Industrial developments in co-injection/long fibre technology

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ABSTRACT

Cannon recently introduced the InterWet technology to provide an efficient method for the co-injection of Polyurethane foam and glass fibres or fillers. The potential end-users of this technology are all those manufacturers looking to make large, thin, sturdy composite parts, using all the advantages of Polyurethane. InterWet is now industrially utilised at a number of leading producers of composite parts for the transportation industry.

EARLY INNOVATION

How and why Cannon developed their own Polyurethane/long-fibre co-injection technology is now a well-known story. The market's demand for the improvement of an existing technology launched in 1995 caught Cannon's interest and in mid 1997 a development project was launched. The modification of an FPL* head allowed for a design where the reinforcing fibre (or inert fillers) can be thoroughly wetted, all inside the mixing head, generating a very homogeneous blend with a compact production tool.

The results of this preliminary work were shown at the Polyurethane World Congress 1997 in Amsterdam.

The later addition of a pneumatic device significantly improved the distribution of the blend in open moulds, with great advantages in terms of surface aspect and speed of operation. A paper presented at 1998's SPI Polyurethane Expo in Dallas, Texas summarised this early innovation and presented all its advantages. Since then the system has been commercially promoted, the first industrial plants have been ordered and installed and are now in full production. The technology is in continuous evolution, and the research for more innovation has never stopped. *(Picture 1)* In order to promote its use and minimise the potential obstacles, Cannon have co-operated with the chemical supplier who - from the beginning - has invested most resources into the co-injection technology, supplying two InterWet machines into Huntsman Polyurethanes R&D Centres in Belgium and USA.

Picture 1 - Cannon's InterWet R&D facilities are available in Italy and in the USA

Out of this co-operation, some interesting projects have seen the light, and we detail these in the following paragraphs.

RECENT DEVELOPMENTS

The latest main developments concern:

- the handling of glass and fillers
- the flexibility of use
- the safety of the process.

One of the main needs for an industrial production was to guarantee the smooth flow of glass roving from the stock to the head. Supplied in rolls, the glass roving has to travel from the storage area, a carton box sitting on a pallet, to the head, mounted on the dispensing robot. The quantities of glass used in industrial production require a fully-automated method for feeding the machine. The glass industry supplies the rolls of roving in boxes where the end of one roll is spliced (connected) to the beginning of the next one: by simply pulling the thread, one would therefore be sure that the head is continuously fed with roving, till the box is empty. In real life this operation is sometimes difficult, due to the shape and disposition of the various spires of the roving in each roll, and the possibility of blocking the flow of roving - with the resultant production of a scrap part - is high if the feeding system is not adequate.

Storage and feed

Cannon have industrialised a storage and feeding system, whose typical configuration consists of a storage area for two or three boxes holding 1000 kg of glass roving each. The flow of roving, driven by compressed air, is eased along the whole path from storage to head, in a combination of rigid and flexible piping with properly designed bends and connections. Each feed line is independent, and several safety checks - electro-optic probes sending pulses to the central PLC - have been introduced into it, so that any malfunction in this area immediately stops the process rather than producing scrap parts. *(Picture 2)*

Picture 2 - Feeding the reinforcements from the storage to the mixing head requires a careful design of all the moving parts involved, to avoid any blockage.

Alarms detection

Specifically, one sensor checks the presence of glass at the entrance to the rigid piping, another checks the glass at the entrance to the chopper, and a third counts the “packets” of chopped glass in the head, just before the mixing chamber.

The logic control of the pulses sent to the PLC is related to the current set output of glass and current number of active blades: should a lower-than-expected number of “packets” be counted in a unit of time, this would mean that one or more blades are not working. If the first probe reports regular flow of roving through the feeding line, the chopper is reported to be operating and the last probe counts no “packets” in transit through the head, this means that the glass is blocked just outside the head. In this case the so-called “birds nest” alarm is set off, and the production is stopped immediately.

Chopper

The chopper - the motorised device breaking the glass roving - has been significantly improved to fulfil the requirements of high-output industrial production.

Picture 3 - The new InterWet head features a wider glass-chopper with higher output and longer life

A new hydraulically-driven rotating blade-holder has been designed, with a diameter of 48 mm, and 12 independent blades. *(Picture 3)* Compared with the first models this chopper has a larger diameter, three times more blades and rotates at a lower number of revolutions per minute, allowing for higher glass output and reduced wear.

Special attention has been paid to the design of the rotating blade-holder: it contains a PLC-driven pneumatic controller that can operate the single blades “on-the-fly”, allowing for instantaneous change of roving length where and when required by the geometry of the moulded part. Having more blades than before, it gives a wider choice in selecting the optimum length of glass for a given part or area.

