Using partitions technique to enhance spray atomisation

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Abstract
There is a moral commitment towards industrial countries to focus their efforts to reduce gas emission in the atmosphere. This paper describes experiments that have been carried out to explore the effects of partition (various shapes) on the spray quality causing breaks on droplets, the paper is related to a patent WO2007015062 (A1), (1, 2, 3 and 4) partitions has played a great role in having new designs working well with reduced VOC's products, none viscous products such as air fresheners, body spray and hair sprays, viscous products such as oil and polish also worked remarkably well with compress air products. The partitions create more turbulence and break up, consequently produces fine droplet.

Introduction

The present invention relates to an atomising nozzle more particularly, but not exclusively, the present invention relates to an atomising nozzle for an aerosol canister and an aerosol canister comprising such an atomising nozzle.

Nozzles are often used to provide a means of generating sprays of various fluids. In particular, nozzles are commonly fitted to the outlet valves of pressurised fluid-fitted containers, such as so called "aerosol canisters" to provide means by which the fluids stored in to container can be dispensed in the form of a spray or mist. A large number of commercial products are presented to consumers in this form, including, for example, antiperspirant sprays, de-odorant sprays, perfumes, air fresheners, antiseptics, paints, insecticides, polish, hair care products, pharmaceuticals, water and lubricants.

In addition, pump or trigger-actuated nozzle arrangements, i.e. arrangements where the release of fluid from a non-pressurised container is actuated by the operation of a manually operable pump or trigger that an integral part of the arrangement, are also frequently used to generate a spray or mist of certain fluid products. Examples of products that are typically dispensed using a pump or trigger nozzle device include various lotions, insecticides, as well as various garden and household sprays. Nozzles are also used in any industrial applications to deliver a fluids or mixture of fluids in the form of a spray.

It has been found that droplet size produced at the outlet orifice of a nozzle can be controlled by incorporating a number of different control features into the fluids flow passageway between the inlet and the outlet which modify the characteristics of the fluid as it flows through the passageway for example it has been found to be particularly beneficial to form two or more expansion chambers along the fluids passageway, each chamber having a constricted inlet opening arranged so that the fluids is sprayed into the chamber.

This is a new innovation which has been developed and tested to enhance the quality of spray of aerosol products with very low volatile organic compound (VOC). The partitions have been used in the chamber where the flow passage of the design actuator .partitions can takes different shapes. The key design of these shapes is made to obstruct the flow in the centre of the flow.

The partitions can be positioned within the chamber to provide internal wall surfaces towards which the fluid may be directed. The outlet of the partitions may direct fluid exiting the chamber into a continuation of the passageway, and the chamber may be disposed next to the outlet and the outlet orifices of the expansion chamber may constitute outlet orifices of the nozzle.

As can be shown below in Figure 1 illustration of moulding cap with partition in Raj's diamond shaped chamber.

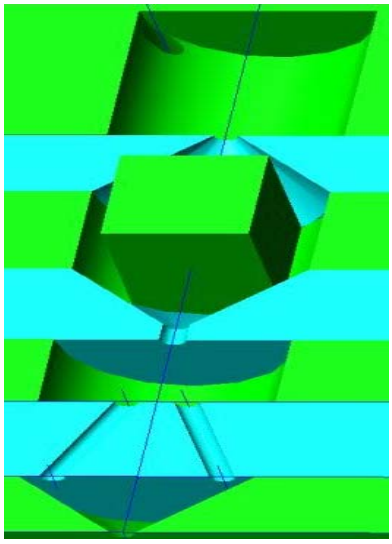

Figure 1: illustration of moulding cap with partition in Raj's diamond shaped chamber.

