It should be noted that the MSI SYSTEM 90 is designed to be installed in a fixed position relative to the pouring furnace and mould, as it is necessary for the inoculant discharge pipe to be located so that inoculant is discharged into the metal stream. Thus, the equipment is most suited to be used in conjunction with automatic pouring furnaces or mounted on a ladle transporter or fixed ladle pouring position. Further information on the practical application and use of the MSI SYSTEM 90 can be found in FOUNDRY PRACTICE 204 and 211.

Mould inoculation

If application of the instream inoculation technique is not possible in a particular foundry, a less sophisticated but simple and flexible alternative is to locate the inoculant within the runner system of the mould.

Initial attempts were based on granular inoculating materials such as ferrosilicon, either poured into the downsprue or located in a pocket or chamber in the running system. Varying degrees of success were achieved, problems being due mostly to the general lack of control over the dissolution of the inoculant. Typical problems included inoculant being washed into the mould cavity, uneven distribution within the casting, and the presence of undissolved inclusions of inoculant affecting casting hardness and machinability.

A requirement was therefore seen for a means of controlling inoculant dissolution, and this led to the development of tabletted products. Foseco have marketed a range of these products for some years, under the trade name of INOTAB. They consist of a granular inoculant and binder pressed or compacted into tablet form. In general, INOTAB tabletted mould inoculants are limited to use on smaller castings due to constraints in tablet manufacture. However, a new generation of INOTAB is now available based on a ferrosilicon alloy which is cast into the required shape. This manufacturing route enables the production of cast inserts in sizes ranging from 20 grams to several kilograms as required. Examples are shown in figure 2.

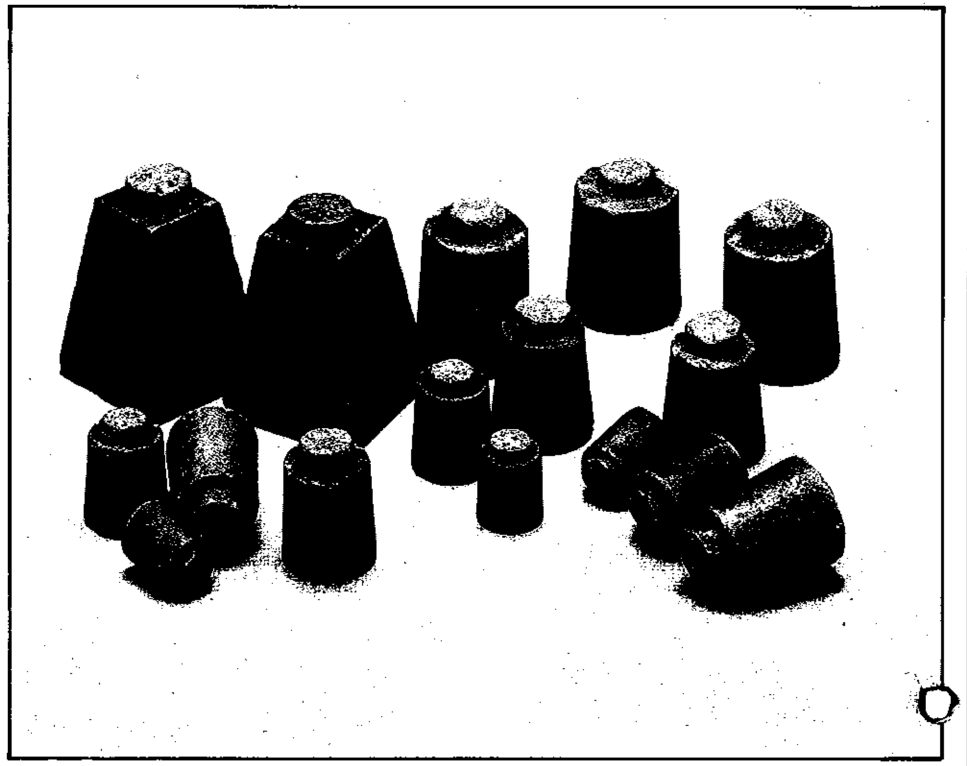


Fig. 2 Various shapes and sizes of INOTAB cast mould inoculant.

Composition

Two types of cast INOTAB are available –

- ☐ INOTAB G for grey iron and lower pouring temperatures.
- ☐ INOTAB N for both ductile and grey irons.

The composition of INOTAB is carefully controlled to ensure optimum dissolution and inoculation characteristics – table 1.

Both products are based on ferrosilicon with balanced quantities of calcium and aluminium for their potent nucleating effect and, in addition, manganese is present to control the melting point of the tablet and dissolution rate.

