# SoliSpray for innovative automotive Dash Insulators

The automotive industry increasingly requires superior noise insulation solutions to provide vehicles which must be acoustically comfortable and - at the same time - of lightweight and with ample spaces in the passenger's compartment.
This article describes two applications for SoliSpray, the new Cannon technology for spraying highly-filled PUR formulations, developed for the manufacture of the Dash Insulator, a large element placed under the instrument panel.

Noise from the engine enters into the cockpit mainly from two places: the metal wall holding the instrument panel and the two "pits" near the front wheels, where on one side the pedals are mounted and - on the opposite one - the front passenger's feet are resting.

A typical Dash Insulator

Several solutions have been applied to meet contrasting needs: high noise-insulation efficiency and low volume. Sandwiches of heavily-filled polymeric facings and flexible foams, felt-based mats, several combinations of synthetic and natural materials. Lightweight, expanded textile-based mats provide an economic solution with medium-good noise insulation, but they steal space inside the cockpit and are prone to moisture absorption.
RRIM-based injected parts provide good sound-proofing but are made out of expensive chemicals as well as expensive production tools and presses.
Thermoformed combinations of heavy layers and various facings are quite labour intensive to obtain. Almost all the current products require expensive moulding tools, either because they must contain rising PUR foams or because they must be heated to provide thermoforming capability.
An alternative, simpler solution was demanded by this very cost-conscious market.

## PROJECT BACKGROUND

Acoustic shield for dashboards, providing a substantial reduction of the noise generated by the engines, have been produced with Cannon equipment for many years by the major suppliers of the automotive industry.
Lately, the preferred solution has been the so-called Heavy Layer, a single-material moulded element obtained by closed-mould injection of RRIM formulations heavily filled with Barite; this is a natural Barium Sulphate powder, containing small amounts of abrasive silica and quartz crystals able to wear severely standard pumps and mixing heads. Piston-driven metering units have been developed since the 1980's for these applications, combined with hardened heads and special injectors providing a stable functioning and constancy of mixing results in the long run.
Injection of the two-component formulation occurs in large, closed moulds, and the pressure generated by the expanding PUR must be held by huge presses to avoid that "flashes" of polymers leak from the mould junction, wasting material and forcing to manually trim the parts after demoulding.
When the industry tried to save some material by thinning the section of the insulator, a quality problem quickly arose: heavily filled formulations are very viscous, they flow with difficulty in thin cavities and produce parts showing air entrapments, heavy flow marks and poor surface aspect. The scrap rate quickly becomes a major problem, also due to the relatively high cost of the formulation, and to the high cost of disposing of these large, scrapped elements.
Moreover the presses and moulds necessary to withstand the injection pressure must be strong and stiff, therefore heavy, large and quite expensive.
The automotive industry needed large parts, able to provide a good level of noise insulation where required by the design of the metal substrate. Parts that must have very different thickness in specific zones, that require back foaming with flexible foam and also a good and robust surface finish, to be assembled by semi-automatic tool into the destined positions.
Placed under the dashboard, these components permit the passage of the many services crossing between the engine compartment and the cockpit: each passage must be precisely sealed, so the finishing with water jet cutting and the weight tolerance are a must.
Not necessarily a part of constant thickness and not necessarily "aesthetic" parts in terms of look: placed under the dashboard, these are large components that even very few mechanics will have the opportunity to notice in the whole life of a vehicle.
A different approach had to be found, using these Barite-filled formulations or something else.

## CANNON SOLUTION

In the late 1990's Cannon were developing a number of manufacturing systems based on the spray technology.
The InterWet solutions - for instance - allowed for the intimate mixing of PUR formulations with long chopped fibers of glass and of other materials, as well as of heavy powders, milled scrap of PUR flexible foams. This technology required a certain amount of efforts for the precise dosing of these external elements, which provided the Cannon PUR R&D team with special skills in handling and mixing these solids.
Careful attention was dedicated to the design of heads able to cope with large amounts of solid, abrasive fillers at relatively high output rate. One of these heads was designed with the geometry of a standard L-shaped Cannon FPL, a Cannon Patent of the late 1970's that has introduced a superior level of mixing efficiency combined with the absence of splash during the open-mould pouring operations. This head - modified in its parts in contact with the solid, abrasive fillers - provided very good results when pouring simultaneously a standard PUR formulation and a number of solid fillers and reinforcements.
When Cannon PUR R&D team was faced with the request of an alternative method to manufacture Heavy Layers for Dash insulators, the filled-spray alternative was immediately taken into consideration.
High mixing efficiency combined with the absence of splash - in presence of high percentages of solid fillers - are also very important features for a spray head.
A number of technical constraints were there to be overcome, but the potential advantages of a "spray approach" immediately appealed the researchers:

- The possibility to eliminate half of the tools: a spray foam only requires the lower half of a mould, not being this a moulding process.
- The elimination of heavy and expensive mould carriers: simple trays would be required to carry the lower mould halves on which the foam will be sprayed.
- The possibility to apply layers of insulating material only where it is really required: the mould areas where it is unnecessary can be simply skipped during the spraying operation. Where more material is needed, a second, even a third "pass" can be applied when the former is sufficiently dried-.
- The possibility to position plastic and metal inserts in mould prior to the spraying: positioned in mould either manually or using robots, they are fully encapsulated by the foam.