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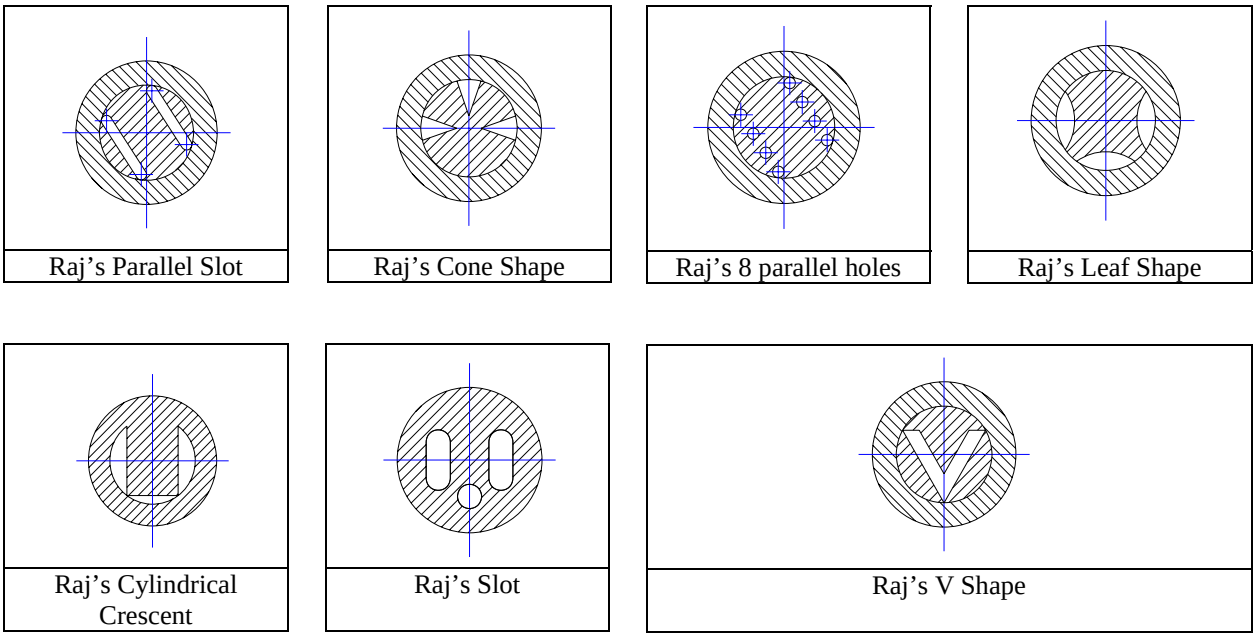


Figure 2: list of Raj's partitions and shapes

Apparatus methodology and procedure

Droplet sizing using a laser diffraction instrument (Malvern and Spray Tec.), an average of three tests had been taken for each data , flow rate was measured by weighing the can, normally average reading will be taken for three readings, the spray time at the average of five seconds. Because consistency of spraying throughout can life is important, droplet sizes and flow rate are measured for full cans, and, typically, for 75%, 50%, and 25% full.

Spray distances from the lenses are at 150mm for body sprays, 200-250mm for hair spray, oil, paint and polish and 500mm for air freshener.

The actuators in the research programme have been specially machined from Perspex (Plexiglas) and Brass, a method of unit construction has been developed so that combinations of different shapes and sizes of inlets, exits, internal passages and flow control devices may be tested systematically because of variation of temperature difference between summer and winter, all tests must be done at room temperature, say 20 centigrade.

Internal features of Raj. designs, as developed for spraying air fresheners, anti-perspirant, body spray, hair spray, polish, oil and paint, key features of the devices are the inlets, pre-throttles, shaped chambers, partitions, throttle(s), straight or angled, leading to the pre-chamber and exits, exits could take different forms from a simple exit to a swirl, a list of products seen below:

Anti Perspeirant:

- Mainly to reduce inhalable <7%, to maintain the spray angle and flow rate.
- Product G, I.
- Spray distance from lenses is 150mm.

Body Spray:

- Reduced VOC.
- Product I.
- Spray distance from lenses 150mm.

Hair Spray:

- Easy (slight reduce VOC) product M.
- Moderate (reduced VOC) product H, L
- Hard (further reduced VOC) product J, K
- Spray distance from lenses 200-250mm.

Results

Three products of hair spray have been tested with different designs, using partitions in a chamber with different types of exits; results are shown in Fig. 3 to Fig. 8.

Figure 3c shows the performances of the two designs during the life times of hair spray aerosol. Both designs in Fig. 3a and 3b produces similar results although a swirl used as exit in Fig. 3b, but because of Raj's diamond shape used in Fig.3b the performance looks same.