Mixing Head

Little work had to be done in the mixing head: the wetting performances were good already. Some work was done to enhance the wear-and-tear resistance of those parts in contact with the glass roving.

New development is taking place in the higher range of output, to improve the wetting effect when dispensing more than 30% of glass on total weight. This output is required by new heavy-duty applications being investigated for the production of large parts for the transportation industry, where size of the parts and productivity requirements - combined with the demand for high mechanical performance - forces the use of fast reacting foams at high output.

Pneumatic distributor

One of the major advantages of InterWet is the superior quality of the laydown of the blend, achieved with a pneumatic device installed on the mixing head. This distributor has been further improved in terms of durability, lasting for some millions of shots before requiring maintenance or replacement. *(Picture 4)*

Picture 4 - The pneumatic device provides very high-quality laydown of the blend

INDUSTRIAL APPLICATIONS

The technology is of particular interest to customers currently using the structural reaction injection moulding (SRIM) process, which can be expensive, messy and labour intensive. It is possible to switch SRIM tools to InterWet/thermoplastic production and benefit from the lower manufacturing costs and improved component quality.

This advanced Polyurethane reinforcement technique improves the technical characteristics and the external aesthetics of a reinforced component. Greater glass content is achievable and there is the opportunity to vary glass loading within the same part by weight and by size to accommodate different applied loadings. The finished component benefits from low longitudinal expansion, high thermal stability and weight savings with strength.

The process also provides design flexibility allowing the integration of ribs and integral fixings.

Since its debut the InterWet technology has been recognised by industrial users as an attractive method for producing large, high-modulus thin parts in composite Polyurethane, moulded alone or in combination with a thermoformed part.

Four plants are in production in France, where a major supplier to the automotive industry produces, on a three-shift basis with two of them, large interior parts for French vehicles. *(Picture 5)*

Picture 5 - Several industrial plants are in operation in Europe, producing components for the automotive industry

One plant is operating in Italy for production of structural reinforcements for the exterior body parts of earth-moving equipment.

One plant has been supplied to Brazil, also for production of large interior parts for the transportation industry.

An interesting development has been generated in the USA, where a major automotive producer will use a large body part made in SRIM: the huge glass preform is made with four glass feeding/cutting machines that were developed for the InterWet technology. Three more units are currently being manufactured and will be operative in the second half of this year.

Thompson Plastics Group, UK

One of the most interesting applications has been generated in the UK, where the Thompson Plastics Group, which specialises in advanced thermoforming technology, has installed one InterWet unit within its Vehicle Industry Division, which is located in Hull.

The division provides engineering solutions in thermoplastics to manufacturers of off-road, agricultural and industrial vehicles and to the specialist automotive and the public transport sectors.

Interested in the new technology for producing their more rigid parts, Thompson Plastics approached ESU Cannon, the Group's supplier of Polyurethane moulding equipment in the UK and EIRE.

Trials were organised in Cannon's central laboratories with an evaluation mould, and gave very positive results.

An order was placed for a complete production unit, supplied in part from Italy – the metering machine and the InterWet kit – and partly by ESU. One book-opening press with 150 tons of clamping force was built in the UK in line with Thompson Plastics' requirements, and a commercial robot with 100 kg carrying capacity was integrated with the glass feeding lines and interfaced with the main control. *(Picture 6)*

The system was commissioned in January 2000 following several months of development activity, and today already boasts a number of component developments exploiting the reinforcement technology. Additional InterWet equipment is foreseen to meet production requirements by the third quarter of the year 2000.

Thompson Plastics has applied the technique to the reinforcement of components formed with a PMMA/ABS or PMMA/ASA-PC for exterior and UEV (unsupported expanded vinyl) for interior applications. Coupled with the utilisation of foamed in-place inserts and fixing, the opportunities for an engineered "b" surface have been fundamental to the success of the process.

Picture 6 - The first InterWet plant of Thompson Plastics, UK, manufacturing parts for the transportation industry.

The company currently uses thermoplastics for many interior trim components. Now, by applying InterWet PU reinforcement they are able to offer parts with improved anti-squeak, vibration control and noise absorption performance.

The ability to produce rigidly supported soft touch materials is also of interest as a means of enhancing internal styling. *(Picture 7)*

The InterWet PU reinforcement provides structural rigidity, load bearing strength, high impact resistance, thermal insulation and abrasion, solvent and oil resistance - all key considerations in the design and manufacture of exterior components. *(Picture 8)*

These strengths will all be coupled with the well-acknowledged advantages of using a thermoplastic skin: UV resistance, surface gloss, scratch resistance and chemical resistance.