The production of INOTAB cast mould inoculants is backed by a comprehensive Quality Assurance program to maintain high product quality. This ensures that the cast inoculant tablets have:

- Accurate weight control to give reproducible inoculation effect
- Excellent dimensional reproducibility to ensure positive location of the tablet in the core print
- Minimal cold laps or slag inclusions.

Size range of INOTAB

Table 2 lists the weights and dimensions of the truncated cone shape used to produce INOTAB up to 150 gm weight. Other sizes of product may be available to suit customer's requirements, including truncated pyramids and keel blocks.

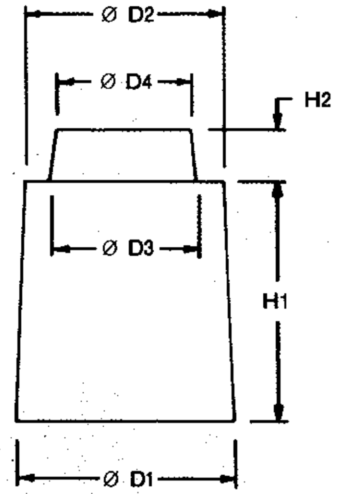
Metallurgical benefits

INOTAB mould inoculants can be used as either the only inoculating medium for a casting, or at lower application rates as a booster to conventional ladle inoculation. A number of benefits are possible:

- Lower overall inoculation costs
- Increased flexibility in the mould pouring process
- Increased flexibility in base iron silicon content
- Improved casting machinability
- Improved mechanical properties
- Reduced heat treatment rectification.

Typical chemical analysis	Silicon	Calcium	Aluminium	Manganese	Iron
INOTAB G	65-67%	1% max	4.3% max	3-4%	Balance
INOTAB N	70-75%	0.8-1.5%	2.5-3.5%	1-2%	Balance

Table 1. Composition of INOTAB mould inoculants.



Type	WT (g)	Nominal dimensions (mm) ØD1	ØD2	ØD3	ØD4	H1	H2
20	20	21	19	14	13	23	5
40	40	26.5	23	16	15	29.5	5
60	60	29	26	18	17	33	8
80	80	34	27	19	18	37	8
150	150	39	35	21	18	46	8

Note: The actual weight of INOTAB may vary up to ± 10% of the nominal weight.
OTHER SIZES AND SHAPES MAY BE AVAILABLE ON REQUEST.

Table 2. Dimensions of INOTAB mould inoculants.

Application

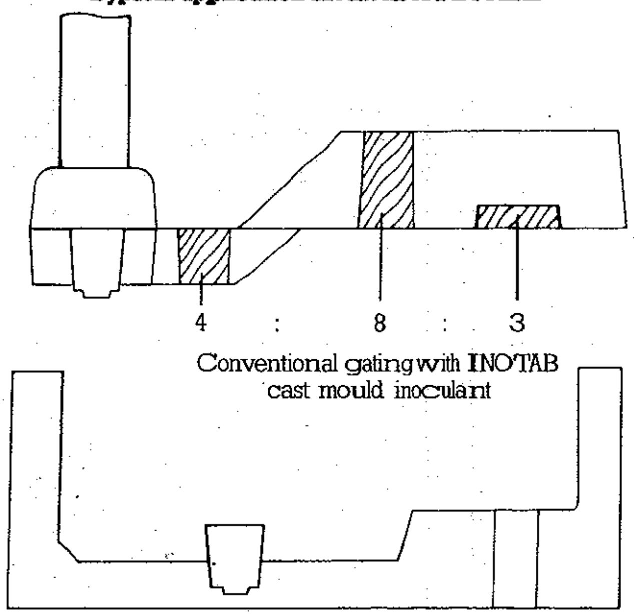
INOTAB mould inoculants can be placed at the base of the downsprue or in a pouring basin as illustrated. Foseco have developed a core print design which will allow positive location of the INOTAB in the print. It is important that the product is located so that all metal entering the casting cavity of the mould passes over the INOTAB mould inoculant to ensure uniform inoculation.

Because INOTAB mould inoculants in common with other late stage inoculation techniques are much more effective than conventional ladle inoculants, lower application rates can be used, typically 0.07-0.20% of the total cast metal weight. This will however depend on the iron quality being poured, the degree of inoculation required, metal temperature and mould pouring time. It is recommended that INOTAB cast mould inoculant tablets are used in conjunction with a Foseco filter to obtain maximum benefits in terms of optimization of casting properties and that a minimum pouring temperature of 2500°F (1370°C) be maintained.

