Cores and Core Binder Systems

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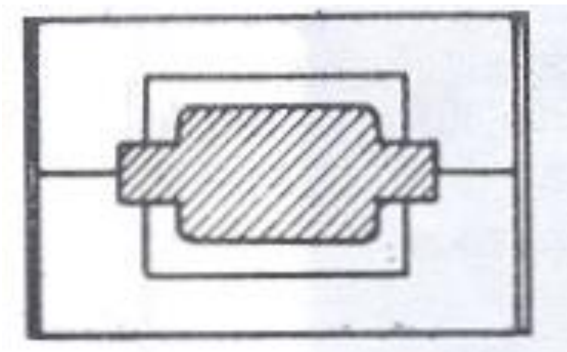
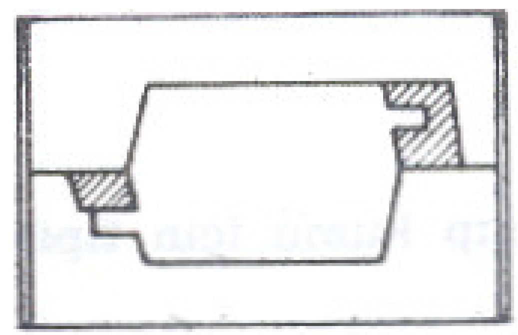
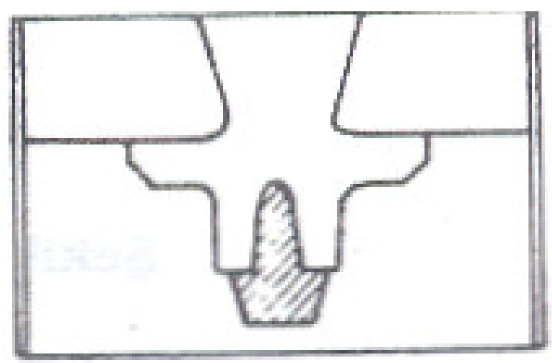
Functions of cores



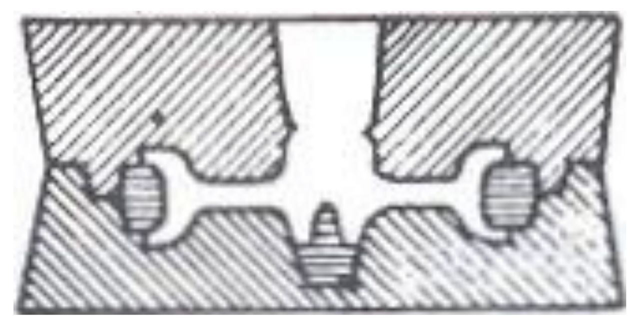
Inside cavities, hollow shapes



Thin ledges



Deep cavities



Whole core molud

Production and properties of cores

- Cores are prepared in metal or wooden boxes (moulds).
- Sand is compressed into the box with pressing, vibrating or blowing.
- Cores must have high wear, fracture, thermal shock and metal penetration resistance with good collapsibility.
- Also cores must generates gas in low volume and have sufficient permeability and hot strength.
- Natural sands can not be used for core making.

- Core sands are synthetic sands and their clay content must be lower than 1%.
- Silica powder, iron oxide and clays (inorganic binders) decrease collapsibility and increase resin consumption.
- Rounded grains have a low surface-area-to-volume ratio and are therefore preferred for making cores because they require the least amount of binder.
- Generally grain size of core sands are greater than moulding sands.
- Grain sand distribution of core sands are narrower than moulding sands. (Core sands: 3 sieves, Mould sands: 5 sieves.)

Classification of resin binder processes

Although a wide variety of resin binder processes are currently used, they can be classified into the following categories:

- No-bake binder systems
- Cold box binder systems
- Heat-cured binder systems

In the no-bake and cold box processes, the binder is cured at room temperature; in the shell moulding, hot box, and oven bake processes, heat cures are applied. Selection of the process and type of binder depends on the size and number of cores or moulds required, production rates, and equipment.