As illustrated in Fig. 4a, b and c using a "KS6 swirl" results in finer droplet sizes distribution than those obtained using models with "KS65 swirl", with little effect on flow rate, using diamond chamber, and two throttles hitting each other in a pre-chamber then a swirl.

Fig. 5 and Fig.6 shows a comparison of KS6 and KS65 design with their original cap.

Fig. 7a, b demonstrates advantage of the diamond chamber design to original cap in terms of finer droplet sizes. It can be seen from Fig.8 a, b that the partition positioned in the diamond chamber; produces by the multiple exits hitting each other soon combine downstream, the partition act as turbulence generators, whilst also producing vapour release. As seen in Fig. 9 a, b and c, reduced VOC body spray design in Fig 9a produces finer drop size with compassion to Fig. 9b , when adding two divergent throttles hitting inside convergent chamber and acting as exit.

A typical diamond chamber with partition have been used to test anti-perspirant product showing obvious reduction in inhalable drops less than 7 micron as seen in Fig. 10.

Fig. 10, 11 and 12 illustrate anti-perspirant design using Design 1 and 2 and Fig. 12a, b and c shows a comparison of D1 and D2, D2 has an advantage on D1 with less inhalable.

Discussion

Most of the products are reduced VOC or further reduced VOC, compress air and anti-perspirant. As shown in figures 3 to 12, model designs consist of inlet, could take different shapes, horizontal, tangential or vertical inlet, inlets also could control the flow rate. pre-throttle works with body spray as flow control as well as create more fine droplets with no penalty to flow arte. With anti-perspirants it reduces the inhailables by increasing the drop sizes, pre-throttle sizes has to be optimised to be effective otherwise using wrong size could be counter productive, more experience needed to match such deigns with such products.

"throttle" stage, could take different forms, such as two throttles hitting each other figure 4a and figure 8a in a pre chamber which create more droplet breaks or single or more angled throttles hitting the wall as shown in figure 9a which convert kinetic energy into pressure energy near the wall leading to a pre-chamber, chamber shape and sizes can be determined by knowing the product and other characteristics required followed by an exit orifice stage.

It has been shown that in some designs long chambers after inlets could give better mixing to produce finer droplets as demonstrated in figure 3a..

Rajab's diamond shaped chambers as shown in figure 3a to 11a consist of divergence conical leading to a chamber followed by convergence conical. The chamber length of the chamber can be optimized and determined depending on several factors such as flow rate required and the type of product.

Converged Conical chambers behaves well since create local pressure drop, converged or diverged conical chambers can also be used as exits as illustrated in figures 3a, 3a, 10a. It has also been shown that a small around tip on the exit could narrow the drop size distributions, reduces large droplets on the sides, also can reduce liquid collection

Raj's shapes "partitions" can be positions in cambers shown in figure 3a to figure 11a. These shapes can help to create more turbulence,

Throughout the paper, all Raj., designs are selections include different straight or angled throttle(s), shaped chambers, partitions, conical(s) and exit stages that have been tested for different products

Systematic tests were undertaken, in order to reduce the drop size diameter as well as the inhalable fraction of droplets, i.e. the percentage of droplets smaller than 7 microns, with no effect to the flow rate.

Raj designs illustrate flow control devices that have been explored, including a shaped chambers, Raj diamond, Raj partitions for breaking up unsteadiness and segregation after the valve and corners, and a pre-chamber before the exit orifice convergence and divergence conical and throttle(s) provides a local pressure drop which causes vaporisation of a proportion of the hydrocarbon

Systematic tests enabled selection of optimum combinations of exit orifice and throttle sizes, chamber shapes and partitions with the aim of producing fine sprays but with reduced inhalable fraction of droplets. This is achieved by producing a near-homogeneous two-phase mixture in the pre-chamber which completes atomisation inside and just downstream of the exit orifice. Minimization of liquid film on the exit orifice wall also appears to assist in reducing the width of the size distribution.

For anti-perspirants it has also been shown that the spray angle is increased by decreasing the exit size. But this will affect the drop sizes which makes it finer

therefore increase the inhalable sizes percentages those less than 7 microns. In the other hand if the exit size decreased the drop sizes increased and spray angle will be narrower.

