Refrigerator cabinet sealing – A robotized solution

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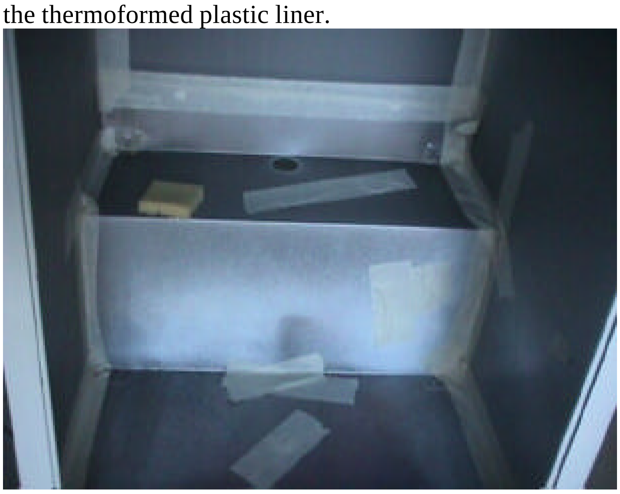
Abstract

In the production line of domestic refrigerators the accurate sealing of the cabinet before the injection of the PU foam is a necessary operation to avoid material leakage during the cabinet's filling. This cabinet' sealing operation is still completely manual and presents significant disadvantages, such as high labour requirements and non-ergonomic operations.
Cannon describes in this paper the recent experiences made in their Italian R&D labs for the sealing of cabinets with a poured-in-place PU system.
The use of a flexible system minimises the volume occupied by this non-insulating PU: during its expansion the rigid insulation foam will compress this open-cell sealing material. The use of a robot replaces all manual operations with an automatic process.

Cabinet sealing, still a must

A modern domestic refrigerator is a mass product characterised by a fierce price competition: this reflects in a continuous research for cost-cutting improvements, aimed at reducing the price tag without losing quality and functionality. Therefore we have seen in the last decade important projects for re-engineering the refrigerator's assembly method and for simplifying its part's list. Among the manufacturing tasks that influence the industrial costing of refrigerators and freezers, one stands out for its peculiar high cost of labour and low cost of raw material: the sealing of the cabinet's outer shell in order to avoid leaks of Polyurethane during the foam's expansion phase. This operation takes place in the cabinet's assembly line, after that all the electric wires and the coolant's pipes have been positioned with adhesive tape on the metal mantel and before inserting the thermoformed plastic liner.



Picture 1: The conventional sealing of a refrigerator cabinet, before the introduction of the rigid Polyurethane foam, is usually made with adhesive paper-tape.

The operator must bend into the cabinet and manually stick paper tape in all those places where – due to the interrupted surface of the metal and tiny holes in the corners of the structure – foam could escape during expansion and polymerisation. *(Picture 1)*

If properly executed, this repetitive operation saves a lot of scrap, a lot of finishing manual work, potential big damages to the foaming stations in case of major leak, but requires a lot of attention, some tape, sometimes the application of small patches of low-density flexible foam (to allow for the escape of air but to stop the foam), and a lot of non-ergonomically acceptable work.

Looking for a solution

Cannon have made in the recent years a number of very positive developments and industrial experiences in the area of specialistic gasketing applications. Polyurethane foams and dispensing technologies of various nature are available today for direct application on metal and plastic surfaces, to produce a continuous gasket or seal: practical examples include the production of lids and doors for electric control cabinets, application of a seamless seal in a lighting fixture for fluorescent tubes, direct gasketing of drum lids, etc. *(Picture 2)*

Cannon R&D labs have thought, and made, a system to apply a continuous seal of flexible Polyurethane foam into the cabinet prior to the insertion of the plastic liner. The benefits deriving from this system mainly involve the savings in manpower, the low cost of the Polyurethane formulation and the repetitive sealing result, deriving from a robotized task.

Picture 2: Typical Polyurethane seals made pouring a flexible formulation over flat or grooved metal and plastics surfaces

The foam required to fulfil this task would have to react very quickly, in order to stick also on vertical parts of the pouring path and to allow for immediate handling of the areas surrounding the seals. A low-density foam able to form promptly a thin skin on its surface – as spray foams do – would fit the picture.