No-Bake Processes

A no-bake process is based on the ambient-temperature cure of two or more binder components after they are combined on sand. Curing of the binder system begins immediately after all components are combined. For a period of time after initial mixing, the sand mix is workable and flowable to allow the filling of the core box/mould pattern. After an additional time period, the sand mix cures to the point where it can be removed from the box. <u>The time difference between filling and stripping of the box can range from a few minutes to several hours, depending on the binder system used, curing agent and amount, sand type, and sand temperature.</u>

Furan Acid Catalyzed No-Bake. Furfuryl alcohol is the basic raw material used in furan no-bake binders. Furan binders can be modified with urea, formaldehyde, phenol, and a variety of other reactive or non-reactive additives.

Phenolic Acid Catalyzed No-Bake. Phenolic resins are condensation reaction products of phenol(s) and aldehyde(s). Phenolic no-bake resins are those formed from phenol-formaldehyde where the phenol-formaldehyde molar ratio is less than 1. Again, as with furan no-bakes, these resins can be modified with reactive or nonreactive additives.

Furan resin core

Ester-Cured Alkaline Phenolic No-Bake (Alphaset).

The ester-cured phenolic binder system is a two-part binder system consisting of a water-soluble alkaline phenolic resin and liquid ester co-reactants. Both the resin and co-reactant are water soluble, permitting easy cleanup. Physical strength of the cured sand is not as high as that of the acid-catalyzed and urethane no-bakes at comparable resin contents. However, with care in handling and transporting, good casting results can be obtained. The distinct advantages of the ester-cured phenolic no-bake systems are the reduction of veining in iron castings and excellent erosion resistance.

Alphaset resin core

Silicate/Ester-Catalyzed No-Bake. This no-bake system consists of the sodium silicate binder and a liquid organic ester that functions as the hardening agent. High-ratio binders with SiO_2:Na_2O contents of 2.5 to 3.2:1 are employed for this process, and mixtures usually contain 3 to 4% binder.

Sodium silicate (Na_2SiO_3) + Liquid ester hardener → Cured polymer

Alumina-Phosphate No-Bake. Alumina-phosphate binders consist of an acidic, water-soluble alumina-phosphate liquid binder and a free-flowing powdered metal oxide hardener. Although this system is classified as a no-bake process both of its parts are inorganic; all other no-bake systems are organic or, in the case of silicate/ester systems, inorganic and organic.

Oil urethane no-bake resins (also known as oil-urethane, alkyd-urethane, alkyd-oil-urethane, or polyester-urethane) are three-component systems that consist of Part A, an alkyd oil type resin; Part B, a liquid amine/metallic catalyst; and Part C, a polymeric methyl di-isocyanate (MDI) (the urethane component).

The phenolic urethane no-bake (PUN) binder system has three parts. Part I is a phenol formaldehyde resin dissolved in a special blend of solvents. Part II is a polymeric MDI-type isocyanate, again dissolved in solvents. Part III is an amine catalyst that, depending on strength and amount, regulates the speed of the reaction between Parts I and II. The chemical reaction between Part I and Part II forms a urethane bond and no other by-products. For this reason and because air is not required for setting, the PUN system does not present the problems with through-cure or deep-set found in other no-bake systems.

