Cannon JL – A New Approach To High-Pressure Mixing In Polyurethane Technology

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ABSTRACT

The Cannon JL is a new family of high pressure L-shaped mixheads. The acronym JL stands for “Jet Less” identifying that mixing of the two reactive liquids is not obtained by injectors. The high turbulence - formed and maintained in a relatively narrow mixing chamber where the two component streams are delivered – does the trick. The liquid components are metered in a common chamber and then flow to the mixing chamber through variable restrictions where they acquire the necessary energy for efficient mixing. At the end of the mixing chamber an L-shaped geometry transitions the flow into a much larger delivery chamber, decreases its turbulence and permits the delivery of the mixed blend with a very laminar flow. (Figure 1)

PRELIMINARY CONSIDERATIONS

Three decades of direct experiences in high pressure mixing has taught Cannon that the reduction in diameter of the mixing chamber is important in improving and maintaining turbulence and ensuring a very high mixing efficiency. Yet, it is also known that small diameters of the mixing chamber do not maintain turbulent flows due to the high rate of dampening of turbulence caused by the effect of the viscosity - the turbulence of a liquid flowing into a small diameter bore decreases proportionally to the distance from the axis of the chamber, to reach a quasi-laminar flow on its periphery.

Therefore, assuming that the objective of our research was “to bypass the threshold imposed by the physical dimensions of the classical injectors and obtain a mixing chamber small enough to overcome the dampening effect of the laminar shear”, ultimately the most effective answer and easiest way proved to be - “Get rid of the injectors and find a different smart way to originate turbulence”.

The geometry of the head had to be chosen to properly adapt the mixing efficiency to the flow rate while also having the possibility to set the system to a variety of flow rates and ratios.

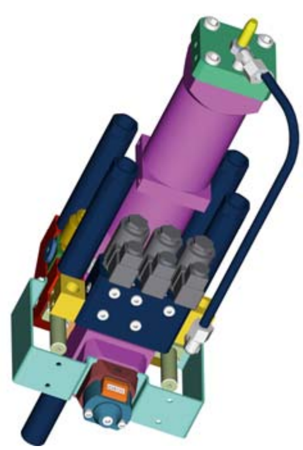


FIGURE 1: JL Jetless Mixing Head Model JL-24

SOME BACKGROUND ON MIXING EFFICIENCY

The mixing of at least two fluids is normally performed through turbulence. There are many ways to create or maintain turbulence and all of them have a different way to maintain a high level of energy dissipation throughout shear into the fluid.

The most well-known ways are:

- Static mixers
- Dynamic mixers
- High speed of the streams and jets,
- Impingement of jets and streams

The well-known problem of static and dynamic mixers is the need to clean them by flushing with an appropriate solvent. The other two ways involving jets and steams can be performed using a proper mixing chamber and a piston that cleans the mixing chamber and controls the transients at the start and the end of pouring.

A NEW APPROACH

Now imagine decreasing the size of the mixing chamber sufficiently to generate a stream flow speed of ten meters per second, and to use the front shape of the cylindrical piston which seals the mixing chamber, to create high shear restrictions. The result is the Jet Less head - a mixhead where its L-shape geometry permits the usual reduction in turbulence of the flow exiting from the mixing chamber and to pour it in laminar form. In the JL, the mixing is performed by the combination of two co-axial chambers. In a first annular chamber the two (or more) reactive liquids are delivered simultaneously by proper metering devices. A large piston with a V-shaped front occupies the annular mixing chamber. Grooves carved on the piston surface provide the re-circulation of the liquid components back to the tanks when the head is not operating. By hydraulically driving the piston backwards, we create the annular mixing chamber - a hollow cylinder with V-shaped top and bottom faces. The components flow into the chamber at the same pressure. The size of the V-shaped common chamber and of the related piston can be set as desired. What is important is the size of the cylindrical mixing chamber, which has the same center line of the piston and of the related cleaning pin. This pin has a cylindrical shape and freely slides along the central line of the mentioned piston. The pin front, combined with the V-shaped faces, forms two twin restrictions. The components flow through these restrictions and reach the mixing chamber in twin streams, where they mix at high velocity. The sharp-edged shape and the component's pressure create and improve the mixing turbulence, which is additive and maintained along the mixing chamber. The central pin is hydraulically controlled backward to perform the mixing and forward to clean the mixing chamber at the end of the injection. (FIGURES 2-5)

The front position of the pin can be set manually, using an adjustment knob featuring a very fine pitched screw, to properly define the restrictions and adapt them to the flow rate required to create and maintain the pressure in the V-shaped chamber.

