Innovative Solution for Manufacturing Insulated Curved Roofs for Industrial Buildings

by Max Taverna and Giampaolo Spanio– Cannon Group

Abstract

The replacement of asbestos-based flat and curved roof panels provided the opportunity to replace poorly-insulated roofs with energy-efficient insulating elements, obtained foam-backing various facings (fibrous-concrete, painted steel etc) with a low-density Polyurethane rigid foam.

This paper illustrates the innovative equipment supplied recently to manufacture curved insulated roof panels using a very compact, highly automated plant based on rotating mould carrier.

Replacement of Asbestos-based roof panels: an opportunity for Polyurethane

When health authorities defined the carcinogenic effects of asbestos and related derivatives, a wide number of products (from car brakes to protective cloths for fire-fighters) had to be re-engineered in order to eliminate the dangerous raw material. Widely used in the building industry for good mechanical properties and resistance to fire, asbestos-based flat and curved panels cover an immense surface of industrial, commercial and domestic buildings. Their progressive replacement is called by national laws and by the pressures of consumer and environmental groups.

Simultaneously, in several European countries it is expected soon the introduction of new safety rules that demand the possibility to safely walk above the roof elements without breaking them.

Producers of building materials have quickly provided the market with valid alternatives to the simple old elements: Asbestos has already been replaced in these panels with synthetic reinforcements – usually combinations of PVA and PE fibers (Polyvinilalcohol and Polyethylene) – that, blended with a fine grade of cement and silica, provide excellent mechanical properties and resistance to atmospheric agents and ageing. A metal version, made with pre-painted steel or anodized aluminum sheets, is also on the market.

Obviously the replacement of old roofs and vertical elements is a major investment for the building's owner, and is generally associated with other major maintenance works, to "refresh" to building and add some value to a depreciated asset.

The time is right for an improvement: the two above mentioned health- and safety-oriented motivations provide to the end-users (and to the Polyurethane industry) the opportunity to replace poorly-insulated roofs and cladding elements with energy-efficient insulating panels of various size and shape; these can be made foam-backing various facings (fibrous-concrete, aluminium, painted steel etc) with a low-density rigid foam.

Among these building elements, one specific type of panel stands out for its wide diffusion and for the manufacturing difficulties linked with its peculiar shape: the curved, grooved roof panel used to cover industrial buildings and warehouses. *(Fig. 1)*

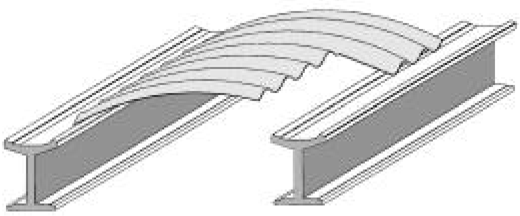

Figure 1 – Old curved panels for roofs – often containing Asbestos fibers – can be replaced with new Polyurethane-insulated ones.

Manufacturing Problems

These curved elements have an average dimension of 1x4 meters, and the fibrous-concrete ones are produced by compression, with presses able to apply a clamping force of up to 10,000 tons. Due to their dimensions, the production requires large manufacturing halls, and automating the process is the key to obtain constant results and a low cost. Applying a layer of Polyurethane foam under one of these elements – with a flat containing panel on the opposite side, to complete the sandwich – requires a number of operations that enhances the necessity for automation and precise repetition of tasks. Cannon have identified a good potential in this market niche of the building industry, and decided to put engineering resources to provide an innovative manufacturing solution.

The labour- and space-intensive process of foaming these large and quite heavy panels has been re-evaluated by Cannon engineering specialists and a highly automated solution has been envisaged.

Cannon Solutions

Using proprietary concepts derived from other space-taking manufacturing processes (such as long, flat sandwich panels, or domestic refrigerators and freezers) Cannon have designed and built a dedicated foaming plant for Società Italiana Lastre of Verolanuova, Brescia, in Italy. *(Figure 2)*

Figure 2 – A compact, highly-automated, dedicated solution has been designed by Cannon to produce insulated roof panels.