## INITIAL DEVELOPMENTS

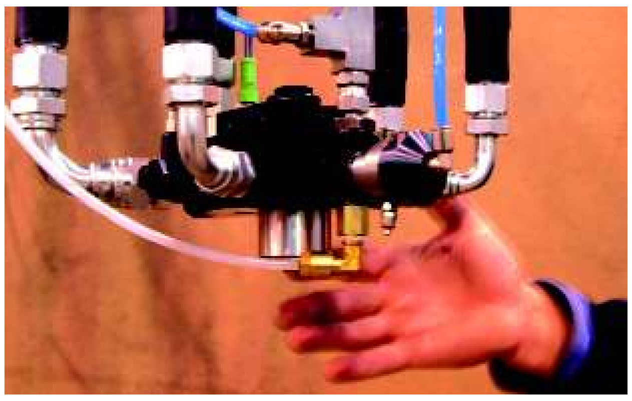
A development project was initiated, to explore the limits of the available metering and mixing equipment and define the parameters for the optimum solution.
A piston-dosing Cannon HE lab machine was specially modified and dedicated to this project, as well as a large portion of the R&D lab with a robot handling the spray head, a fully-enclosed spray cabin with forced ventilation of exhausts gases and all the necessary ancillaries and moulds.
A team of specialists - from various departments of the Company - was fully dedicated to this task for several months.
First things first, a proper formulation had to be found.
To start with, also using the previous experiences with moulded formulations, a level of 50% of Barite on the total applied polymer was set as the minimum one to guarantee good acoustic properties.
The peculiar reology properties of fast and heavily filled formulations require special settings on the temperature control side: extra heating capacity was built into the component tanks and feed lines, able to guarantee - at least on the filled Polyol side - a running temperature close to 90 °C.
The matter was rather new also for experienced Raw Material Suppliers. A number of them - all the main players in this field of the Automotive industry - were invited to take part in this challenge.
The first of them came with drums of basic chemicals and jars of their "magic powders" and played in Cannon R&D Lab until a decent reactivity profile was obtained and reproduced for a sequence of spray applications of one grade of filled foam.

Strong skin, in spite of the thin applied layers, and minimum overspray between layers was soon obtained in Cannon R&D Labs.

Various types of pump- and piston-driven dosing units are available at Cannon for the application of spray foams for automotive components

After much work and efforts a number of good Heavy Layers was produced: they were judged interesting and worth the continuation of the project. A sort of "starting point" of the technology was set, and the process entered in its "refining phase".
A number of basic problems was identified and duly tackled. They mainly involved four areas: mixing quality, effect of abrasive powders on the mechanical components, design of the spray nozzle and head cleaning procedure at the end of the spray job.
Mixing quality of Polyurethanes - in general - derives from several factors: ratio and nature of components, output, size and geometry of the mixing chamber.
When the components are (more or less) of the same order of magnitude of viscosity, specific gravity and temperature, what happens in a traditional impingement mixing chamber is by now clear and consolidated - at least for those who know what they are dealing with. But when the same parameters are, as in this case, heavily unbalanced, what happens in a tiny mixing chamber is widely uncertain and cannot surely be monitored with a video camera. Not in real life, at least. Only by using dedicated FEA (Finite Elements Analysis) software and mathematical models one can simulate those processing situations with a good margin of reliability, using less time and less resources than when using a "trial and error" approach.

Specifically for the Polyol side - characterised by a very high specific gravity and brought at very high temperature to lower its extremely high initial viscosity - a special new design of jets was derived from other branches of the industry, particularly from the hydraulic science. An optimised stream of material was obtained, whose speed can reach well above the 100 meter per second limit that transforms this flux of filled liquid almost in a water-jet cutting tool!
Opposite story for the Isocyanate stream, characterised by very low percentage, viscosity and specific gravity. For this component a totally different injector was designed, that performed optimally with the opposite one carrying the filled Polyol stream.



Compact and characterised by a perfect spray pattern, the new Cannon head performs very well with highly filled formulations.