Applications of Raj.s designs is achievement of a major reduction in hydrocarbon content for air-freshener sprays, hair spray and body spray with no adverse effect on the drop size distribution.

In order to do this hydrocarbon propellant level is reduced in the can during the filling operation, and also the liquid propellant must be replaced by water. This produces problems in obtaining good atomisation for three reasons; (1) the can pressure is reduced, (2) flash vaporization is reduced, and (3) surface tension and viscosity of the liquid phase are increased.

Development work showed that to solve these problems it was considered necessary to (1) ensure significant vapour release occurred within the actuator, (2) produce a highly turbulent flow, but at length scale small compared with the flow geometry, and (3) minimise the size of the exit orifice.

Reduction in can VOC content is obtained without worsening the drop size distribution (volume and median diameter is around 40 micron for air fresheners), 30 to 60 microns for different types of reduced VOC.

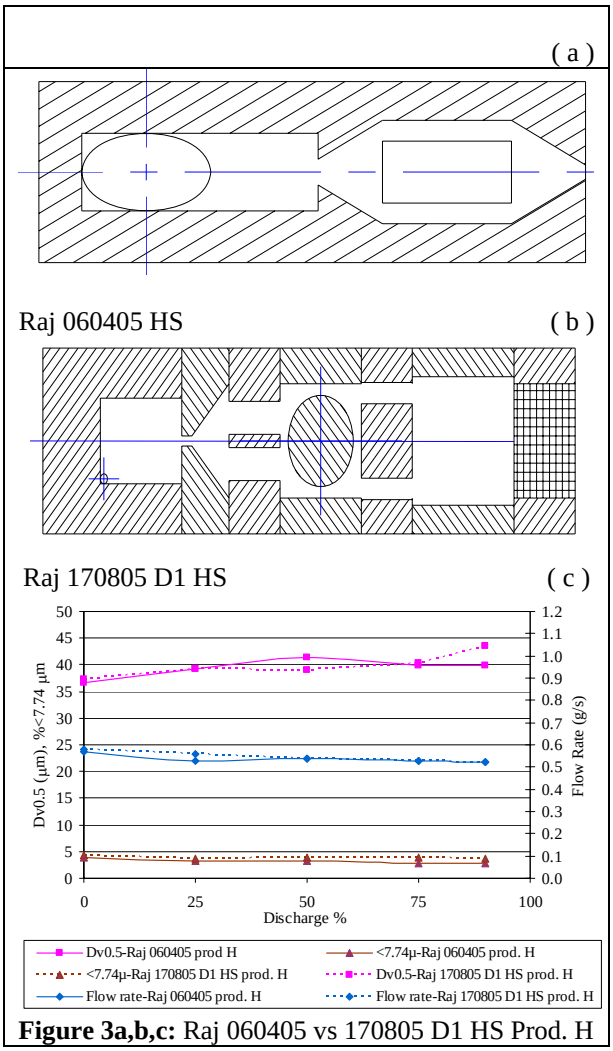


Figure 3a,b,c: Raj 060405 vs 170805 D1 HS Prod. H

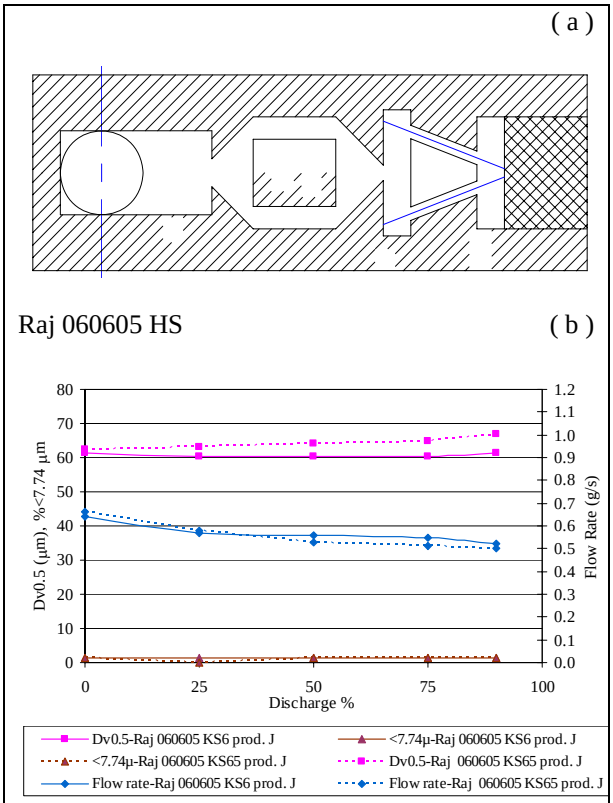


Figure 4a,b: : Raj 060605 KS6 vs 060605 KS65

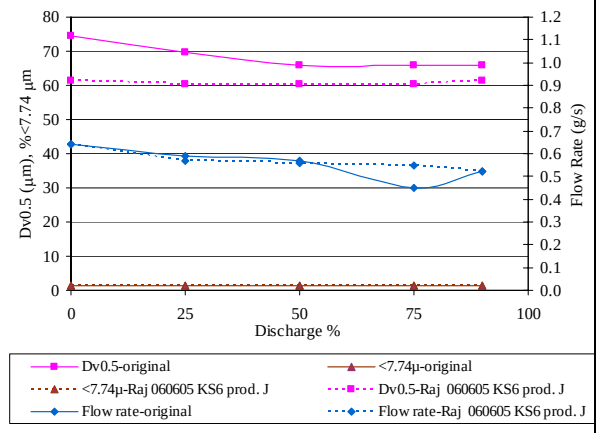


Figure 5: Original vs 060605 KS6 product J

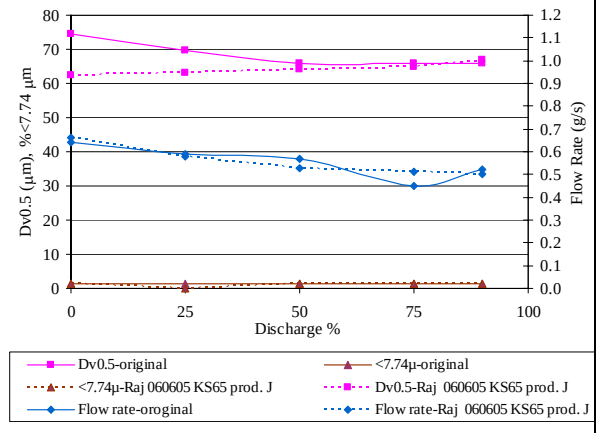
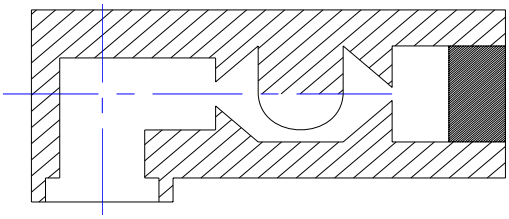


Figure 6: Original vs 060605 KS65 product J

(a)



(b)

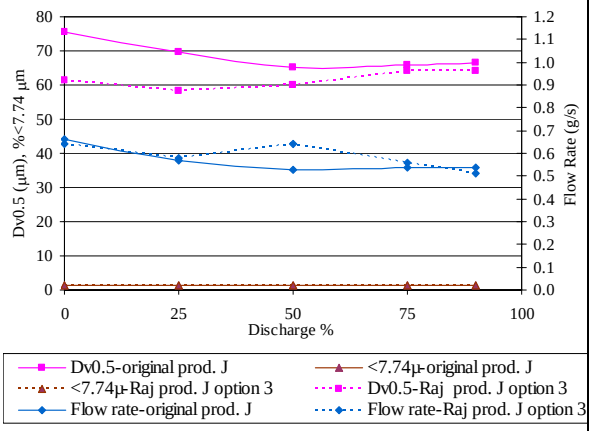
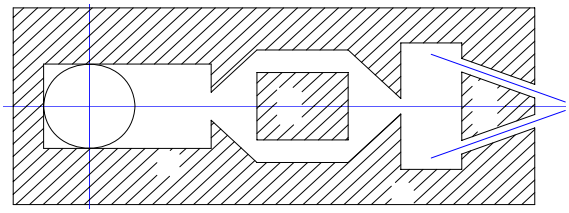