The dispensing system could derive from that used for the above mentioned sealing applications, for which Cannon have designed low-pressure metering and mixing equipment able to work at output as low as 0.5 g/sec. Due to the slightly higher output allowed in this technology – where typical acceptable output would be in the area of 10 to 30 g/sec – a self-cleaning impingement mixing head could be used, fed with two-component formulation dosed at a medium-high range of pressures.

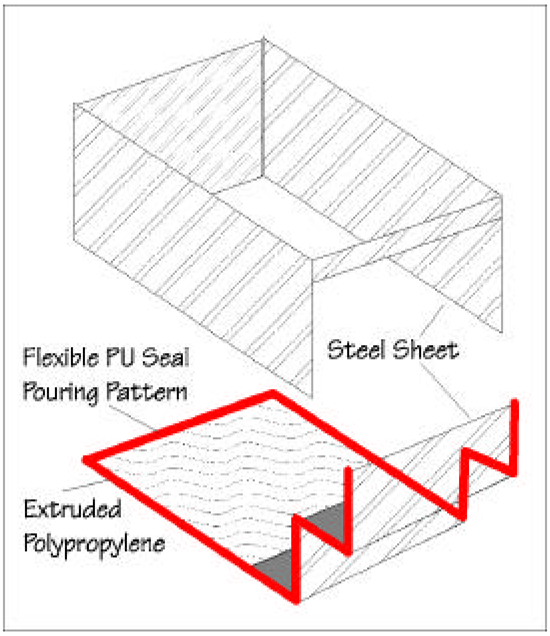
The joint interest of an important manufacturer of refrigerators, a major supplier of Polyurethanes as Dow Europe, and Cannon made the evaluation phase of this project a real quick achievement.

Trials were organised in Cannon central R&D labs north of Milano, in Italy, using metal cabinets taken from the customer's assembly line prior to the application of the conventional seal of paper.
These cabinets - a standard single-door model - are characterised by the combination of a metal sheet (constituting the sides, top, bottom and compressor faces) with a flat extruded sheet of hollow Polypropylene (used for the rear side of the cabinet). *(Picture 3)*

This assembled structure is particularly prone to leakage, due to dimensional irregularities that could exist between the two different materials.

Dow Italia TS&D supplied a two component formulation based on VORALUX® HK 440 Polyol and SPECFLEX® NS 540 Isocyanate, an all-MDI based product characterised by very fast reaction profile and low density *(see Table 1)*, developed for sealing applications with spray foam machines.

Cannon set up a two-component medium-pressure dosing unit able to work in the output range required by this task (around 10-30 g/sec) at a mixing pressure of 100 bar.



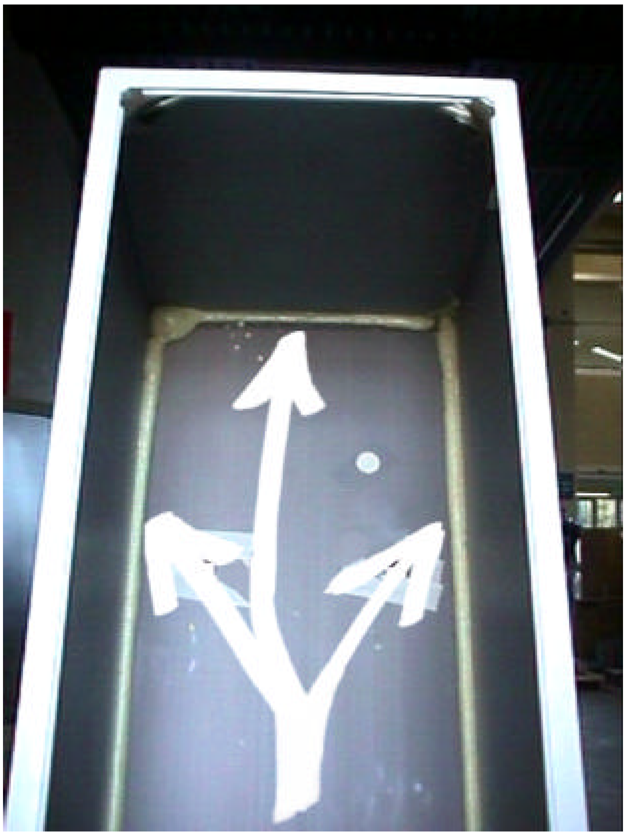
Picture 3: layout of a standard refrigerator cabinet in bent metal sheet, with the rear wall made with an extruded Polypropylene sheet

A small mixing head was fitted on this machine, the Cannon LN5, *(Picture 4)* whose compact design allows for the use of small and economic robots required by this industrial environment.