The production requirements were to manufacture insulated roof elements made with an external curved, grooved facings in fibrous-concrete, and an internal flat facing in either fibrous-concrete or painted steel. Minimum manpower was demanded, and the possibility to produce different models in size and facings, but also with different assembly details. *(Figure 3)*

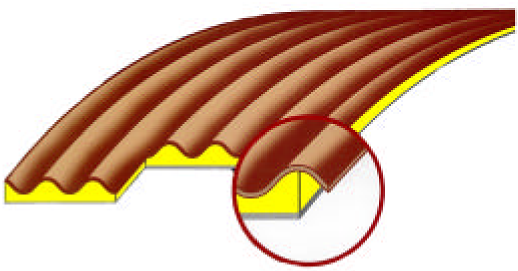

Figure 3 – An insulation thickness of 30 to 80 mm can be applied between fibrous-concrete or painted steel facings

Main characteristics of the supplied plant are a compact layout, high degree of automation, flexibility in producible models, and quality insulation properties due to optimum distribution of foam. This plant covers 275 net m^2 , produces every hour 20 roof elements of 1.1 x 3.8 m each, with a curve of 42 cm. and a thickness of insulating foam ranging from 30 to 80 mm. Two operators execute one preparation task, and one forklift operator supplies pallets of facings and removes pallets of panels.

Several interconnected sections compose this foaming plant *(Figure 4)*:

1. Automatic handling system of stacks of upper and lower facings
2. Preheating station for the fibrous-concrete curved, grooved facing
3. Assembly station for the sandwich panel
4. Polymerisation jigs
5. Dispensing/Mixing/Foaming station
6. Automatic handling and palletising system of finished panels
7. Computerised Control Unit

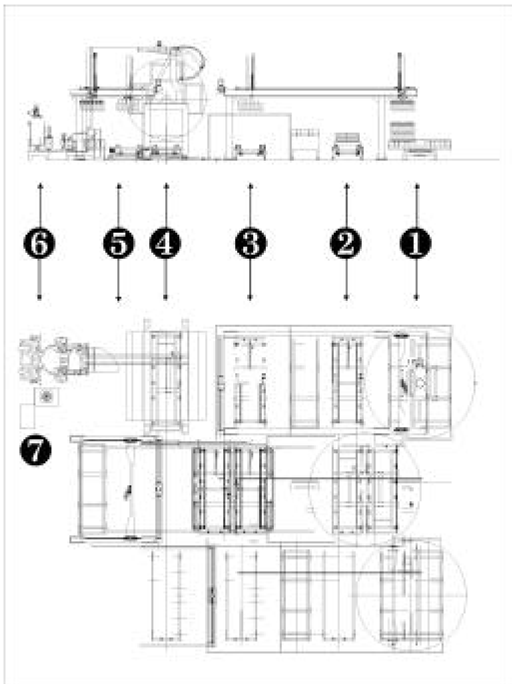

Figure 4 – The complete plant covers a net area of 275 m^2

The production sequence works as follows:

- Stacks of 80-100 curved, grooved, 5-mm-thick fibrous-concrete sheets are transported by forklift (using special metal pallets) up to an unloading/centring bay, mounted on a rotating platform with two side-by-side docks. Leaving the stack on the unloading station, all the sheets are automatically centred; when the other dock is empty the platform rotates and the full dock is positioned near the pre-heating station. *(Figure 5)*