Reference

1. Taylor, K.C. Further developments in automatic metal stream inoculation equipment and its application to the process control of iron casting quality. Foundry Practice No. 211, 3-8.
2. Emmott, R.N. Metal stream inoculation using MSI SYSTEM 90: applications and installations. Foundry Practice No. 204, 3-5.

Typical application methods for INOTAB



Conventional gating with INOTAB cast mould inoculant

INOTAB cast mould inoculant set in pouring basin

Editorial policy is to highlight the latest Foseco product and technical developments. However, because of their newness, some developments may not be immediately available in your area. Your local Foseco company or agent will be pleased to advise.

The TRIBONOL process – for improved greensand casting quality

Greensand moulding is widely used in the manufacture of a large variety of castings. This is due to its versatility and compatibility with different types of mould making equipment. The need for high production rates and increasing casting design complexity has placed a growing demand on green sand mould quality. However, even with an optimised green sand system, problems of poor surface finish due to metal penetration and burn-in persist in many cases.

The TRIBONOL process represents a unique solution to problems of poor casting surface finish.

Casting surface finish problems from greensand moulds have traditionally been dealt with in a number of ways:

- ☐ Use of external cores instead of greensand
- ☐ Use of new facing sand
- ☐ Application of a liquid coating
- ☐ Increased shotblast times

Of these, the application of a liquid coating is often favoured, as it is easy to implement and involves low capital cost.

However, liquid coatings are difficult to apply and can often generate more problems than they solve, as they reduce mould permeability and can leave wet patches leading to blows, gas holes and inclusions.

The TRIBONOL process overcomes the disadvantages of liquid coatings and also offers benefits over other methods of improving casting surface finish.

In the TRIBONOL process a dry powder called TRIBONOL coating is applied directly to the mould surface. The powder is sprayed using a simple *tribostatic* application unit. The application unit can be either manual, see figure 1 or an automatic multi-gun system, see figure 2.

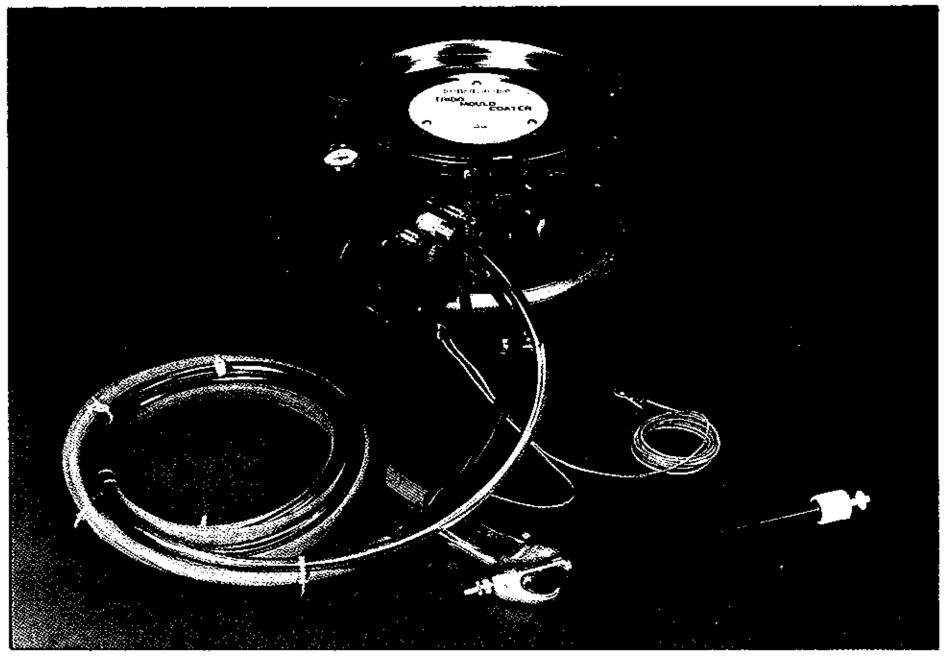


Fig. 1 TRIBO MOULD COATER – TMC Unit

The TRIBONOL coating is given a frictional charge as it passes through the application gun. Since the charge is generated by friction there is *no electrical supply or high voltage* involved. As the charged powder leaves the gun it is attracted to the greensand and adheres to the surface. The spray pattern of TRIBONOL is *not* as directional as a wet spray system and a very uniform coating layer is deposited. Shadowed areas and pockets are more effectively coated, see figures 3 & 4.

Since the TRIBONOL coating is *solvent free* there is no need to dry the coated mould. This means quick mould closure and unaffected productivity.

