ILASS 2008
Sep. 8-10, 2008, Como Lake, Italy

Paper ID ILASS08-8-4

BENEFITS AND UTILIZATION OF FURTHER DEVELOPMENTS OF DESIGNS USED WITH HYDRO CARBON AND COMPRESSED GAS, ANTI-PERSPIRANT AEROSOLS

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ABSTRACT
Volatile Organic compounds and inhalable particles become a serious problem unless radical changes occur in the aerosol industries to limit these compounds in our environment, there is an interest in either reducing the hydrocarbon content and the inhalable in aerosol cans or removing it completely. This paper describes experiments that have been carried out to explore the effects of flow control devices, shaped chambers, multiple passages, partitions and throttles on the flashing flow and quality of the spray causing pressure drops, turbulence, circulation, vaporisation which are leading to new generation of household aerosols. This paper is related to an innovation patents WO2005005053 (A1), WO2005005055 (A1), WO2005005054 (A1) and WO2007015062 (A1), (3-6). Partitions have also played a great role in having new designs working well with anti-perspirant products.

Introduction

Because of the ease of atomising by using a flashing propellant, there has been remarkably little published research on how the internal geometry of the actuator affects performance, where the actuator is the cap of the can, which fits on the valve and contains the exit orifice. The exit may be a simple orifice, such as for antiperspirants, or a swirl-insert, for example for polish and paint sprays. Currently the propellants used are blends of liquefied hydrocarbon, mainly butane and these are classified as Volatile Organic Compounds (VOC's). Legislation controlling VOC use is becoming increasingly strict and is already affecting the household aerosol market in California [1]. The key performance parameters of an aerosol are the discharge rate, the particle size and the cone angle. Safety is also a key requirement [1]. The aims of this investigation are: To develop improved, aerosol actuators using a new manufacturing technology. To enhance spray quality, drop sizes and to reduce the inhalable. To achieve spray performance improve the characteristics of existing aerosol anti-persiprant. To gain improved understanding of internal flashing flows.

A spray is generated when a fluid is caused to flow through a nozzle arrangement under pressure. To achieve this effect, the nozzle arrangement is configured to cause the fluid stream passing through the nozzle to break up or "atomise"
into numerous droplets, which are then ejected through an outlet of the arrangement in the form of a spray or mist.

The optimum size of the droplets required in a particular product concerned and the application for which it is intended. For example, pharmaceutical sprays that contain a drug intended to be inhaled by a patient (e.g. an asthmatic) usually requires very small droplets, which can be penetrated deep into the lungs. In contrast, a polish spray preferably comprises spray droplets with larger diameters to promote the particularly if the spray is toxic, to reduce the extent of inhalation.

The size of the aerosol droplets produced by such conventional nozzle arrangements is dictated by a number of factors, including the dimensions of the outlet orifice and the pressure with which the fluid is forced through the nozzle. However, problems can be arising if it is desired to produce a spray that comprises small droplets with narrow droplet size distributions, particularly at low pressure.

The desire to reduce the level of propellant used in aerosol canisters is topical issue at the moment and is likely to become more important in the future due to legislation planned in certain courtiers, which proposes to impose restrictions on the amount of propellant that can be used in hand-held aerosol canisters. The reduction in the level of propellant causes a reduction in pressure available drive the fluid through the nozzle arrangement and also results in less propellant being present in the mixture to assist with the droplet break up. Therefore, there is a requirement for different types of designs of nozzle arrangement that is capable of reducing an aerosol spray composed of suitably small droplets at low pressure.

It is an object of the present work and inventions to provide design of nozzles that is adapted to generally control the size of the droplets generated when compared with conventional nozzle devices, as well as to narrow the droplet size distributions. Also to enable small droplets of fluid to be generated at low pressures, i.e. when fluids contains reduced or depleted levels of propellant, or a relatively low-pressure propellant such as compressed gas, is used, or a low pressure systems is used, such as a pump or trigger.

On household applications, there are a very wide field of so called "aerosols cans" or "packaged aerosols". Examples of these are; aerosol cans, such as deodorants, hair-spray, anti-perspirants, air fresheners, polishes, cooking oils, cleaning spray and insecticides. This invention, (3-6) helps to develop designs of actuators which help the reduction of VOC in the cans.

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, anti-perspirant sprays, de-odorant sprays, perfumes, air fresheners, antiseptics, paints, insecticides, polish, hair care products, pharmaceuticals, water and lubricants.

