BY MARK EVANS

THE MAKING OF A GLASSY MATRIX

The making of vitreous china products such as toilet bowls and tanks, lavatory basins and urinals would seem as simple as taking some clay, moulding it, drying it, glazing it and firing it. In actual fact, the process is really a complicated balancing act between two of the Earth's most basic elements of water and fire. Following the process from start to finish instills a new appreciation for the true value of the sanitaryware we sell, install and use each day.

The four basic steps in the making of sanitaryware, which have not changed substantially since the process was first discovered over 2,000 years ago, are: casting; drying; glazing; and firing.

Vitreous china, as defined by British Ceramic Research Ltd., is "essentially a mixture of crystalline materials in a glassy matrix. Its three basic components are filler, flux and clays. Components are chosen to satisfy the many requirements of the production process from casting slip preparation to firing. One part of the process often requires a material with a property that conflicts with that required for another."

The clay material is normally a mixture of American Ball Clay and China Clay. Fluxing materials may include talc, gypsum or feldspar, and the filler is a silica or quartz mix. While some manufacturers mix their own clay from dry ingredients on site, many manufacturers buy a clay slurry called slip from a clay mining/milling supplier. This is shipped by rail in tanker cars to the pottery for further processing.

PRODUCTION PROCESS

When each piece is cast, it passes through several stages of production enroute to becoming a finished product. During the casting process, some of the initial moisture content has been lost from the clay slip. This is what causes the piece to hold its shape and allows it to be released from the mould. Following casting, the piece is known as greenware. The green piece is 12-15 per cent larger than it will be as a finished piece. This is because it will shrink due to moisture loss as it progresses through the production process.

Prior to being fired in the kiln, the greenware must be dried. This can be done by storing the product in an open environment where the air temperature and humdity levels are controlled. Production is limited by the amount of space available for drying and the amount of time required to adequately dry the ware. Today, pre-fire drying is most commonly done in dryers that accelerate this process with either heat/air or by microwave.

MOULD MAKING

In order to cast any piece, a mould of some sort is required. The process varies based on the casting method used, but each product begins as a model reproduced from a CAD/CAM rendering. It is from this model that the product is ultimately cast. There are four basic methods of casting employed today:

1. Bench Casting

Bench casting is the oldest and least technologically evolved casting process. The mould making process in bench casting is a four-step process that begins with the making of the model. From there, an opposite or negative of the model is cast in plaster. This is the block or master mould. The plaster from which it is made differs from the other moulds as the block mould is the mould from which all other moulds will be made. As such it must be resist-

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Photo Mansfield

ant to damage. From the block mould, a negative is again cast to provide the true form of the piece. This is known as the case mould.

The case mould is the mould from which the working moulds will be cast. In the bench casting process it is also made from plaster. This is the mould that will be used to produce the working moulds. In its lifetime, the case mould will produce between 100 and 200 working moulds.

Internal parts of a bench bowl casting with mould sections in the background.

Photo File Photo

The actual production is derived from the working moulds. The plaster in the mould actually wicks moisture from the clay slip. As stated earlier, it is this loss of moisture that results in the greenware piece taking shape. Once the green piece has reached the desired dimension, the excess slip that fills the mould is drained off and the mould is opened to release the piece. Beyond a certain point, the mould loses its ability to draw water from the casting and produce suitable greenware able to hold its shape. These moulds will yield 50 to 100 pieces before they require replacement.

Bench casting is a manual process where individual moulds are filled by hand and cast one or two times per day (24 hours). This casting process is limited by the filling/drainage cycle, the need to dry the moulds between castings, and the time required to dry the greenware prior to firing. The quality of the cast pieces is relative to the skill of the casters (which must be high). The advantage is that the low cost of working mould production allows for intermittent production in small volumes of a wide variety of items.

2. Battery Casting

Battery casting differs from bench casting in that the molds are designed to be assembled and filled in batteries or gangs. The filling/drainage cycle is often partially automated resulting in a greater number of casts, typically three or four per day.