Wet spots, blows or mould scabs, resulting from conventional liquid coatings application, are eliminated with the use of the *dry* TRIBONOL powder coating.

Case History 1

This is an advanced North American grey iron foundry, producing predominantly diesel engine blocks for mid size and large trucks.

The foundry was experiencing burn-in problems in certain specific areas of an eight cylinder block. This burn-in was not removed on shot blasting and the castings needed extensive manual cleaning, giving production bottle necks and poor productivity.

The problem occurred in the cope face of the mould. The copes are moulded automatically and then transferred directly to the mould closing station. This gave very limited access to the copes as there is only one mould length between the moulding station and closing station.

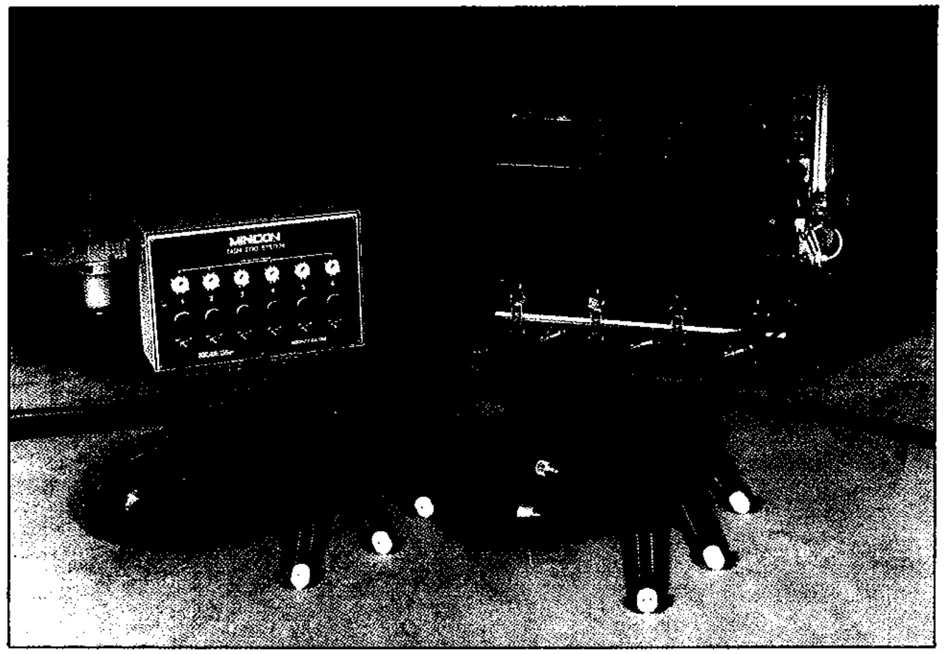


Fig. 2 TRIBONOL automatic spray equipment

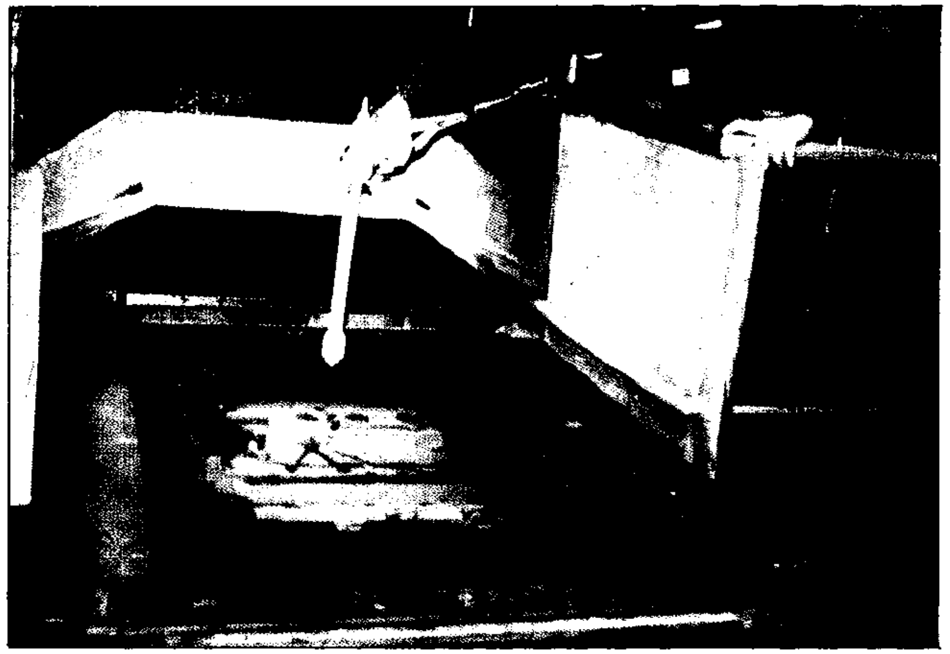


Fig. 3. Manual TRIBONOL application

Initial trials were conducted using the manual TMC Unit. The TRIBONOL coating was sprayed upwards on to the cope in the four problem areas. The resultant castings showed virtually no burn-in. Further trials confirmed these results. However, manual spraying of the TRIBONOL coating in a closed area under a mould was not practical and consequently the foundry automated the TRIBONOL application.