When the piston is closed against the corresponding V-shaped faces, the mixed blend is squeezed out from the chamber; cleaning it perfectly.

In this new head:

- The V-shaped chamber is sufficiently long to permit recirculation and delivery.
- The mixing chamber has the appropriate length to mix with efficiency.
- It ends into a much wider and longer delivery chamber directed 90° downward.

With this solution, the mixing chamber can be as small as necessary and desirable since the twin restrictions create a very efficient and homogeneous turbulence.

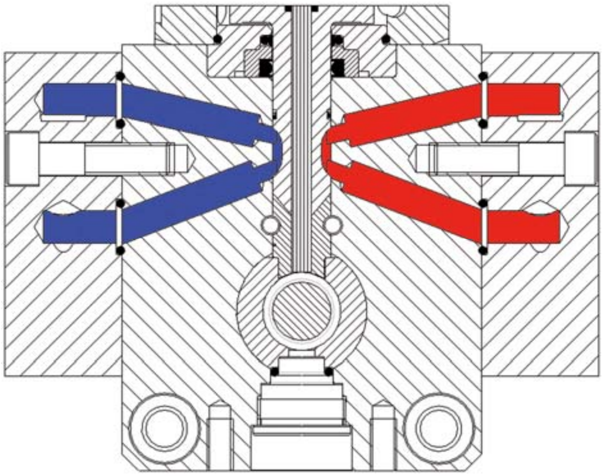


FIGURE 2: High Pressure Recircualtion Through Mixhead

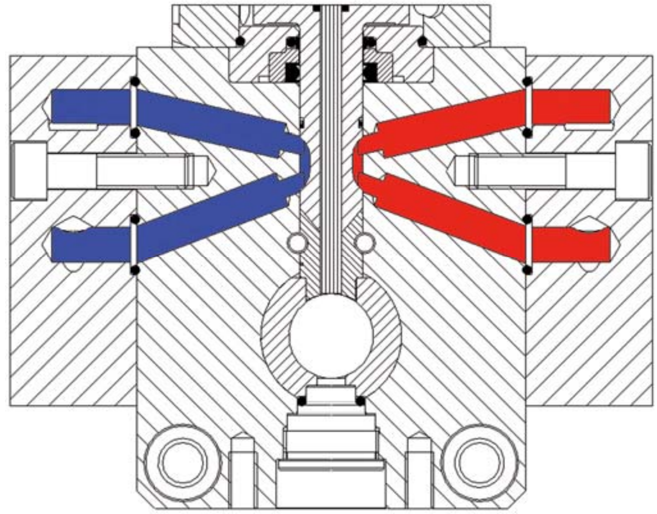


FIGURE 3: Discharge Piston Open

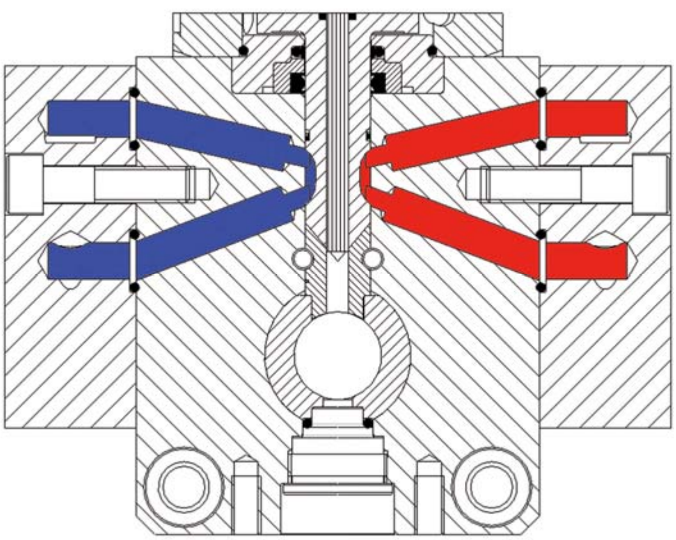


FIGURE 4: Pin Retracting

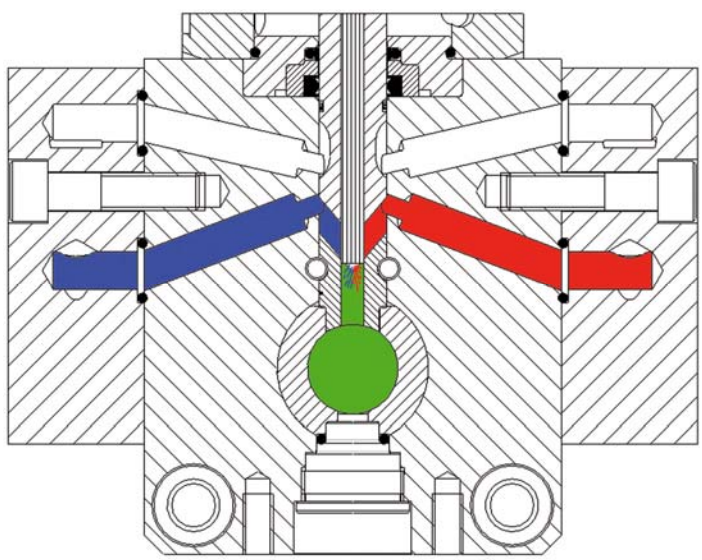


FIGURE 5: Mixhead Pouring

LONG NOSE… BUT RELIABLE!

The JL features a long and wide discharge duct, where the main purpose is to dramatically decrease the high speed and turbulence of the stream, to perform a final mixing, and to smooth down the whirling of the stream. As the stream exits the head, it becomes laminar and can flow out into the mold with the ideal behaviour desirable. The mixheads' length enables it to reach very deep injection points not possible by other designs.

The discharge duct and the self-cleaning rod have specific features:

- The duct is formed by a long bushing that can be easily replaced with other models which have different lengths and diameters.
- The self-cleaning rod has a dual diameter. A larger front, where the diameter precisely matches the duct to strip the residual film of foam from it during its cleaning stroke, and a rear section with a reduced diameter connected with the control piston.

The up and down movement of the rod - for opening and closing the duct - removes and pushes out the residual foam remaining in the pouring chamber, while stripping out the reacted film from the walls. In the meantime, the rod is acting like a pump for flushing and recirculating a small quantity of lubricant oil that is contained in a small spacer chamber built behind it. This system is connected to a lubrication circuit provided with a filter for the regular cleaning of the oil at each cycle of the rod (Figure 6).

The relatively small sliding surface of the rod prevents the sticking of the surfaces and permits the use of a slim cylinder enabling the reduction in size and weight of the mixhead and improving ergonomics when handled for manual operations.

The three hydraulically-driven movements are controlled by three valves which are mounted directly on the mixhead (Figure 7). This allows for replacement of standard mixheads with the JL without modifications of the control system. The mixing system, the mixhead itself, and the cleaning system are patented.