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.

The partition 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.

Apparatus, Methodology and Procedures

The practical utilization of more complex designs of nozzles in household aerosols is made possible by a new manufacturing procedure. Figure 1a shows a typical aerosol can were the "actuators" is that part that fits on the valve. Most actuators are in two parts, the main body and the exit orifice insert. A new injection moulding technique, allows the actuator and exit orifice to be made as one part, as illustrated in Fig. 1b [2]. This is achieved by moulding a hinged cap as one unit that fold together after manufacture. Apart from the advantage of cost, it is now possible to incorporate a wide range of flow control devices and orifice designs into a single injection moulded part.

An experimental programme has used transparent actuator caps, as in Figs 2 and 3 with high-speed video recording, and droplet sizing using a laser diffraction instrument, brass models also have been used because they last for longer.. The actuators in the research programme have been specially machined from Perspex (Plexiglas) and 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. Figure 2 shows an example of one of the assembled units and figure 3 shows the internal features the design, as developed for spraying anti-perspirant. 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. Flow rate was measured by weighing the can. Key features of the devices are the throttle(s), leading to the pre-chamber and exit, as can be shown in figure 4 illustration of moulding cap with partition in Raj's diamond shape chamber.

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 times reading, the spray time on average of five seconds. Spray distances from the lenses are 150mm for body sprays, 200-250mm for hair spray, oil, paint and polish and 500mm for air freshener.

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, The aim is to enhance a spry quality for the anti-perspirant products, to reduce the inhalable <7%, to maintian the spray angle and flow rate, test carried out at 150mm distance from the lenses,

Discussion

Considering first anti-perspirant sprays, these contain complex combinations of powder, silicone oil, perfumes and additives as well as the liquid hydrocarbon. Systematic tests were undertaken, in the first instance in order to attempt to reduce the inhalable fraction of droplets, i.e. the percentage of droplets smaller than 7 microns. Figures 2 and 3 illustrate flow control devices that have been explored, including a "dogs-leg", for breaking up unsteadiness and segregation after the valve and corner, and a pre-chamber before the exit orifice.

The throttle 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 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. Minimisation of liquid film on the exit orifice wall also appears to assist in reducing

The width of the size distribution. Fig. 5 shows size distributions for the new actuator and a typical current commercial design, and Figure 6 shows the performances of the two designs during the life times of aerosol cans.

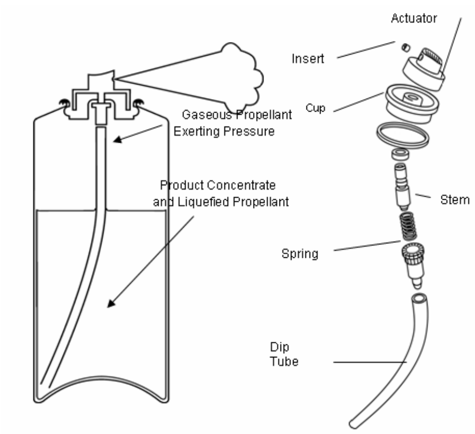

Figure 1a: Typical aerosol can and valve system (Courtesy BAMA, London)

Figure 1b: New actuator technology design [2]

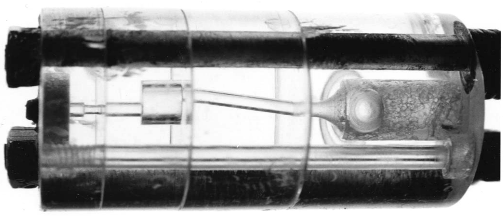

Figure 2: Top view of Raj D35 anti-perspirant atomizer

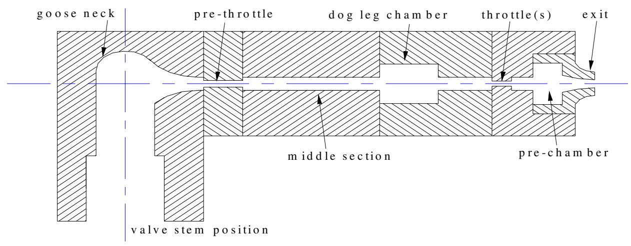

Figure 3: A typical Raj Design 35 developed for anti-perspirant sprays.