Figure 7a, b:Original vs Raj 060605(option3) prod. J

(a)



(b)

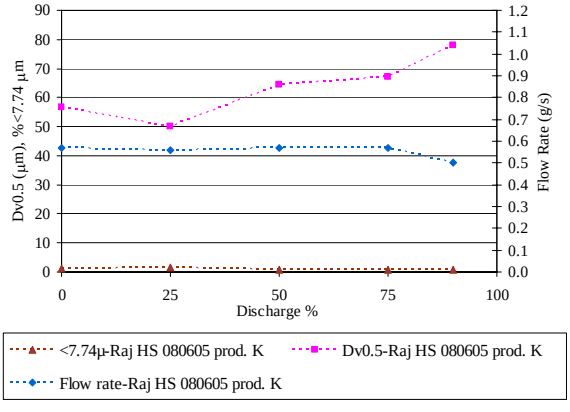
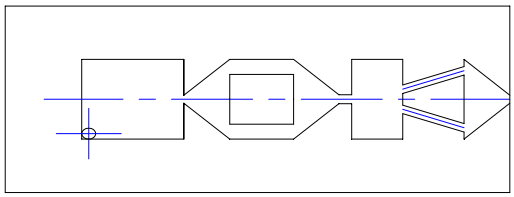
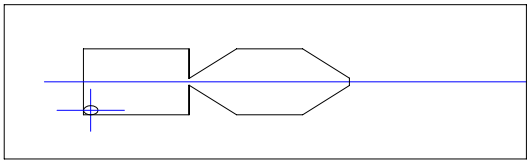


Figure 8a, b: Raj 40463 080605 HS product K

(a)



Raj 290905 BS (b)



Raj 140606 BS (c)

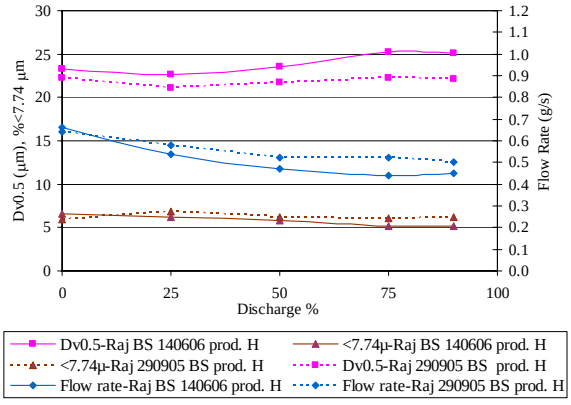
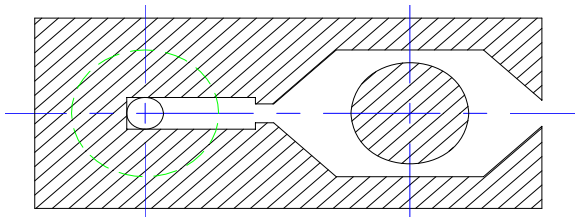


Figure 9a,b,c : 290905 vs 140606 RVOC BS prod. I

(a)



(b)

