Clay rooftiles are manufactured by re-pressing preformed clots or cakes between two moulds which represent the negative of the required shape. A distinction is made between top moulds and bottom moulds, and also between surface and accessory tiles.

Clay clots

After preparation of the clay and extraction of the air entrained in the mixture, continuous strips are drawn out of the extrusion press, and clots of a specific length are cut and transported to the press on conveyor belts. In the press, the clots are pressed between two plaster moulds to form a roof tile blank. The plaster mould must be able to withstand the mechanical mould pressure in this process as well as exhibiting adequate porosity to take up the quantity of water coming out of the clay compound during pressing.

Plaster selection

The selection of the plaster and plaster/water ratio are mainly determined by the characteristics of the clay compound in use; its abrasive properties, water retention capability, plasticity, tendency to adhere, water flaws etc.. The geometry of the pattern, size of the clot, its positioning on the plaster mould, speed of the press and intensity of the mould suction, also help determine the requirements for the plaster moulds.

Resistance and porosity

The aim is to achieve the optimal balance between mechanical resistance and porosity. Resistance to abrasion will give long mould service life, however achieving this level of resistance is normally to the detriment of a plaster's capacity to absorb the water from the clay during pressing. Optimal ratios have to be adjusted to each set of production conditions.

Top moulds

On the press, a distinction is made between top moulds and bottom moulds.

Surface tiles are made on revolving presses with the top moulds forming the punch of the press which thus carries out considerably more work cycles than the rotating bottom moulds beneath it. Typically there are 14-18 press strokes per minute with a ratio of six bottom moulds to one top mould. The top mould usually produces the visible surface of the roof tile, and the quality of the visible surface is assessed by the press operators.

In order to be able to take up an increased quantity of water a system of channels is provided in the upper mould, which only has to make vertical movements. Water is extracted from the mould during pressing by the application of a vacuum, which allows the mould to retain good suction capacity even with a high plaster/ water ratio.

Bottom moulds

There is normally no water extraction from bottom moulds, but as these moulds are pressed less frequently on the swivel press, they take up water during the revolution cycle of the press. As a rule, a film of water is required on the bottom mould so that when the press is opened the blank remains stuck there.

Accessory tiles

These include special sizes, and articles which due to a particular shape require a separate production line e.g. ventilators, flashing tiles (edge tiles with pressed on vertical side flanges to cover gable edges) or ridge tiles. Due to the geometry of the pieces and the way the clay flows, special presses and kiln furniture are required, along with adjusted drying and baking times. Slower swivel presses or rotary table presses are used here. In spite of the slower press cycle, lower plaster/water ratios frequently have to be used.

When manufacturing accessory tiles, the quality of clay compound should be strictly controlled. If there are fluctuations in the composition of the compound, the demands on the plaster mould will be greater. The vacuum applied to the upper moulds can be controlled at the press, and should be set at around 60% to ensure possible compensation in the event of fluctuations. The speed of the press has a considerable influence on the possible moulding performance of the moulds. If the speed is increased the plaster moulds are under more strain, as the amount of water pressed out of the clay has to be taken up more quickly. In order to make this possible a higher void space is necessary. The mechanical loading is greater due to the higher speed, making faster wear of the moulds unavoidable.

Mould Wear

When the plaster moulds are worn down by the stresses to the extent where the produced blanks no longer meet the customer's quality requirements, the moulds are changed. Worn moulds are taken to the mould casting shop where the residues of plaster are removed from the matrices by chiselling, or spraying out the plaster residues using a high-pressure water jet. If the plaster is chiselled out, the matrices or edging strips are often damaged and this has a negative effect on the quality of subsequent moulds.

Tile Drying

Blanks are laid on drying frames and taken through the climate chamber dryers or flow line dryers by automated conveyor systems. Blanks dry in around 10-30 hours, losing about 20% of their overall weight. The dried roof tiles are removed from the dryer and taken to the baking oven by transport devices. Any dry breakages which occur will be segregated and recycled, however tiles which break after baking should not be recycled as this would have an extremely abrasive effect on the plaster moulds.

Engobing

After drying the blanks an engobe or glaze may be applied. Small faults or plaster abrasion dust sticking to the surface are covered by coating the surface. The engobe is applied by spraying, centrifuging, pouring or dipping, before the dried blanks are fired.

Engobes are coloured slurries baked into the surface at around 1070°C and are crack, abrasion and scratch resistant under normal stress. The engobed roof tiles are more resistant to ultraviolet rays, frost and weather than uncoated tiles. Glazes are glass-like coatings for roof tiles matched to the ceramic base.

The glazed layer is around 0.15-0.4 mm thick and seals and improves the tile surface.