The abrasion problem was a very serious one. Natural Barite extracted from mines and roughly pulverised is sold "as is" including all its natural pollutants, mainly silica-based quartz-rich sands. They are very abrasive, even if present in small percentages. It is quite understandable that pumping through a Diesel-like injector a dispersion of a lot of this earth in Polyol, at speed above 100 mps can be quite an experience - for both the injector doing the job and for that positioned in front of it in a tiny mixing chamber. This aspect was solved many years ago for the RRIM heads. The solution was found by making the injectors in hard metal alloys. The optimum very hard grade was found with several sets of trials, and the specially designed injectors (plus their seats) were made with it.
The spray nozzle - positioned at the exit of the discharge duct - seriously influenced two major processing aspects: the geometry of the "stroke" of blend projected on the mould' surface, and the industrial reliability of the process: seriously attacked by the abrasive fillers, it required a special execution in very hard alloy and a peculiar design, to provide a very flat and regular triangle of projected material.

A specific projection angle was selected as the optimum one to guarantee complete control of the spraying pattern, allowing for a correct number of "passes" on the mould and for a minimum overlapping of foam between two contiguous strokes. After thorough development, helped by the use of a laser simulator which optimised the computer-programming of the spray patterns, the best results were achieved with a overlapping width lower than 5% of the stroke's width.
The same design allowed to define a spraying distance from the surface of min. 300 - max. 800 mm, to cover the widest range of requirements dictated by the smallest and the largest moulds used for this process.
Cleaning the head after the spray operation involved a number of practical considerations, mostly linked to the repetitivity of results required by an industrial automated operation. The high material reactivity required the development of a small washing device which cleans the discharge duct and the spray nozzle with few grams of an ester-based cleaning agent, an environmentally-friendly solvent recoverable by distillation.

## INDUSTRIALISATION OF THE PROCESS

Once applied all the described developments on the lab machine, a second series of trials was organised and run using moulds of potential customers of this technology, and the results very soon proved that the development work had been successful.


The piston-dosing high pressure metering unit is usually located over the spray booth.

## A positive German industrial experience

One of the leading German manufacturers of sound deadening systems for automotive applications - a Cannon customer for more than 25 years - required a solution for a large part they had to supply to BMW.
A heavily-filled formulation, based on Polymeric Isocyanate (35 pbw), Polyol with amine-based catalysis (100 pbw) and Barite, well dried to remove water (350 pbw) was tested, to produce a large Dash Insulator containing, in the final blend, 70% of solid filler.
Seen in the pre-blending drum, the Polyol side looked like thick mud. The simple idea of spraying that mud puzzled a lot the development team. This blend was transferred to the Polyol tank using a special pump, and once there it was recirculated for a while at 85°C and processed at this high temperature, working with a pressure on the nozzle of 180 bar. The Isocyanate was processed at 35 °C and pressure of 190 bar.
The result was beyond any expectation. A perfect layer of well-mixed polymer was obtained, which allowed for the deposition of several "passes" one over the other, increasing the final part's thickness where it was needed and keeping a minimum layer there where it was just necessary a thin film, enough for handling the part safely during the extraction of the part from the bottom mould half. The lightweight mixhead produced a perfectly triangular spray pattern, with a very flat and regular section. The external border of the spray left a minimal drop-out of no more than 2-3% of material, free from any pulverisation effect. The overlapping between contiguous "strokes" was - as expected - contained below 4% of the spray width.
The measured thickness of a single layer was of one mm (+/- 10%) across the whole "stroke". The "stroke" was applied regularly, continuously and with constant speed on the curves, avoiding any effect of build-up or lack of material, typical of applications where the robot does not keep a regular speed when changing its direction.
This is an unwanted result deriving from the use of large, heavy heads with many high-pressure pipes: the new Cannon spray head deriving from this development - able to work in a output range of 80-200 g/sec - features a size which is one quarter of those used by a qualified competitor for the same task, it weighs only 4 kg and can be mounted on a small robot, the same size of device used for a simple painting task! Also the number and size of pipes is very contained, limiting the dimension of the device that must be brought over a mould for a spray operation. This is a major advantage when the job must be performed in a mould destined to perform a foam-backing task immediately after the spray operation: in this case, in fact, the upper mould half is present, and many times it is not opened at a full 90° aperture during the spray job. The use of a small head with a lighter piping allows for better entrance over the lower mould half, and for less risks of collision with the upper mould surface.
The development work was validated, and Cannon supplied a complete solution including piston-dosing high pressure metering unit, the new spray head, plus all the required ancillaries. This plant is in production in Germany since June 2008.