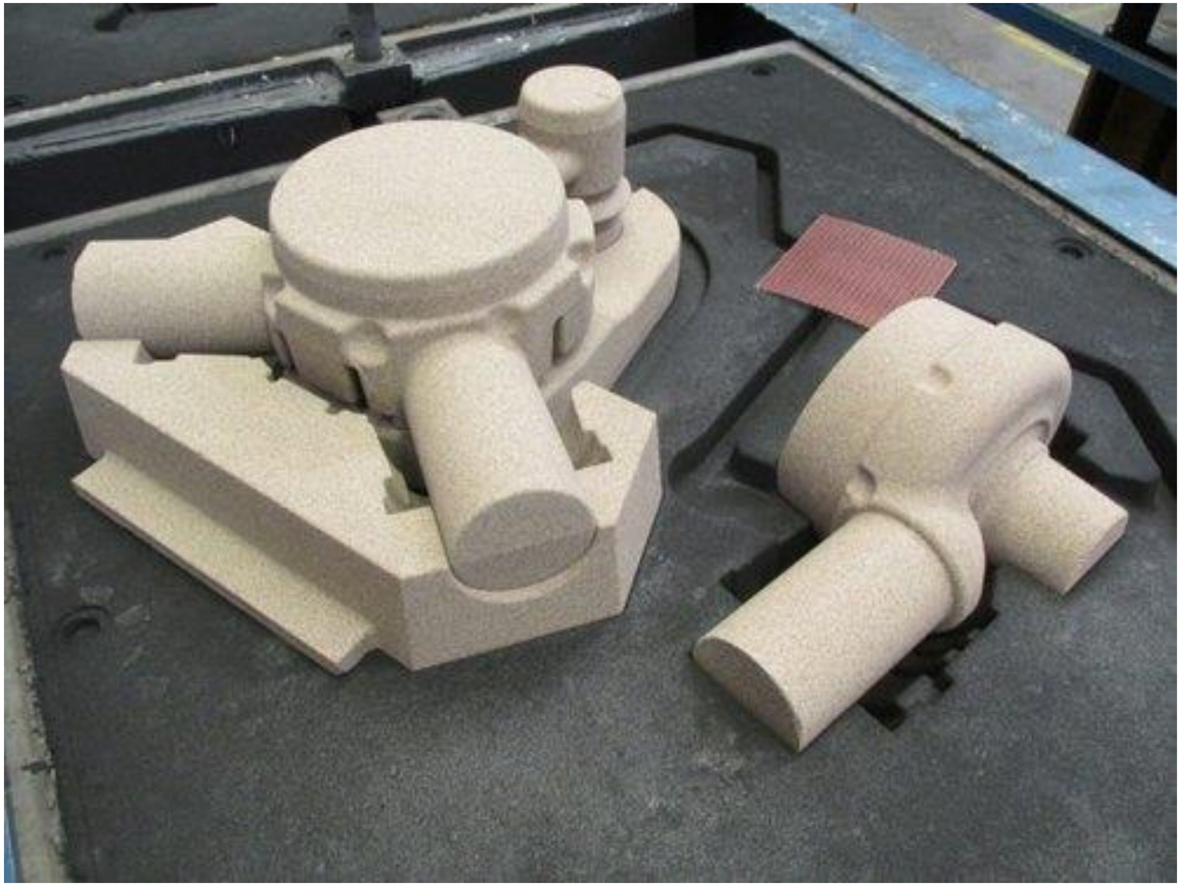
The polyol-isocyanate system was developed in the late 1970s for aluminum, magnesium, and other light-alloy foundries. Previously, the binder systems used in light-alloy foundries were the same as those used for the ferrous casting industry. The lower pouring temperatures associated with light alloys are not sufficient to decompose most no-bake binders, and removal of cores from castings is difficult. The polyol-isocyanate system was developed to provide improved shakeout.

Cold Box Processes

The term cold box process implies the room-temperature cure of a binder-sand mixture accelerated by a vapour or gas catalyst that is passed through the sand. Several different cold box systems are currently used, employing different binders and gas or vapour catalysts—for example, triethylamine or dimethylethylamine for phenolic urethane binders, sulfur dioxide for furan and acrylic epoxy binders, methyl formate for ester-cured alkaline phenolic binders, and carbon dioxide for silicate binders.

Phenolic Urethane Cold Box (PUCB). The process uses a three-part binder system consisting of a phenolic resin (Part I), a polymeric isocyanate (Part II), and a tertiary amine vapor catalyst (Part III). Sand is coated with the Part I and Part II components and compacted into a pattern at room temperature. The tertiary amine catalyst is introduced through vents in the pattern to harden the contained sand mix. The catalyst gas cycle is followed by an air purge cycle that forces the amine gas through the sand mass and removes residual amine from the hardened core. It is recommended that the exhaust from the core box be scrubbed chemically to remove the amine.

$$\text{Phenolic resin + Polyisocyanate} \xrightarrow[\text{(Vapour amine catalyst)}]{} \text{Urethane}$$



Cold box resin cores

SO_2 Process (Furan/SO_2). The sulfur dioxide (SO_2) process can be described as a rapid-curing, gas activated, furanvno-bake. Various furfuryl alcohol-base resins, blended with an adhesion promoter, are used to coat the sand in the range of 0.9 to 1.5%.