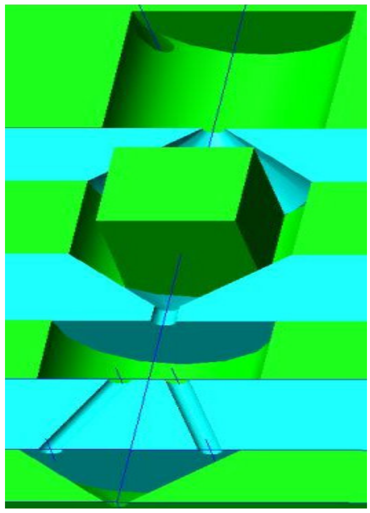

Figure 4: illustration of moulding cap with partition in Raj's diamond shaped chamber

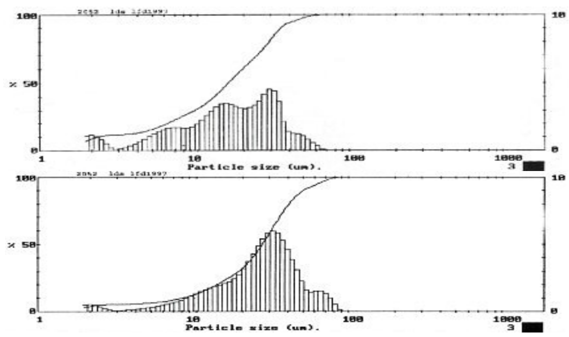

Figure 5: Anti-perspirant drop size distributions, (top) from a standard commercial actuator and (bottom), from new design.

Figure 7, 8, 9 and 10 shows graphs for four different products, A, B, C and D using same Design 35 for anti-perspirant and how the new technology design has advantage on original design, all results showing great reduction on drop sizes and inhalables.

Figure 11 shows the effect of pre-chamber just before the simple exit on the drop size, the shorter expansion chamber shows better effect on reduction of drop size on anti-perspirant when using Raj D55A7B62.

Figure 12 demonstrates the effectiveness of the pre-throttle on inhalables on anti-perspirant product A by two third when using pre-throttle compared with no pre-throttle, Raj D35. Also the pre-throttle sizes needs to be optimized.

It has also been proven for anti-perspirant cans that another, upstream, “pre-throttle”, see Fig. 3, has a strong effect on the flow rate. Therefore a pre-throttle can control the flow rate without necessarily having an effect on the drop size. For anti-perspirants it has also been shown that the spray angle is increased by making a countersink in the exit orifice up to 40^o angle to the axis, and the drop size remain unchanged. As illustrated in Fig. 13 using a “dogleg” (Fig. 3) results in finer droplet sizes distribution than those obtained using models with no dogleg, with little effect on flow rate using 1THA7° throttle.

Figure 14a, to 16a demonstrates performance of anti-perspirants. Figure 14a, b shows a comparison of original cap anti perspirant spray with Raj AP design 5. The inhalables of the Raj designs are far less than the inhalables of the original cap, whilst still maintaining the same flow rate.

Figure 15a and 15b shows the comparison between the original design caps with the Raj Design 35. These are the same product, but using different designs. The inhalables of Raj Design 35 are extremely low compared with the original can.

When comparing the difference in droplet sizes between figure 14 and 15, design 14a has an advantage over design 15a on maintaining droplets around 25μm. Figure 16b shows a comparison of angled throttle designs B65 and B62, the smaller exit (B62) shows better inhalables than the larger exit (B65).

Throughout the paper, all Raj’s 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) provide 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. Minimisation 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.

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. 17. Fig. 17, 18 and 19 illustrate anti-perspirant design using Design 1 and 2 and Fig. 19a, b and c shows a comparison of D1 and D2, D2 has an advantage on D1 with less inhalable.

All the products are anti-perspiriants. As shown in figures 1 to 19, 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.

The “throttle” stage, could take different forms, such as two throttles hitting each other in a pre chamber which create more droplet breaks or single or more angled throttles hitting the wall 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.