## A positive Italian industrial experience

Adler is an Italian car part manufacturer belonging to a family group which owns similar plants in Italy, Poland, France, Brazil, Turkey and India. They provide all sorts of interior parts to Fiat, VW-Porsche, Peugeot, Iveco, Suzuki and other vehicle manufacturers, utilizing several thermoplastic and Polyurethane technologies.
In their plant in Pisticci, strategically well positioned to supply all Fiat's plants based in southern Italy, Adler produces - among other parts - the Dash Insulator of the Grande Punto model. This large sound-deadening part (it measures 165x90 cm) rather than being made, as they do for other vehicles, by back-foaming with PUR a PVC thermoformed skin, thanks to the availability of the new Cannon SoliSpray technology has been designed as a "All PUR" product composed by a thin layer of sound absorbing compact sprayed PUR, back-foamed with low-density flexible PUR foam.
The two different processes are applied in sequence on the same production line, a carousel system dragging several mould carriers. Each of these book-opening mould carriers holds one large mould. The thin, high-density skin is sprayed directly on the surface of the lower mould, and the flexible foam layer is lately poured over the skin by a second dosing unit.
The upper part of the mould is closed over the lower part immediately after the open-mould pouring operation.
The finished two-layers Dash Insulator is demoulded after a short cure, and the cycle restarts.
The sprayed skin is composed by a two-component formulation, which contains from 50 to 65% of mineral filler over the finished product. For this application a fine powder of Calcium Carbonate is employed, in a filler-to-polyol ratio of 150/100 that can reach the 250/100 value.
Again, also in this case the major obstacle for a correct application of this formulation derives from the very high viscosity of this blend: at 25 °C the blend is a solid mass bearing a viscosity of 40,000 cps. Only by heating it up to 80 °C its viscosity reaches a more reasonable - but still problematic to process - value of 16,000 cps.


Six kg of filled PUR skin are sprayed over a naken mould: more than half of the formulation consists of a fine Calcium Carbonate powder!

Major advantages of Calcium Carbonate versus the previously described Barium Sulphate - still maintaining a very high insulation capacity - are the lack of abrasion effect over dosing machine and mixing heads, and a slightly lower specific gravity. This translates into easier process and some weight reduction of the component, bearing a higher mileage to the vehicle to whom the Dash Insulator will belong.
Adler development and production staff - new to this filled spray technology - had to learn each and every trick of the trade to reach an optimum result.
As usual, the best compromise had to be found among formulation, machine, head and mould, and the learning curve was pretty long. Cannon worked very close to the customer to adapt and optimise the process, and this co-operation worked.


The special Cannon head guarantees a precise and uniform spray pattern, for optimum distribution of the filled formulation where it is needed by the part's design.


A view of Adler's spray and foaming plant for FIAT's dash insulators near Matera, Italy.

At the end of the lesson, few basic point were made clear: the best results were obtained with an output range around 80 g/sec, an extremely precise control of the component's temperatures was a must, some time has to be invested in the beginning to define the most efficient spraying path for the robot, and the final skin should be composed - for practical reasons linked with the maximum specific weight of the final piece - by a maximum of three layers.
The fast reacting formulation, fine tuned after several sessions of industrial trials, allowed for a very quick sequence of "passes" over the mould, optimizing the cycle time and providing high productivity to the line. This high reactivity allows for the application of a uniform thickness of material also on the vertical slopes of the mould: dropping of liquid is minimized after its application over the mould' surface, guaranteeing homogeneous layers of skin in each cross section of the insulating part.


One Cannon piston machine is dispensing the heavily filled formulation, another feeds the second layer of sound absorber, a light flexible foam.

A perfect skin, whose weight is around 6 kg ( 1.8 kg/sqm for each layer of one millimetre of thickness), guarantees a nice aspect for the external side of the piece and high adhesion for the flexible foam PU formulation which is poured over it a few seconds after the skin has dried.
Says Lino Mondino, Adler's Chief of the Engineering and Innovation Department: *"It was not an easy learning, it was not as fast as we hoped, but now it is there and it works very fine. We supply extremely good parts made efficiently and this is what our customers - and we too - like mostly! This is what counts, today.»*

## THE ADDED VALUE

What did Cannon achieve from this new SoliSpray development project? Quite a lot:

- An industrial process, currently in operation in Germany with 70% of Barite and in Italy with 50 to 65% of Calcium Carbonate.
- An important saving in tooling - if the process is applied without a subsequent back-foaming operation - because it can even avoid the use of mould carriers and cuts to less than half the investment in moulds. The larger the part, the more convenient the process results.
- A high-quality finished part characterised by uniform thickness and constant distribution of solids within the polymer, and by a very high differential between thick and thin parts, not obtainable with a moulding process.
- A system usable for both a mass production of standard cars and for small series of large parts for trucks, buses and special vehicles. All with the same equipment.

The development continues, and interesting developments are in the "boiler room" at the moment. Have a complex spray project in mind? Talk to Cannon: They Know How!
(www.cannon.com)


A 100% PUR part, this dash insulator for the FIAT Grande Punto model.