Four guns, mounted on a frame, are used to coat the problem areas. As the cope moves into position above the frame, spraying is automatically triggered for a predetermined duration. Mould closure occurs immediately after the spray cycle.

Case History 2

This is a large North American grey iron foundry producing automotive components. Blocks and cylinder heads are the main castings made.

The foundry was experiencing burn-in problems and had tried to use a water based coating. The coating was applied and then passed under water-based infra red heaters. However, the amount of coating applied was limited as over application led to incomplete drying, and subsequent blows and inclusions in the castings. Also, burn-in remained a problem.

Trials were conducted with the manual TMC Unit and demonstrated a dramatic improvement, such that fewer cleaning room personnel were required to process the casting.

Due to the large mould sizes and high moulding line speeds the foundry purchased two TRIBONOL automatic spray machines, one to spray the copes and one for the drags.

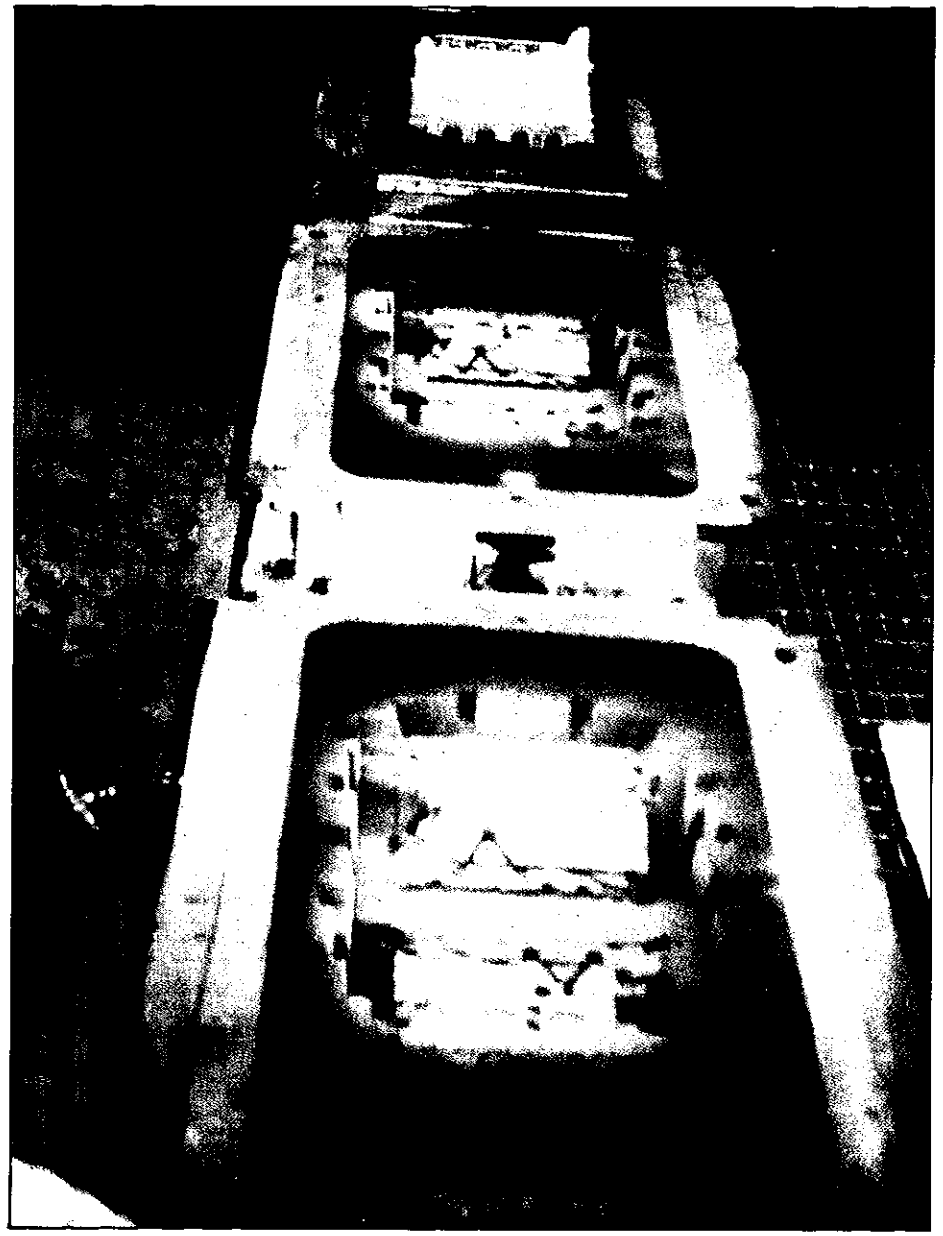


Fig. 4. TRIBONOL application, coated moulds prior to closure

Conclusion

The TRIBONOL process is a cost effective method of improving casting surface finish quality from green sand moulding.

The TRIBONOL process offers the following benefits:

- Reduced cleaning costs
- Controlled coating application
- No potential for liquid coating related casting defects.
- Elimination of new facing sand and/or external cores.
- Easy automation
- Low capital cost of equipment

The TRIBONOL process is covered by US patent number 4,873,114 and corresponding patents in other countries.

occurs at the shakeout, at the expansion chamber just downstream from the hammermill scrubbers, at the fluidized bed drier and at the cooler/classifiers. The use of dry baghouse filtration through 'ultra fine pore' bag media has been found to be extremely effective for fines collection.

On average, a total *new sand addition of 7%* is made to the sand system by constant new sand blend-in prior to moulding and from certain new sand cores entering the system at shakeout. With the VELOSET process, new sand additions are not necessary for any technical reasons. In point of fact, sand reclaimed by the process actually exhibits properties that are superior to those of new sand. Therefore, new sand additions are required only to replenish 'attrition losses' and, thereby, maintain sand system level.