Picture 4: The Cannon LN5 mixing head used for this low-output medium-pressure injection

Table 1 - Reaction Characteristics of VORALUX® HK 440 Polyol and SPECFLEX® NS 540 Isocyanate

Reaction Characteristics	Unit	High Pressure Machine
Cream Time	Seconds	1-2
Gel Time	Seconds	3-5
Tack-free time	Seconds	2-3
Free rise density	Kg/m^3	30-40
Metering Ratio Pol/Iso	Pbw	155/100
At 30°/50° Iso/Pol component temperature	*® Trademark of The Dow Chemical Company*	



Picture 5: The flexible Polyurethane seal applied to the linear segments of the sealing pattern

Trials were set for manual application of the foam, holding the light pouring head with one hand. It would not be a problem to extrapolate the results of this trial to the use of a robot for this operation. The total length of pouring was 4 meters in a 7-step path along three sides of the cabinet.
Working at output, temperatures and pressures indicated in *Table 2*, a very good application of a continuous profile of flexible, self-skinning low-density foam was obtained. The linear tracts of the pouring pattern were characterised by very homogeneous section and aspect. *(Picture 5)*
In the corners and in the vertical sides, where the manual dispensing speed had been different, a small difference in deposited material was noticed. *(Picture 6)*

Picture 6: The flexible seal applied to the inner corners of the cabinet

By experience, this was clearly not a problem to be solved, since robotised foaming applications are programmed to work at constant speed exactly to prevent the problem of over- or under-distribution of material on non-linear paths. With a properly programmed pouring path the industrial cycle time for sealing one cabinet can be as low as 40 sec.
The applied foam has a very soft touch, and shows a free-rise density of 40 g/lt: this reflects in a very good compressibility, so that when - a few minutes later - the cabinet will be filled with rigid foam, this will compress the open-cell flexible seal and reduce its volume down to a negligible thickness, not influencing the thermal efficiency of the insulation material. *(Picture 7, below)*

Table 2 - Processing Conditions during Trials

		Test A		Test B		Test C	
Machine Settings	Unit	POL	ISO	POL	ISO	POL	ISO
Material Temperature	°C	50	25	50	25	50	25
Output	gr/sec	5	3	12.2	7.8	15.2	9.8
Viscosity	Cps	600	50	600	50	600	50
Mixing Pressure	Bar	75	60	70	70	100	90
Type of Flow		Laminar		Laminar		Laminar	

Applications

After the lab trials the system has been engineered for an industrial application. Considering the environment where it is destined to work (the assembly line) it has been optimised, reducing dimensions and noise to the minimum, and cutting all unnecessary components so that a budget indication for a system composed by dosing unit and robot is around 100,000 Euro (120,000US$).
Applications for this technology include all types of domestic and commercial refrigerators.

Obviously for mass production the pouring can be robotized, while for large models produced in small series or discontinuously (commercial refrigerators and freezers, refrigerated displays for desserts and ice-cream parlours, etc.) the sealing operation can be performed distributing the foam manually, with the light head mounted on a simple extension that avoids non-ergonomic positions.

Conclusions

By listening to specific customer requirement, making use of technological experiences acquired in similar fields and co-operating with leading suppliers of raw materials Cannon have been able to develop in the past 35 years a number of fundamental innovations in the field of Polyurethane processing.
The technology described in this short paper will not change the way Polyurethanes are made, but brings another small, significant contribution towards the industrialization of a field that, in spite of a (sometimes) labor-intensive process still acknowledges a steady growth rate of 3-5% per year.

Biography

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.