooling time has expired.

Large quantities of sand cores are used for the manufacture of engine block and cylinder head castings in clay-bonded moulds. After pouring and shake-out these cores usually remain as easily decomposable burned-down sand lumps but also as loose, easily floating individual sand grains in the mostly clay-bonded return moulding sand, which occurs during the shake-out of the poured moulds.

This return sand is prepared and recycled but due to the surplus of core sand, the circulating moulding sand volume is constantly increasing. The surplus return sand has to be separated from the cycle and reclaimed.

Among the negative effects of core-intensive casting manufacture are, in addition to higher preparation costs, the negative technological influences on the moulding sand quantity. This includes the preparation of clay-bonded return sand that has been 'weakened' by a very high supply of core sand which is not energy-efficient and is connected with a considerably higher consumption of additives. Also, during the disposal of the surplus return sand, valuable additives such as lustrous carbon formers get lost. In addition, the disposal as such is relatively expensive due the high content of fines.

The reclamation of mixed residual sands with a high percentage of fresh clay is technically difficult and its energy efficiency is much lower than in case of the reclamation of 'pure' return core sand and clay-bonded return sand that has been subjected to thermal stresses.

That is why a far-reaching reduction of the core sand supply to the moulding sand circulation system has been in the focus of the new moulding plant. To solve this task, Künkel-Wagner made use of modern concepts for the shake-out process and of appropriate modern equipment when designing the layout of the moulding plant.

The shake-out process comprises several steps:

- Opening of the flask parcel, removal and punch-out of the cope flask.
- Loosening of the residual return sand above the cluster.
- Turnover of the drag flask and dumping of the loosened residual sand.
- Lifting of the cluster from the drag flask by means of pins acting from below gripping through the pallet.
- Take-over of the cluster by means of a fork acting from below.
- Placement on a vibrating trough conveyor from the side.
- Short turnover of the drag flask to dump the remaining core sand.
- Punch-out of the drag flask.

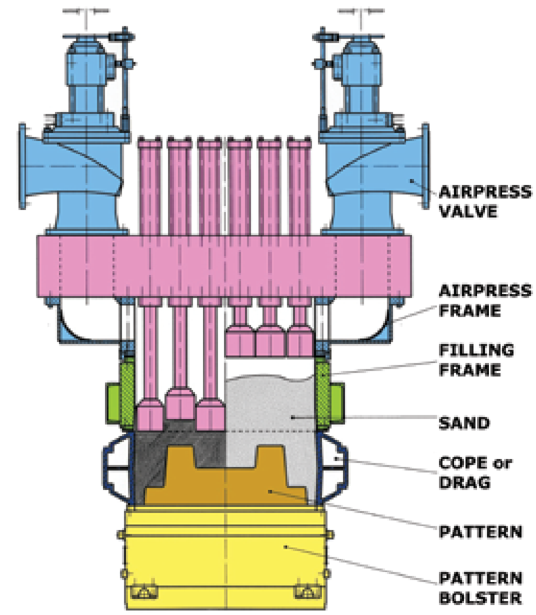


Fig 3. AIRPRESS plus 2000 mould compaction technology – schematic view of machine arrangement

Using the selective shakeout performed according to the concept explained above, the core sand supply and thus the surplus of return moulding sand has been considerably decreased.

In 2007, Künkel-Wagner celebrates its centenary. For many decades the company has been a market leader in the area of moulding technology and sand preparation technology. With numerous innovations the company has gained an international reputation as a specialist in this industry, this development being continued by the outstanding results that were achieved with this major project.

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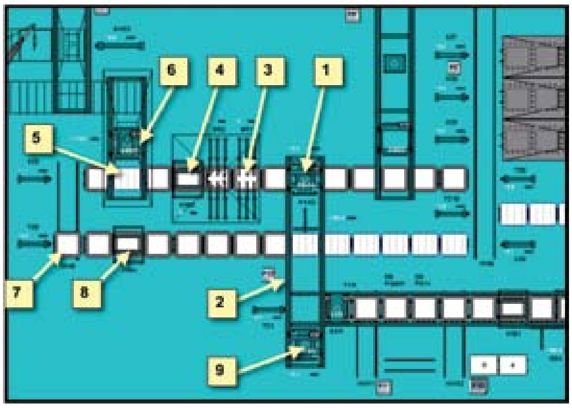

Fig 4. Legend: 1 – separating device to open the flask parcel; 2 – transfer unit to transfer and punch out the cope flask; 3 – hold down and piercing units to loosen the sand parcel; 4 – turnover device with hold down system to dump the residual return sand; 5 – mechanism to lift the cluster from the drag flask by means of pins acting from below through the pallet; 6 – transfer device to carry and to transfer the cluster; 7 – transfer car to move the drag flask and the pallet on the next conveying line towards the pallet return; 8 – turnover device to dump the residual sand; 9 – transfer unit to transfer and punch-out the drag flask