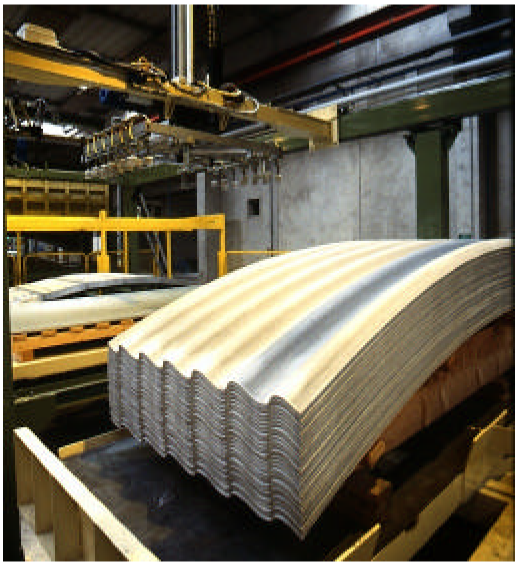

Figure 5 – The unloading/centring station for the upper facings

- When required, a roof-mounted 3-axes robot with vacuum suckers picks-up one curved element and moves it laterally over the pre-heating station. Here a series of low-inertia, high-efficiency MVL IR elements (a Cannon development) heat the fibrous-concrete sheet to remove all humidity and ensure that – when foamed a few minutes later – its surface temperature will be of 40°C. *(Figure 6)*

Figure 6 – Preheating station, with low-inertia Cannon MVL infrared elements

To achieve this result the temperature of the sheet must reach 80°C at the end of the heating phase. When the panel has reached this pre-set temperature the MVR heaters automatically stop.

- In the meantime in the contiguous assembly station one empty mould-half has been transported and fitted with the lower facing of the sandwich, that can be either fibrous-concrete or pre-painted steel. These facings – that come from an unloading/centring bay equal to the one described above for the curved facing – are automatically deposited on the bottom of the mould. The operators apply strips of thin flexible Polyurethane foam over the perimeter of the panel, to prevent the contact between rigid foam and the mould inner sides. When the lower facing and the sides are ready, one heated curved element is transferred here from the pre-heating station – using the same robot described above – and deposited over the just-prepared lower mould-half.

Figure 7 – Loading/unloading cart , servicing the assembly station

- When required, this package is transferred with a wheeled system on the loading/unloading cart that services the foaming jig. *(Figure 7)* To save service time and energy this cart has been designed with two places: one is used to return an empty mould-half to the assembly station, the other to bring a ready mould-half to the foaming jig.

The core of the plant is constituted by the special foaming jig, *(Figure 8)* designed to hold four large moulds, mounted on the four sides of a square-sectioned steel structure rotating around its longer side. This design derives from the Cannon-patented Drum unit, introduced in the early '80s to produce two or four different models of domestic refrigerators in the same foaming station, with a zero-time-mould-change system. For this larger products a bigger version has been designed, with four mould carriers.

Figure 8 – The use of Cannon proprietary Drum Unit - in a special version for curved roof panels – allows for the injection of four panels in the same foaming fixture, saving space and simplifying maintenance.

- When one finished panel is ready for demoulding, the operation is performed on the lower of the four moulds. This is opened with a parallel movement of the lower platen, which goes over an unloading table with cylindrical rolls and wheels. While the mould carrier opens, the lower mould-half remains caught on the wheels of the unloading table and is extracted with a sliding movement, axial with the jig. It is deposited on the empty place of the loading/unloading cart, that makes one side step at the end of this operation, to present the mould-half containing the sandwich (ready to be injected with foam) in front of the jig. The same unloading table with cylindrical rolls and wheels lifts the package and brings it into the lower mould, which then closes with an upward parallel movement and locks it in position.
- The Drum unit with four mould carriers rotates clockwise by 180°, so that the newly-introduced sandwich is brought to the uppermost position and is now presented with its concave side upwards. A Cannon LN mixing head, mounted on a pivoting head carrier, is introduced in the injection hole, positioned midway on the long side of the mould. This is the ideal foaming position, because the liquid Polyurethane is injected in the mechanically-most critical part of the curved panel, where we do not want to have air traps and junction lines of rising foams. The reacting liquid wets this part of the panel in a very homogeneous way, then the foam starts rising and distributes sidewise, pushing all the air out of the two short edges of the panel. Optimum distribution of densities is hence obtained, and the well-controlled temperature of the facings helps the foam's flow. *(Figure 9)*
- Polyurethane is dosed using a Cannon "A-System 100" high-pressure metering machine, where Polyol and Isocyanate are currently fed by 220-lt drums or 1 m^3 cubic containers. In a future extension a tank storage system can be connected with the machine, to avoid all manual substitution and the handling chores linked with drums and of small containers. The machine dispenses the 8 kg of foam in approximately 7 seconds, and the foam shows a final moulded density of 45 kg/m^3 . The innovative aspect of this plant is enhanced by the future possibility of using liquid Carbon Dioxide-blown rigid foams, characterised by superior adhesion to metal facings and attractive cost.