Currently, Frog, Switch reclaims more than 27,000 tons of sand per annum using the VELOSET process.

Practical experience

The no-bake moulding area is served by one 30 ton per hour continuous mixer. The VELOSET process sand *93% reclaimed/7% new sand* is cooled instantaneously prior to entry to the continuous mixer by a novel microprocessor-controlled 'cryogenic' sand cooling system – designed and built by Frog, Switch. This cooler is extremely efficient, compact in size – measuring 18" x 18" x 72" – and cost-effective to operate. Sand temperature at the mixer is *narrowly controlled to 70-74°F – 21.1-23.3°C – year-round.* This close attention to sand temperature control provides extremely consistent performance in terms of mixed sand bench life, strip time and ultimate strength development.

The specific binder and hardener products used by Frog, Switch consist of especially developed VELOSET 2000 binder and VELOSET catalyst 1 – a unique type of ester.

Feed rates of sand, VELOSET binder and VELOSET catalyst are monitored and controlled into the mixer by a sophisticated microprocessor/feed compensator system, the heart of which is the SCRATA MICON 2000 binder control unit. This commitment to process control has enabled Frog, Switch to reduce the VELOSET binder addition to *2.5% based on sand weight.* The VELOSET catalyst addition is maintained at the rate of 10% based on binder weight added.

With the VELOSET process, the ultimate tensile strength levels achieved are comparable to, or greater than, those obtained with the former organic resin no-bake process used.

Mixed sand bench life is maintained within a range of 18-20 minutes. Flask sizes range from 5 ft. square to 12 ft. in diameter or 6 ft. x 14 ft. rectangular. Total sand mould weight for their largest casting produced in the VELOSET process is approximately 80 tons.

Patterns are stripped in four to six hours after mould strikeoff. Following strip, mould surfaces are spray or brush coated with an olivine/magnesite solvent light-off coating. On average, castings are poured within 12 hours of mould finishing. However, certain moulds are stored for up to 72 hours over a weekend or other shutdown periods.

Core requirements are produced using three methods:

☐ Silicate/CO_2 – new sand

☐ Alkyd-oil no-bake – new sand

☐ Oil sand – new sand

In certain casting configurations, internal cores are made with VELOSET process sand by forming the core as an integral part of the cope mould, see figure 3. This practice provides significant advantages in terms of casting quality and cost reduction.