Both types of surface treatment allow the tile to be coloured completely independently of the clay compound used. In the subsequent firing process the glaze or engobe and the tile are bonded together.

Firing

Modern firing techniques allows tiles to individually, horizontally fired, without touching, to give faultless surfaces.

After placing the blanks on the cassettes these are stacked on the tunnel kiln trolley. The tunnel trolleys run-through the pre-heating zones and firing zones of the tunnel. The firing temperature is around 1100°C. The total time in the kiln is between 10-24 hours, depending on the equipment used. After firing, the tiles are separated from the firing aids, checked for quality, sorted and packed. Both the firing and drying processes are usually circulatory systems, with the drying circuit coupled directly to the press.

Plaster preparation

Automated equipment is set up to allow predetermined mix parameters adapted to the requirements for each type of tile being produced (batch size, mixing time, plaster/water ratio) and to allow a mixture of two plaster components.

In most cases it is an advantage to mix under vacuum to avoid air and increase the final strength, however it is important to integrate cleaning between mixes. Use of automated plaster equipment has led to increased demand for consistent plaster quality, since small fluctuations are no longer manually compensated for during the plaster preparation phase. Such fluctuations can lead to subsequent stresses on the working mould.

Plaster and water are recorded and added by weight during the feed process. The temperature of the plaster should be around 20° C, and that of the water not below 15° C. The temperatures should not fluctuate as this can immediately lead to uneven working characteristics, due to uncontrolled plaster crystallisation. The moulding plaster is slowly introduced into the mixing water and allowed to stand for one to two minutes. This allows the air introduced during

powder feeding to escape before mixing starts. Containers and tools must be free from residues of set plaster.

The stirring speed is dependent on the type of stirring tool, the shape and the size of the container and on the preparation size. The whole quantity should move evenly without air being entrained. The formation of a funnel at the stirring shaft during stirring must be avoided. After mixing the slurry should be homogeneous, pourable, free from lumps and air bubbles. The mixing time should be adapted to the plaster/water ratio to avoid leaving the plaster slurry for too long in the mould, to avoid sedimentation.

Plaster working moulds

There are two methods of working with plaster working moulds.

Working mould matrix firmly clamped to the master mould.

The plaster slurry is introduced into the closed mould body through a pouring hole. Depending on the size of the pouring holes the plaster slurry must be a thin liquid in order to allow any air bubbles to escape. Setting must start shortly after pouring the plaster slurry in order to avoid sedimentation in the standing moulds.

Plaster slurry cast directly on to the surface of the master mould.

The mould is held in place by a retaining frame until it achieves a consistency which allows the frame to be removed. The frame is removed and the working mould matrix is placed on the soft plaster and pressed in hydraulically. Timing when to place the matrix onto the plaster has a fundamental effect on the properties of the working mould. If the setting process is already too far advanced when the matrix is placed on, the working mould will be compressed. This will change the pore structure and the water take-up will be reduced, making the mould unusable.

In both manufacturing processes, water removal channels are laid into the upper moulds, which normally press the visible face of the tile. This is achieved by fixing resilient plastic cords, between 0.5-1.5 cm in diameter, onto the working mould matrix. The tubes are fixed by prepared eyelets or by using small quantities of plaster. After the plaster sets, the tubes are removed from the set mould.

The cavities which remain once the tubes are removed, are used to remove the water from the surface of the mould during use, by the application of a vacuum. The tubes can be positioned with respect to problem zones according to the experience of the mould caster on the different designs. A film thickness of 1 cm of plaster must be maintained in order to avoid cracking.

After the setting process the halves of the mould remain closed for around 15-20 minutes. To ensure trouble-free de-moulding, the face of the mould should be treated with a suitable parting emulsion before pouring in the plaster. The use of substances containing grease must always be avoided, to prevent sealing the mould surface. Special plaster parting compounds based on water/natural oil emulsions are suitable.

During the setting phase the plaster must not be put under mechanical stress or opened up too early. When opening the mould it must not be tilted. This sort of stress could lead to mould breakages when the mould is being used even though the mould has exhibited no visible signs of damage.

Storing plaster moulds

It is recommended that the moulds be allowed to stand between 2-6 hours before use.

After this time plaster recrystallisation of the plaster has progressed to an extent where adequate hardness is achieved. In general, before being used on the press, the mould should be washed with water to open up the pore cavities.

If the moulds are stored for longer, and dry out due to this, water-soluble components of the mould will be carried to the surface of the mould with the water and deposited there. This process can seal the surface such that even complete submersion of the mould will not achieve the accustomed performance of the product.

If the moulds are kept moist during storage the covering material should be chosen with care. If they are covered with plastic sponge this can cause the surface to begin to dissolve and lead to a reduction in its ability to hold its shape.