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(THE GLOBAL SALES AND MARKETING OFFICE OF TIGER INTERNATIONAL INC. JAPAN IN THE USA)

THE PROCESS OF MANUFACTURING OF HIGH QUALITY CONCRETE MASONRY PRODUCTS

HOW THE PRODUCTS ARE MADE IN TIGER EQUIPMENT

The global growth of the demand for lower cost, yet high quality, construction materials have given rise to the use of concrete masonry units of good dimensional accuracy, high compressive strength (making the product load-bearing in many instances) manufactured in industrial high-production factories rather than “back-yard” manual operations. **TIGER** equipment has therefore created the most complete line of equipment in the world to fill this need.

Concrete products, in general, and especially concrete “MASONRY” products are produced today in almost every country in the globe. Concrete masonry units are highly versatile in the way they are manufactured as they can be made with many local varieties of raw materials available around the globe.

Concrete masonry units can be manufactured in tens-of-thousands of different types, sizes, shapes and colors. Many of these different “concrete masonry units” can simply be made in the same production plant by simply changing the molds or forms used in the main concrete products machine that resides in the factory among other pieces of required ancillary equipment.

There are many variables involved in manufacturing concrete masonry products in a **TIGER MACHINERY** equipped plant. It is a process that is simple and yet effective and that generally follows a sequence of operation as detailed herein in the following paragraphs:

- 1) Storage or basic raw materials
- 2) Materials batching/formula creation
- 3) Mixing
- 4) Product forming via vibration-compression in molds/forms
- 5) Product handling
- 6) Product Curing
- 7) Cubing and packaging
- 8) Storage prior to sale

STORAGE OF BASIC RAW MATERIALS:

The normal basic raw materials utilized in the manufacture of high quality concrete masonry units are cement (many types), clean sand, clean smaller and larger aggregates (many varieties from heavy weight to light-weight, clean water and sometimes admixtures/additives and/or coloring agents.

The raw basic materials normally delivered to the concrete masonry products manufacturing plant via large trucks or via rail bulk cars.

Cement is normally supplied in bulk form and/or in sacks of varies sizes from the std. 40 to 50 Kgs sacks (90 to 100 Lbs) to JUMBO size sacks of 1,000 to 2,500 Kgs (1 to 2.5 tons or 2,000 to 5,000 Lbs). When in bulk it is pneumatically transferred to cement holding silos for storage which are equipped with dust collecting systems.

Sand (or other fine sizes aggregates of 2.5 mm or less in diameter), and coarse aggregate (2.5 mm and up in size up to 8/10 or 12 mm) are normally stored in a stockpile in the factory's main yard.

As the materials are needed for consumption they are transferred or conveyed to storage bins in a batch-plant facility that feeds the production facility. A normal and common method of transferring the basic raw materials from stockpiles to the batch-plant bins is via means of a large capacity front-end loader. Many factories use labor-saving conveyor belts and stackers.

Some basic aggregates utilized to manufacture high quality normal weight concrete masonry products include:

- A) Fine sand (washed river-bed sand, washed natural sand, washed beach sand and/or manufactured sand from crushed materials among others).
- B) Natural gravel (various types and sizes). The gravel may be either natural or produced by crushing stone at a stone source/quarry suitable for making good quality properly sized aggregates.
- C) Crushed stone. The crushed stone is produced by crushing stone at a stone source/quarry suitable for making good quality properly sized aggregates.

Some aggregates used in the manufacture of unique light-weight concrete masonry products include fired-expanded shale, fire-expanded-clay, natural light-weight material such as pumice, tuff and volcanic scoria, sometimes blended with sand, some natural slates, expanded blast furnace slag, sintered fly ash, some ground and screened sulfur-free coal cinders.

The use of light-weight aggregates can reduce the weight of a concrete masonry product by about 5% to 55% when compared to normal-weight concrete masonry units (normally without sacrificing structural properties). Lightweight masonry has higher fire ratings and superior insulation properties.

The use of specialized aggregates in lightweight masonry generally cost slightly more than normal-weight block, depending on the availability of light-weight aggregates and the proximity of the aggregate source to the concrete masonry producing plant.

The bonding or “cementing” ingredients normally used are various types of cements, fly-ash and other “puzzolanic” materials that have cement-like properties.

Some factories utilize more expensive "high-strength or early-strength" cements to reduce overall costs or to provide a faster product delivery to the end-user/customer.