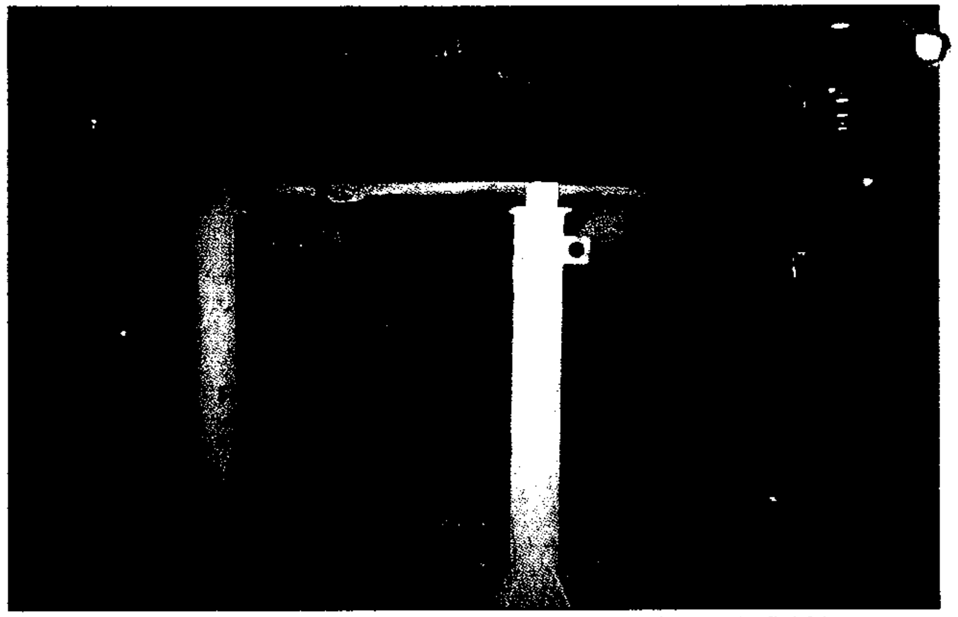


Fig. 3 Cope mould with "integral core" shown on trunions for mould finishing.

Manganese steel castings of finished weight from 20 pounds up to 20 tons have been produced by Frog, Switch using the VELOSET process. Typical castings made include large "primary" mantles, bowl liners and jaw plate castings used in rock crushing equipment, see figures 4 and 5. Significant improvements have been realized in the overall casting surface quality and cleaning costs have been reduced. Gas pinholing and expansion-related defects are virtually removed.

Fig. 4 Primary mantle casting after shakeout finished weight = 15.5 tons.

Fig. 5 Large jaw plate casting.

Apart from the technical and economic advantages obtained, the most significant benefit of the VELOSET process to Frog, Switch is the vast improvement in overall *environmental quality inside and the area surrounding the foundry.* The odour, smoke and fume experienced at Frog, Switch with the previous organic resin no-bake system are eliminated since the conversion to the VELOSET process.

Conclusion

The success reported by Frog, Switch with the VELOSET process is not unique. In 1990, 14 foundries worldwide will be using this innovative process with similar results.

Growing environmental pressures to use cleaner moulding systems, increasing demands for improved metallurgical quality and the necessity to reduce production costs in order to remain competitive in a global market, make the VELOSET process truly the moulding system for the 1990's.

The VELOSET process is covered by one or more of the following US patent numbers: 4,416,694; 4,070,196; 4,194,918 and corresponding patents in other countries.

Benefits of late stage inoculation techniques for cast iron

The iron foundry industry is currently responding to customer demands for castings of thinner wall section, increased mechanical properties and good machinability. Good metallurgical process control is a prerequisite, and control of inoculation practice forms an important part of ensuring optimum casting properties.

Ladle inoculation has been the accepted technique for many years, but is subject to the well known fade problem of the nucleation effect decreasing with time. This can lead to variability of inoculation between the first and last casting poured from a ladle, or more significant problems where metal is held for a considerable time before pouring.

The increasing use of automatic pouring furnaces linked to automatic moulding machines, in which iron may typically have a dwell time of 20-40 minutes, also highlights the problems associated with fading of inoculants. It may be difficult in this instance to restore the nucleation level by a secondary application of inoculant, and usually requires an initial over inoculation to try and compensate for the loss during holding, with the possibility of increased slag and dross formation. These problems have led to the increasing use of late stage inoculation in which iron is inoculated either in the metal stream between ladle or pouring unit and the mould, or by locating the inoculant in the runner system of the mould itself.

This ensures that all iron passing into the mould cavity is correctly inoculated, fade will not occur, and since nucleation takes place at the optimum time, a reduced quantity of inoculant is required compared to conventional ladle inoculation. It is well documented that late stage inoculation is several times more effective than a conventional ladle treatment.

Foseco markets a comprehensive range of inoculants and amongst them are products designed for both the instream and mould inoculation techniques.