Figure 9 – Loading and unloading are made using the lowest mould, while foam injection is performed in the uppermost.

- The LN head – specially designed for applications where a long "nose" is requested – is characterised by high-pressure recirculation of components up to the injection nozzles, to ensure the thorough optimisation of both liquid's temperature and viscosity prior to the injection.
- At the end of the injection, when the foam has filled the panel, the Drum rotates backwards by 90°, to allow for the unloading of a polymerised panel from another mould.

The foaming sequence continues with this alternated movement of 180° clockwise and 90° counter-clockwise, that guarantees optimum exploitation of the movements and leaves the panel in polymerisation for the required 10 minutes of curing time.

The double-place unloading cart - that received the finished panel still positioned on its mould-half - moves sidewise once more, to allow for the automatic pick-up of the part with another dedicated 3-axes suspended robot: this stacks the panel on a special pallet, and when this is full of product it is removed by the forklift and sent to the warehouse. *(Figure 10)*

Figure 10 – Finished panels are automatically stacked in pallets after demoulding

As already said, the system produces 20 panels per hour with three people on 275 m^2 of factory floor.

Three combinations of upper and lower facings (fibrous-concrete/fibrous-concrete, fibrous-concrete / painted steel and painted steel/ painted steel) can be used with this plant, designed to handle various types of materials.
Future extensions of the system are foreseen in the original project: the inclusion of another Drum unit would make use of the same dosing unit (only some rigid piping and another mixing head would be required) and the same loading/unloading cart. Doubling the capacity would therefore not mean repeating the investment.

Advantages
The main advantages of this solution are economies, flexibility and quality, deriving from:

- Limited floor occupation, due to the compact layout of the Drum unit foaming jig and to the rational use of robots and loading systems. Similar systems based on conventional rows of fixed presses occupy more than double of space.
- Low cost of labour, thanks to its high degree of automation and to the reduced maintenance to be carried on a single rotating mouldcarrier instead of multiple conventional ones.
- High manufacturing flexibility, thanks to its ability to produce different models.
- High quality of the finished products, due to optimum mixing and distribution of foam.

Future developments

Cannon R&D teams in various countries are actively investigating new ways to produce various types of insulating panels for dedicated, specific applications. The use of innovative foaming methods and technologically evoluted mould carriers is constantly studied and applied. Use of vacuum-assisted foaming jigs, for instance, could reduce cycle times and moulded density of the foams.

Cannon welcomes enquiries for the study and the construction of this kind of innovative plants: the successful story of the last 35 years of history – thanks to the strict co-operation of end users and Raw Material Suppliers – proves that "Together We Can Make It!"

Biographies

Max Taverna - born in Buenos Aires, Argentina, in 1949 - has an education background in industrial chemistry. He worked five years for Upjohn's Polyurethanes Division in Italy, and joined Cannon Afros as European Sales Manager in 1982. Since 1986 he has co-ordinated all the Group's communications activities, and is today Cannon Communication's Director.

Giampaolo Spanio - born in Verona, Italy, in 1951 - holds a degree in Mechanical Engineering from the University of Roma, Italy. After a decade of activity in Defense Systems Engineering and a position as Technical Manager for a major plastics extrusion machinery company he joined the Cannon Group in 1991. He's currently the Group's Technical Director.