The process can be used alone to produce composite mats for non-visual components. Headliners are also likely to be a major opportunity as, coupled with fabrics rather than thermoplastics, the PU reinforcement material will provide a good quality part at a relatively low cost.

Already producing vacuum, pressure and twin sheet formed exterior, non-visual and interior components for its vehicle industry customers, Thompson Plastics sees opportunities for applying the new technology to the production of both exterior body panels, including engine panels, access covers and roofs and interior parts, including door panels, parcel shelves, headliners, dashboards and fascias. *(Picture 9)*

Picture 7 - The ability to produce rigidly supported soft touch materials enhances the internal styling.

Picture 8 - The InterWet reinforcement provides structural rigidity, load bearing strength, high impact resistance, thermal insulation and abrasion, solvent and oil resistance.

FURTHER DEVELOPMENTS

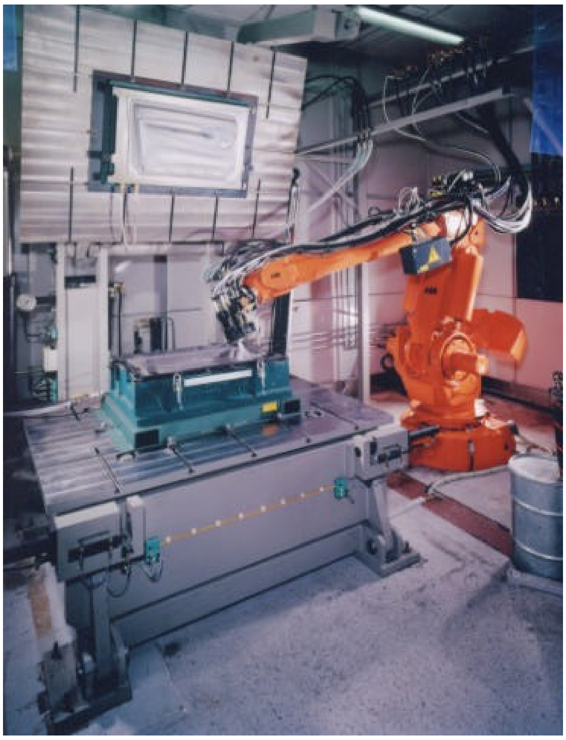
New Applications

Several projects for automotive and non-automotive applications are currently in various stages of development – all strictly bound by confidentiality agreements that do not allow any further form of communication in this paper.

Fillers

InterWet is a co-injection system able to use both glass and other reinforcing fibres or fillers. Most of the development has focused until now on the use of glass roving, since this is what the market demands at the moment.

The use of inert fillers such as sand, barite, heavy-weight fillers, wood-flour and foams has been further investigated in Cannon R&D laboratories. Particularly interesting is the use of reground Polyurethane, derived from scrapped domestic refrigerators, shredded seats and insonorisation mats, investigated on behalf of several customers.



Picture 9 - The new technology is suitable for the production of both exterior body panels and interior parts for the transportation industry.

Proper feeding and dosing equipment is the key-point for an industrial use of these bulky, irregularly sized fillers. A general-purpose device, able to feed various types of filler with good reliability, has been designed and tested successfully. Cannon intends to investigate these applications together with the interested parties, and welcomes any constructive project proposal for co-operation.

CONCLUSIONS

The first industrial experiences of InterWet with glass roving confirm that technical consolidation and industrial reliability have been achieved in a relatively short time, when compared with the state of the art of the competition. Commercially speaking the project is only at the beginning of a potentially enormous development. Both fibres and fillers present such a variety of sources and applications that it would be pointless to list here the expected goals of this development. Cannon have opened up their two development laboratories– in Italy and in the USA, both equipped with complete InterWet machines - to interested parties for the evaluation of constructive projects. As usual, only the constructive co-operation between end users, suppliers of chemical raw materials and equipment manufacturer will bring forward the most successful solutions.

BIOGRAPHIES

Max Taverna

Max was born in Buenos Aires, Argentina, in 1949 and has an education background in Industrial Chemistry. He worked five years for Upjohn's Polyurethanes Division in Italy and joined Cannon Afros as the European Sales Manager in 1982. Since 1986, he has co-ordinated the Group’s communications activities and currently serves as the Director of Communications.

Alberto Zarantonello

Alberto was born in Gallarate, Italy, in 1959 and holds a Degree in Chemical Engineering from the Politecnico di Milano.

He joined Cannon in 1986 and worked for eight years in Cannon Tecnos, the Group's Automotive Division. Since 1994 is Sales and Marketing manager of Cannon Afros, the "Wet" systems Division.

* *FPL = Cannon Patents*