Fly-ash and some puzzolanic materials are cheaper than cement and are also used to improve the properties of the concrete mix when wet. Because these raw materials are very moisture-sensitive, cement and puzzolanics are normally transferred directly from trucks or rail cars to storage silos pneumatically using pipelines.

MATERIAL BATCHING AND FORMULA CREATION

Normally the basic raw materials have already been conveyed or transferred via front-end-loader and/or belt/bucket conveyors and/or elevators to the storage silos of a modern batching plant facility. (cement –grey or white or a special-type, fly ash and other puzzolanics are already stored in a 100%-dry silos with dust collectors and aggregates are available in pen or closed bins or silos).

The batch plant is a very important part of the manufacturing process. It is a facility (part of the whole concrete masonry manufacturing plant and process) where all the basic aggregates are measured either via weight or volumetrically to obtain a recipe or formula which is a blend of several types and/or sizes of aggregates that will provide the concrete masonry products with a set of pre-defined characteristics, such as strength, texture, and Finess Modulus, etc.

The cement, fly-ash and other puzzolanics are normally measured by weight.

As they are needed, the raw materials in the storage bins and silos are transported to a weighing or “batching” system set of scales or volumetric feeders (normally belt operated and timed by timers). Once the desired blend (recipe/formula) is obtained to ensure batch consistency the materials are transported or discharge to/over a concrete mixer.

MIXING OF THE CONCRETE

There are many types of mixers that are suitable for the mixing of concrete for the concrete products industry.

Some mixers are designed for wet-mixes and others for semi-dry mixes. In the Concrete products industry the mixers required are those used for semi-dry mixes.

Normally a concrete masonry product contain (at forming/molding) time a minimum moisture content of 3.5 %, and can go up to and including 8% (by weight). Normally, 5% is the moisture content used in 90% of all concrete masonry products manufactured in the world.

The semi-dry mixers come in various types from:

- A) Spiral-blade or ribbon-type mixers (various sub-types)
- B) Horizontal pan-type mixers, (various sub-types)
- C) Twin-shaft and/or multiple-shaft and/or paddle mixers both vertical and horizontal in configuration.

The most common and preferred type mixer used in the industry is the ribbon or spiral-blade type mixer which resemble an oversized cylinder turned on its side, with mixing blades attached to a horizontal shaft extending into and through the cylinder also called drum.

The inside of the mixer drum is normally lined with replaceable liners made of various materials from rubber, various plastics like Nylon, hardened steel and Nickel Alloys (ni-Hard).

Normally the basic raw materials are provided or fed into the mixer at the top or side and dumped from the bottom or side when mixing is completed. These materials are dry mixed in the mixer for several minutes before water is added.

The mixing water is metered (by volume in Liters or Gallons and converted to weight in Kgs or Lbs) and it is added automatically. To assure the mix's consistency, water is added to the dry mix using a computerized or electronically controlled moisture meter or water that can work on the principles of potential differential in the electrical resistivity and/or conductivity of the mix or via microwave-action.

Since concrete masonry products generally are formed/molded using a zero slump semi-dry concrete mixture, only a relatively small amount of water is added to each batch/mix.

Admixtures or additives such as plasticizers, super-plasticizers, water repellents, efflorescence reducers, and coloring agents are also added at the time the water is added.

If the mix uses light-weight materials that are very dry a "Pre-wet water" may be added during the mixing of the raw materials prior to the cement and addition of the "final-water". Once the final water is added and the concrete is mixed the consistency is automatically or manually checked, and if required, additional water is added to the concrete mix in the batch.

The mixing time varies with the amount of charging/feeding time required to fill the mixer, the amount of discharge time required to empty the mixer and most importantly with the mixing time itself required by any type of mixer to achieve a properly disbursed material mixture. (A concrete mixture that is homogeneous properly blended and folded onto itself many times and has an "alpha" of mixing of at least 97.5 %).

The amount of total time varies from factory to factory depending on batch plant configuration, mixer style, and raw materials types and can vary from as little as 3 minutes to as long as 8 minutes.

TIGER equipment mixers (ribbon-type) normally use a “mixing-time only” of approximately 4 to 5 minutes.

PRODUCT FORMING VIA VIBRATION-COMPRESSION IN MOLDS/FORMS

After a concrete batch is properly mixed and blended, it is transferred to the concrete product forming/molding machine, where it is supplied/fed into a form/mold inside the machine.

TIGER equipment forms/molds consist of a mold frame that sometimes uses replaceable wear components such as liners, shoes and cores. The vibration applied to the forms/molds can be done in many different ways from vibrating tables, vibrating over or under forms/mold shafts and or/ vibrating shafts attached to the molds.