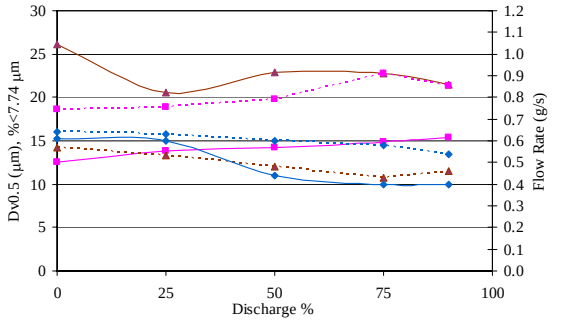


Figure 10a, b: Raj AP Original vs D1 product Q

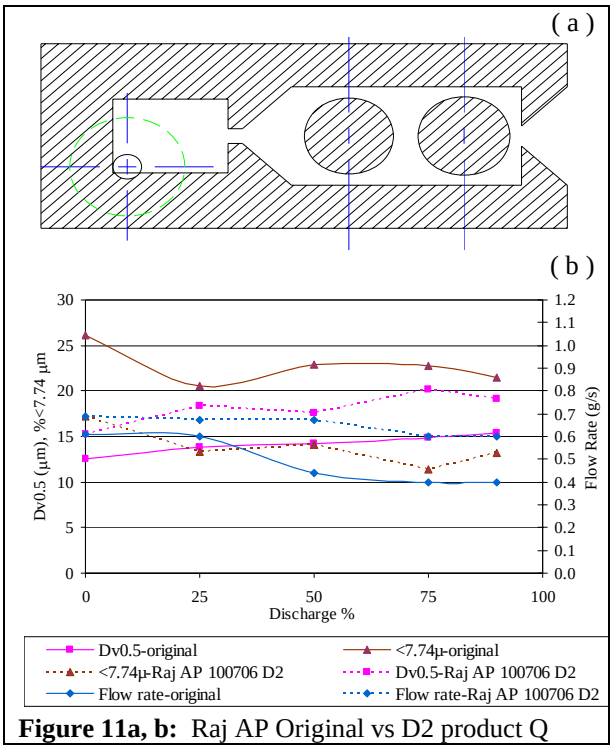


Figure 11a, b: Raj AP Original vs D2 product Q

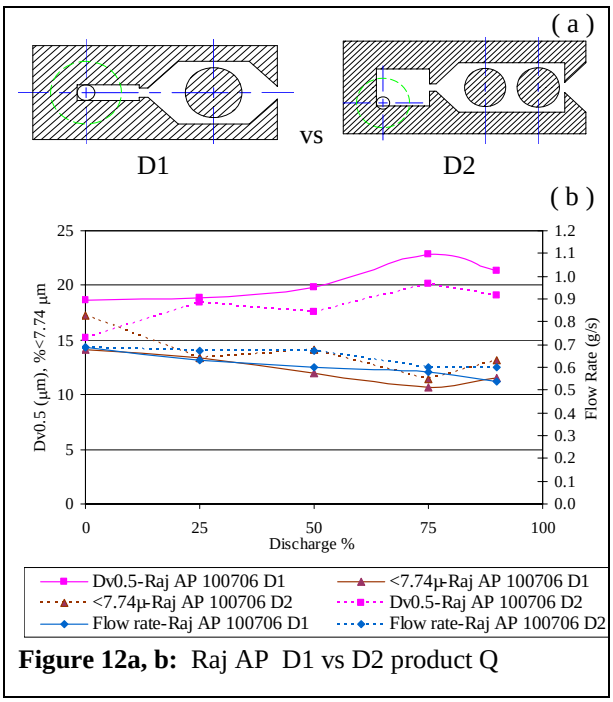


Figure 12a, b: Raj AP D1 vs D2 product Q

Concluding Remarks:

More complex designs of household aerosol can actuators have been made possible by using a new manufacturing technology.

This has made feasible the use of various flow control devices, throttles(s) and pre throttles, and multiple orifice actuators, shaped chambers and partitions with no cost penalty.

An experimental research programme has systematically applied these flow control devices in specially made actuator models for the cases of spraying those very different types of products, non viscous, anti-perspirant, hair spray, body spray, air-freshener and viscous products, polish, oil and paint.

The experiments have shown that these flow control devices permit control of droplet size, control of flow rate, spray pattern manipulation, the production of narrower droplet size distributions, and reduction of can VOC content.

From the experiments carried out by Raj designs on reduced VOC hair spray, body spray and oil. These designs improved the inhalables on anti-perspirants. It has proven that great improvements on reduction of drop sizes and crucial reduction on inhalables by keeping the flow rate the same with comparison to the original cap

More advanced designs of actuators have been made depending on the inventions related to shape chambers, multiple passages of flow and throttles. It is now possible to manufacture household can aerosols such as air fresheners, body sprays and hair sprays with massive reduction in hydrocarbons or volatile organic compounds (VOC).

Also some of these designs can help to atomise viscous fluids such as oil, polish and paint. Also these designs can work with compress gas can products. From the experiments carried out it is obvious that these designs helped several products which was rather difficult not a long time ago. It is also helped to reduce the inhalable of these cans especially with the anti perspirant, oil and paint.

References

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