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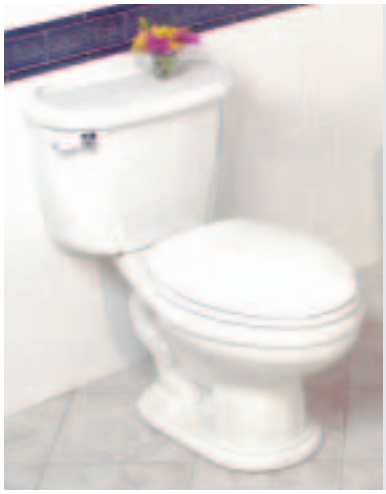

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3. Capillary Casting

Capillary casting is an adaptation of battery casting. It employs plaster moulds that are specially designed to include automated filling and drainage where the moulds are clamped and cast at low pressure. This decreases the amount of time required to fill/drain the mould and accelerates the wicking or capillary action of the plaster. This allows the green piece to be released sooner than with a bench or battery cast process. This method mitigates the need to dry the mould between castings and normally results in four to six castings per day.

4. Pressure Casting

Pressure casting is a very automated process requiring the least intervention from a skilled caster. The mould, which is made from a high-tech polymer compound, will see between 10,000 and 40,000 castings in its lifetime. The pieces are cast at much higher pressure than in the capillary process (up to 20 bar). In the case of a simple piece such as a toilet tank, as many as four or five pieces can be cast per hour. The cost of a pressure mould is much greater than that of any other mould, but the rate of recovery (fewest casting/firing losses) from such a mould is usually at least 10 per cent greater than other casting methods. Couple this with the greater number of pieces cast per employee and per square foot of factory space per day, and the payback potential is apparent.

SURFACE FINISHING

Once the piece is cast, it is transformed from a piece of greenware to a piece of glostware. The glazing (glost) process not only adds a colour to the surface, but also results in the glossy or vitrified finish on the surface of the piece. As the piece is fired in the kiln, the quartz/silica elements in the glaze harden like glass. The durability of this finish has given vitreous china products great longevity in the market place and made them almost irreplaceable in many applications.

When it is ready for the kiln, the piece is sent through on a first fire. If it emerges as expected, it is then tested, inspected, packaged and shipped. However, some pieces may emerge with a minor blemish or defect. These pieces are repaired with a special clay mixture, re-glazed and then sent through for what is known as a re-fire. Depending on the circumstances, it is not uncommon for up to 10 per cent of pieces to be re-fired.

There are two basic kiln types in use today, tunnel kilns and intermittent or

Photo (left) Briggs; Photos Mansfield

transfer kilns. The tunnel kiln operates continuously with a variety of temperature zones within the length of the kiln. When the glostware enters a tunnel kiln it begins a 12 to 24 hour journey where it will go from an ambient temperature of 30 to 40C to firing temperatures between 1,000 and 1,200C in the kiln. The kiln is zoned to provide controlled firing, with thermocouples controlling temperatures to within five degrees Celsius of setpoint. Tunnel kilns are employed where large volumes of similar pieces, requiring similar rates of fire are produced.

A transfer kiln is different in that the kiln cars remain stationary within the kiln during the firing process. These kilns are typically much smaller than a tunnel kiln but require that the pieces spend only seven to 10 hours in the kiln rather than 12 to 24 hours. Transfer kilns offer greater flexibility in making smaller runs of varied products and are also better suited as re-fire kilns.

The rate of firing required is such that once finished, a piece of sanitaryware must have a rate of water absorption of

As sanitaryware is fired in the kiln, elements in the glaze harden like glass.

no more than one-half of one per cent of its total weight. This results in a watertight, durable piece.

Over the years I have had the pleasure of touring a number of potteries and each time was more interesting than the last. From the casters and the skills they possessed, to the technological evolution that has brought vitreous china production into the space age, the process of turning a lump of clay into a plumbing fixture is nothing short of fantastic. HPAC

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