The free radical cure (FRC) process includes all acrylic and acrylic-epoxy functional binders. The binders are cured using an organic hydroperoxide and SO_2. A variety of acrylic-epoxy binders have been developed for both ferrous and nonferrous applications, ranging from 100% acrylic binders to approximately 30:70 ratios of acrylic-epoxy blends. Sand performance and casting properties are influenced by the ratio of acrylic to epoxy functional components present in the binder system.

The phenolic ester cold box (PECB) (Betaset) process was introduced to the foundry industry in 1984. A two-part system, it consists of a water-soluble alkaline phenolic resole resin and a volatile ester vapor co-reactant. Sand is coated with the phenolic resin and blown into the core box. The liquid ester coreactant is vaporized and injected as gas through the sand mix. Because the ester is consumed in the curing reaction, purging of excess ester vapor can be accomplished with the minimum volume of purge air. However, purge air helps to distribute the ester vapor throughout the sand mix. Methyl formate is the preferred ester for curing the phenolic resin because it is volatile and vaporized more easily than other esters. Methyl formate is readily available and relatively inexpensive.

Sodium Silicate/CO_2 System. This system consists of liquid sodium silicate and CO_2 gas, and it is an inorganic system. Silicate binders are odorless, nonflammable, suitable for all types of work (high production to large moulds), applicable to all types of aggregates, produce no noxious gases upon mixing/moulding/coring, and produce a minimum of volatile emissions at pouring/cooling/shakeout.

Shell Process

In the shell process, also referred to as the Croning process, the sand grains are coated with phenolic novolac resins and hexamethylenetetramine. In warm coating, dissolved or liquid resins are used, but in hot coating, solid novolac resins are used. The coated, dry, free-flowing sand is compressed and cured in a heated mould at 150 to 280 °C for 10 to 30 s. Sands prepared by warm coating cure fast and exhibit excellent properties. Hot-coated sands are generally more free flowing with less tendency toward caking or blocking in storage.

Novolac Shell-Moulding Binders. Novolacs are thermoplastic, brittle, solid phenolic resins that do not cross-link without the help of a cross-linking agent. Novolac compositions can, however, be cured to insoluble cross-linked products by using hexamethylenetetramine or a resole phenolic resin as a hardener. A simplified version of the Novolac curing mechanism is:

$$\text{Novolac} + \text{Hexamethylenetetramine} \xrightarrow[\text{(Heat)}]{} \text{Cured polymer} + \text{ammonia}$$

Shell cores

Hot Box and Warm Box Processes

In the hot box and warm box processes, the binder-sand mixture is wet. A liquid thermosetting binder and a latent acid catalyst are mixed with dry sand and blown into a heated core box. The curing temperature depends on the process. Upon heating, the catalyst releases acid, which induces rapid cure; therefore, the core can be removed within 10 to 30 s. After the cores are removed from the pattern, the cure is complete as a result of the exothermic chemical reaction and the heat absorbed by the core. Although many hot box cores require postcuring in an oven to complete the cure, warm box cures require no postbake oven curing.

Oven-Bake Processes/Core-Oil Binders

Core-oil binder is used in combination with a water-activated cereal to produce a coated sand mix that has green strength. Green strength permits the wet sand mix to be blown or hand rammed into a simple vented, relatively low-cost core box at room temperature and to retain its shape when removed from the pattern. The uncured plasticlike cores are generally placed on a flat board or a dryer plate (a supporting structure to maintain the shape of the core) for oven drying. This process translates into a fast method of producing cores or moulds. Except for the subsequent drying operations, the cores are in effect made almost as fast as they are blown.

Video links

- https://www.youtube.com/watch?v=JUqXygYdxkM
- https://www.youtube.com/watch?v=dzveVdWXpc4
- https://www.youtube.com/watch?v=7HYQJ17ghmU
- https://www.youtube.com/watch?v=XUm5QAVpKlk
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