Some complex forms/molds can be expensive, but many **TIGER** equipment forms/molds are very affordable. Depending on the size and type of product and the concrete products machine for which it is designed, the mold can have a limited or an almost unlimited life expectancy.

The forms/molds that have the longest (almost unlimited) life expectancy utilize wear components that are replaceable such as “liners, dividing plates, cores and shoes among others). These components of the form/mold, require periodic replacement, with their durability and longevity determined by the type, shape and hardness of the basic raw materials used in it (aggregates, etc.)

Not all parts of the forms/molds must be replaced at the same time. Different components of the forms/molds can endure/tolerate greater amounts of wear before replacement.

The **TIGER** equipment wear components of the forms/molds are the ones that give the concrete masonry component being manufactured in it its shape. These components can be manufactured in almost any configuration required, as long as that the structural integrity of the products being made by the mold so equipped is not compromised by walls or webs that are too thin, unusually complex or structurally unstable.

One form/mold could manufacture different shapes and sizes of products, depending on the combination(s) of wear parts that are assembled together in the form/mold.

Depending on the sales demand for the particular shape, size or type of product being made, the form/ may be changed after several hours of use or be run for many days.

Some forms/molds can be exchanged in the **TIGER** concrete products manufacturing machine in as little as 5 minutes and sometime even less. Being bale to change the form/mold only allows the company to make a great variety of products.

In today's changing market the producer with the most diversified product base has the best chances of being the leader in the industry.

TIGER equipment and molds permit our customers to manufacture a large diversified high-quality concrete masonry product base. Products that go from hollow-core plain block-type units, to cored and solid brick made in multiple configurations, to paving stones, retaining wall products and sophisticated architectural masonry products using the same equipment in the same facility.

The products are formed/molded via vibration-type compaction and are de-molded out or extruded from the form/mold at the end of the forming/molding cycle in various forms depending on the type of **TIGER** equipment used.

Once the form/mold is filed with the fresh semi-dry concrete mixture, the concrete is compacted by a combination of hydraulic and mechanical (weight) pressure and controlled vibration. In **TIGER** equipment this process varies depending on the machine-type and/or series and from product application to product application. Unlike any other competitors in the world, **TIGER** equipment is the most unique anywhere and has the most versatile line of machinery in the world. As such **TIGER** manufactures machines that can make a variety of types and sizes of products, as well as other machinery that is dedicated to manufacture a specific product series such as pavers in the PS line of machines..

Unique to **TIGER** equipment is the ability to vibrate the entire form/mold or parts of it, vibrate a product table or even a form/mold head, one and/or all, at once.

TIGER equipment vibrates the forms/molds in many different ways to maximize compaction, product homogeneity/uniformity and strength. **TIGER** equipment use forms/molds capable of producing up to twelve standard size products (8"/20 cm wide) at a time.

Depending on the size and type of machine, more than 5,000 products can be made each hour. The form/mold is filled with fresh semi-dry concrete, vibro-compacted and the newly made high-quality concrete masonry product can be de-molded from 4 to 9.5 times per minute.

Compacted, formed/molded products are extracted out of the form/mold onto a steel pallet (Sometimes a hard-wood wooden pallet is used for very small manual machines) and transported to a curing area normally consisting of curing chambers called kilns.

At this point, the concrete products are referred to as "green" or uncured. As the products leave the molding machine, a rotating brush is sometimes used to remove loose aggregate and clean the top of the products. Frequently, a short blast of air is also used remove loose pieces of concrete.

PRODUCT-CURING:

Product curing with **TIGER** equipment can be done in many ways. **TIGER** equipment plants can use natural cure (air-type ambient temperature), steam curing, water-cold mist curing, pressurized curing (Autoclave) or combinations thereof.

TIGER Pallet Transporter type systems use tall, and deep kilns and are rack-less, **TIGER** ABC-Type systems push pallets one with another in special curing sections within a large curing chamber, **TIGER** Rack transporter systems use steel racks for storing the product during curing.

The Rack-type systems are very popular and the most common in the industry. All transport systems associated with the curing chambers style and curing systems are equally effective and it just a matter of preference for the end user.

If using a steel rack system the curing process would be as follows:

Once a curing steel rack is filled with steel pallets of “green” or uncured products, the entire rack is transported, usually on a rail mounted automated rack transporter system,(car, pusher system or otherwise) to a curing kiln automatically. Semi/partially automated or manually operated plants may use a fork lift truck to achieve this.