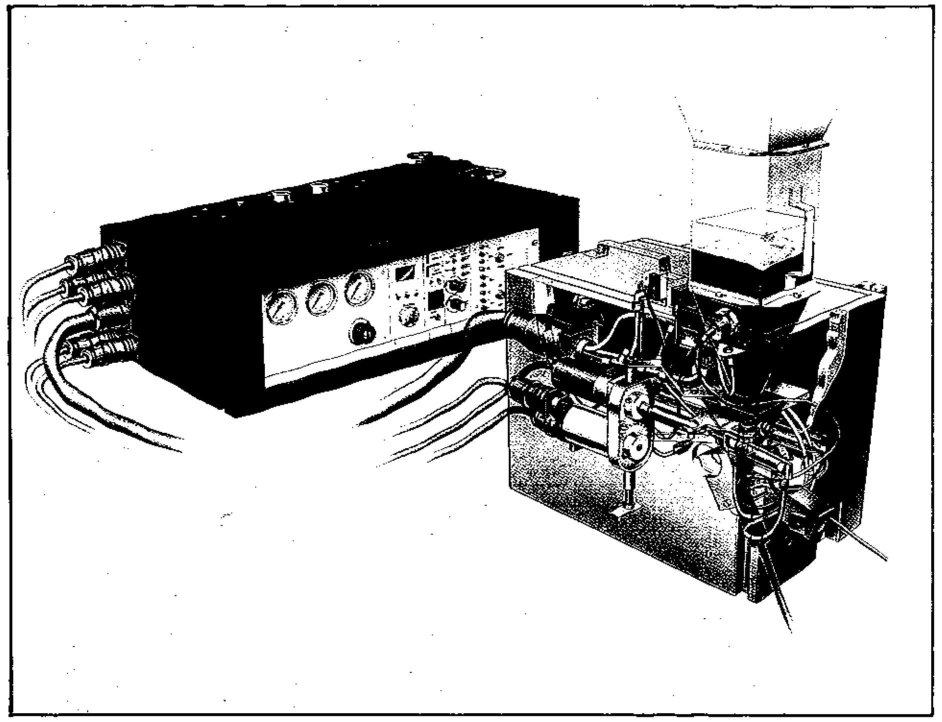


Fig. 1 MSI SYSTEM 90 type 4PN; left the dispensing unit and right, the control cabinet.

Instream inoculation

To obtain the maximum benefits from the instream technique it is important that precise control of the timing and rate of inoculant addition is achieved. The MSI SYSTEM 90, developed by Foseco and the British Cast Iron Research Association, fulfills all of the necessary requirements. Controlled dispensing of inoculant at rates varying from one to seventy grams per second permits accurate reproducible additions for mould pour weights of five kg up to several hundred kg. Over two hundred sets of MSI SYSTEM 90 are now in service throughout the world. Figure 1 illustrates the Type 4PN equipment which consists of a control cabinet and dispensing unit. A specially formulated and graded inoculant known as INOCULIN 90 is recommended for use with the MSI SYSTEM 90 equipment. Additions of 0.05 to 0.10% to grey iron, and 0.10 to 0.20% for nodular iron are generally sufficient to give a satisfactory inoculation effect.

The MSI SYSTEM 90 is compact and versatile and may be used in a wide range of different applications. It is particularly suitable for use with automatic pouring units. Discharge of the INOCULIN 90 may be controlled in two ways:

☐ By in built optical sensor reacting to the beginning and termination of metal flow.

☐ By external electrical signal given by the furnace or stopper rod control system.

In either instance, initiation of INOCULIN 90 flow may be optionally subjected to a timed delay, and duration of flow may be limited by termination of the external signal or an elapsed time basis.

In addition to precise control of inoculant dispensing, the MSI SYSTEM 90 is equipped with built in warning systems to alert on any system malfunction such as:

○ Low inoculant level in hopper

○ Non flow of inoculant

○ Dispensing tube blockage

○ Loss of air pressure

○ Overheating of dispensing system

The warning system can also be linked to the pouring unit or moulding line so that if a fault occurs, pouring will be automatically terminated until the fault is corrected or the control system is manually overridden.

The MSI SYSTEM 90 is designed to function with a very high standard of reliability and accuracy under demanding conditions. Economic benefits can be demonstrated by investment pay back periods based solely on the basis of reduced inoculant consumption which generally run between four and eight months. However, the major benefit associated with the use of the MSI SYSTEM 90 is the ability to maintain accurate and consistent inoculation process control, and thereby ensure optimum casting properties. An example of the degree of control obtainable is that even down to INOCULIN 90 delivery rates of one gram/second, accuracy will be maintained to within ± 10%; this tolerance narrows appreciably as the addition rate is increased.