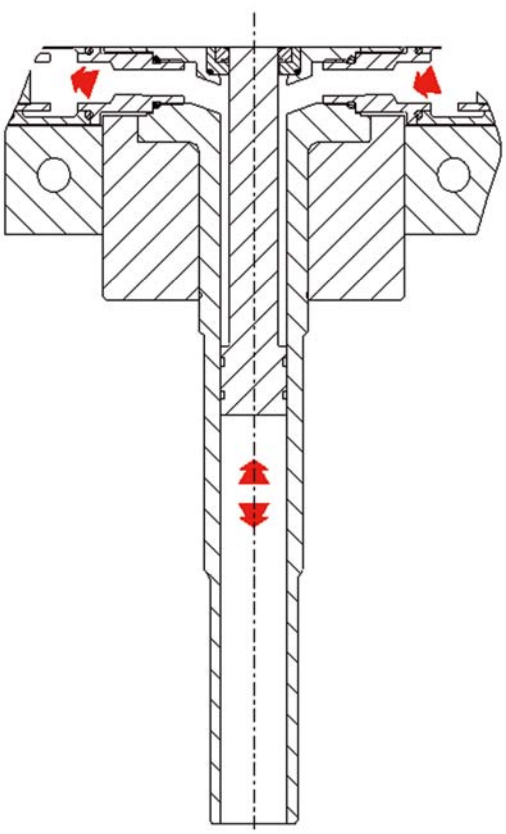


FIGURE 6: Mixhead Lubrication

FIGURE 7: Rear view of Mixhead Showing Hydraulic Valves

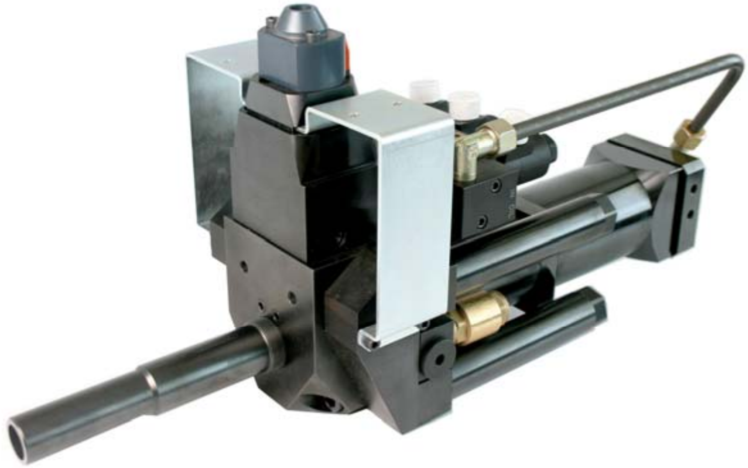


FIGURE 8: View of Long Nozzle

FIGURE 9: JL 24/6

CANNON JL 24 / 6 LONG STROKE

The first Cannon JL head available on the market is the model JL 24/6, featuring a 200 mm long discharge duct with an internal diameter of 24 mm, and a mixing chamber diameter of 6 mm (Figure 8). This head has a total output range from 300 to 2000 cc/sec and is initially prepared for two components, although more streams can be easily added. The most interesting operating feature is its working pressure that ranges from 70 to 210 bar. This lower operating pressure allows for a simplification of the dosing unit (pump type, filters, hoses, etc.). The thin diameter of the piston connected to the cleaning rod guarantees high closing speed and absence of friction problems.

These heads have been industrially tested with rigid and flexible foam for more than one year and with frequent shots (up to 60,000 in one month) and with full technical competency and customer satisfaction (Figure 9).

THE ADVANTAGES

The new Cannon JL head delivers several advantages:

- a mixing method that is significantly more efficient than traditional impingement. The higher efficiency has been computer analyzed and simulated, as well as confirmed by field tests
- the mixing pressure can be reduced to 70-80 bar depending on the chemicals. This allows for the simplification of the entire metering circuit (pump, filters, hoses etc)
- a wider range of flow rates can be handled by the same mixing chamber. The maximum output can be five times higher than the minimum
- it does not require skilled operators to set the head's injection conditions. An easy setting of the central needle accommodates a variety of flow rates and pre-positioning of different flow values can be accomplished manually or in automatic mode, with a very simple operation.
- a very long discharge duct (patented) can enter pouring holes which are normally very difficult to access, and guarantees a laminar discharge flow even at high flow rates. This is immediately applicable for discontinuous insulation panels and for pipe-in-pipe insulation (just to mention two examples of industrial applications which are very popular today).

- the use of the thin and long cleaning rod is greatly appreciated when using very sticky and adhesive formulations
- the internal geometry allows for a better handling of foams expanded with high-frothing blowing agents such as HFC or liquid CO2

Possible drawbacks?

- a mixhead with three movements has more mechanical and hydraulic components,
- the lubricant's flushing system is part of the mixhead. although it is easy to remove and replace with a reasonably longer spacer.
- At the moment the common chamber's pressure has to be set manually., but we can easily implement a well proven automatic setting system as needed

ACKNOWLEDGMENTS

The success in designing the JL originated from the skills and knowledge of the involved people, followed by a deep study of the turbulence phenomena and the possibility to simulate these parameters and calculate their efficiency using a sophisticated fluid-dynamics computerized program.

The shape and design originated from a simplistic, innovative idea and was improved by a team of engineers to create a compact size and perfection of the mechanical solution using simulation of the performances. Another team of engineers performed the tests and the development of the different devices that lead to the present shape and design.

CONCLUSIONS

With the new JL series, Cannon has again introduced new concepts in the art of mixing Polyurethanes. This is not a simple evolution of existing models or the scaling up or down of existing sizes, but true innovation, which was hatched from theoretical study and advanced research.

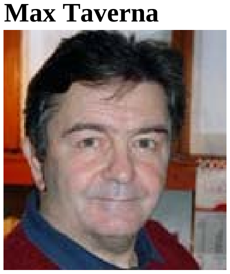
In addition to the mixheads mentioned, new sizes and models are now being prepared for future applications.

BIOGRAPHIES

Maurizio Corti

Born 1954, Maurizio is the Technical Director of Afros SpA, the Cannon Group's Company manufacturing Polyurethane metering and mixing equipment. Maurizio graduated in Mechanical Engineering from the Politecnico di Milano University in 1980, with a work on the theory of control systems, which constitutes the basis of this paper.

Max Taverna



Max was born in Buenos Aires, Argentina, in 1949 and has an education background in Industrial Chemistry. He worked 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 Corporate Director of Communications.