The curing chambers (kilns) normally operate at atmospheric pressure, with temperatures of 50° C to 85° C (120° to 185° F). Normally the concrete masonry products are held in the kilns between 12 and 36 and even 48 hours.

In warm or tropical climates, the heat generated by the chemical process of hardening of the concrete (setting of the cement or “heat of hydration”) is sufficient to raise the temperature of the kiln and the concrete masonry product to desired levels without the use of steam.

In comparison since concrete products are normally cured at a maximum temperature of 50° C to 85° C (120° to 185° F) this means that curing concrete masonry comparatively requires a small fraction of the energy to produce clay brick/block/masonry units, which are fired at temperature as high as 425° C (F 800°).

When the ambient temperatures in the kilns are less than 10° C (F 42°) the use of steam or other forms of generating heat is recommended. If using steam when the kiln reaches its predetermined temperature level, the steam (or other heat generating form) is automatically shut off and the products are allowed to cure for an additional period of time.

Steam, if used, is turned on to maintain 100% humidity. If other forms such as heaters or combustion heaters are used it is also recommended that room temperature water mist system be used to maintain 100% humidity and avoid drying the masonry products.

Successful curing is the combination of the use of higher than ambient temperatures and saturation of the curing atmosphere at 100% humidity levels for as long as possible. The longer the product is cured, the stronger it will become. The stronger the product is after initial curing the easier it will be for the “handling” equipment to “handle” the product and cube it without breaks or cracks or any other damages to it. Finally and most importantly, the longer the product cures, the stronger it will become, allowing this to reduce the use of cement in its manufacture. Using less cement creates a great cost savings at the end of the year, as cement is the most expensive of the BASIC RAW MATERIALS used in the manufacture of quality concrete masonry units.

The entire curing process normally takes 24 hours, but could be shortened by adjusting the mix design and curing temperatures. Products generally achieve 92.5% of their ultimate strength when only 2 to 7 days old.

When making a multitude of products and keeping track of complex and large inventories of 100's or more products, sometimes it pays to have a system that removes cured product on first-in first out basis rather than a first-in last-out basis (FI-FO, versus Fi-LO) as most systems are today.

TIGER equipment is the only manufacturer in the world that offers many systems not only in the Fi-LO configuration but also the much desired FI-FO arrangement.

CUBING AND PACKAGING:

Cured concrete masonry products are removed from the kilns by handling equipment or semi-manually, and are moved to a processing area where optional operations may or may not occur depending on the needs of the producers and the requirements of the market.

Some of these “optional” or ancillary operations can help create, improve or modify concrete masonry units so they fit special niches within the market. Many “architectural-type” units are manufactured with post forming/molding and curing operations such as **SPLITTING, ANTIQUING or AGEING, TUMBLING or RUMBLING, RE-COLORING, GRINDING OR POLISHING, SCORING or PITCHING** among many others. **TIGER** equipment is available for a great variety of these procedures (Splitters, turnovers, delivery stations, etc.) and manipulations of the end product prior to delivery to the cubing and packaging equipment stations.

The masonry units are then normally "cubed" and most of the time they are also palletized.

The cubing of concrete masonry products consists of turning individual masonry units (on their sides or at 90 degrees from their manufactured direction) and creating interlocking patterns that are then placed in alternating and/or consecutive layers to create a “cube” of products that can be handled fast and efficiently.

The cubing is normally done by one or various pieces of machinery that can be pre-programmed to automatically create patterns within the cubes forming thereby different cube-styles

The cubes of masonry products can be placed on a wood pallet, a pallet made of other sized masonry products such as large hollow core blocks put on its side (block pallet) or handled by a fork lift truck using the cores of the product as lifting locations.

Once cubed and palletized, the products can also be “packaged” by means of strapping (with steel or plastic banding, which can be done vertically, horizontally or both), wrapped by means of a shrink wrapping system or stretch-wrap wrapping by means of the use of a automated robotized or semi-automated or even a semi-manual or manual system. Some higher priced "value added" products are covered with plastic bags or are shrink-wrapped for protection. **TIGER** equipment is available to customers to assist or perform all of these operations of the final phases of the manufacture of high quality concrete masonry products.

Once cubed, palletized and packaged the cubes of product are placed in storage by means of stacking them three to five cubes high on the plant’s designated storage yard or storage area. Some more expensive value added products are stored under cover/roof to further protect them from dust, rain, or discoloration from the U.V rays from sunlight. The products then remain in inventory until delivered to a jobsite or picked up by the customers/end users.

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