Rajab’s diamond shaped chambers as shown in figures 17a and 18a 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 figure 17a. 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 17a and figure 18a. These shapes can help to create more turbulence,

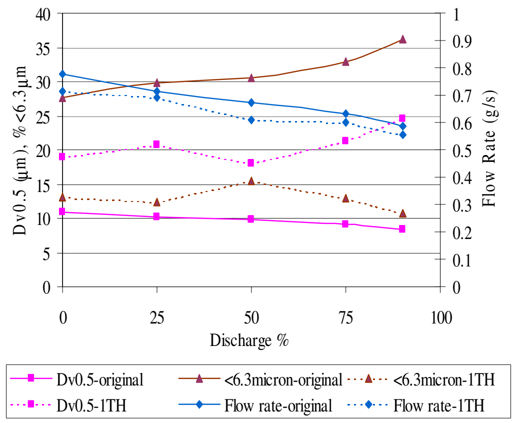

Figure 6: Performance of present and new

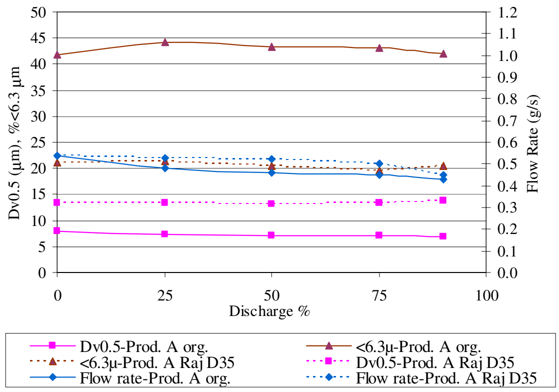

Figure 7: Anti-perspirant, product A

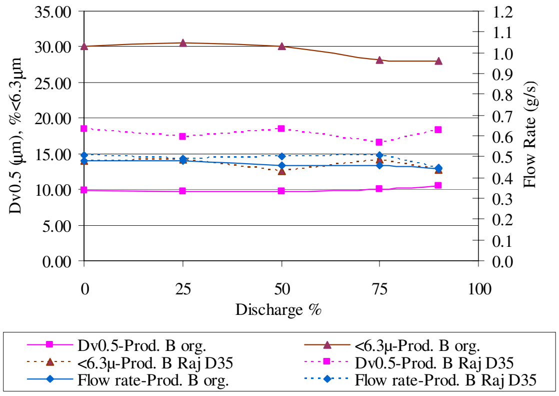

Figure 8: Anti-perspirant, product B

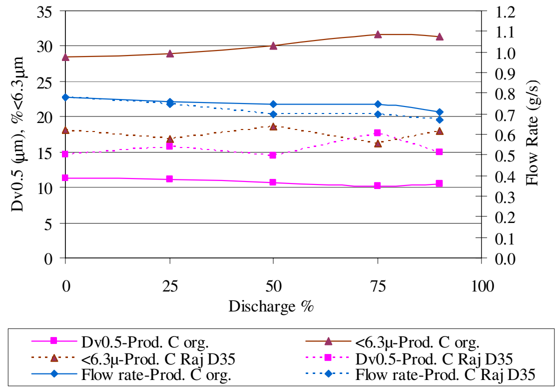

Figure 9: Anti-perspirant, product C

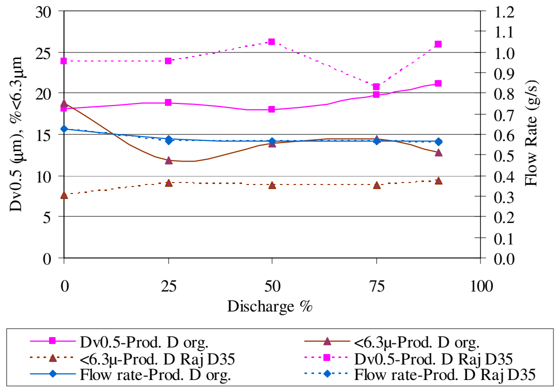

Figure 10: Anti-perspirant, product D

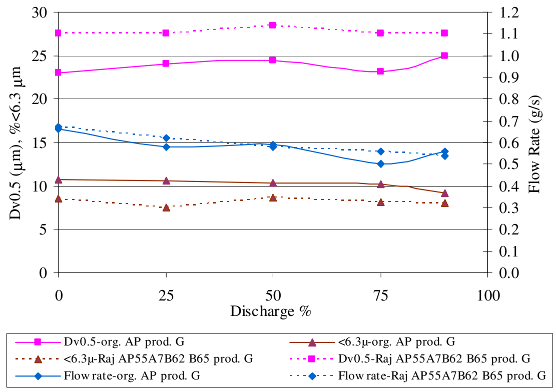

Figure 11: Anti-perspirant, Product G

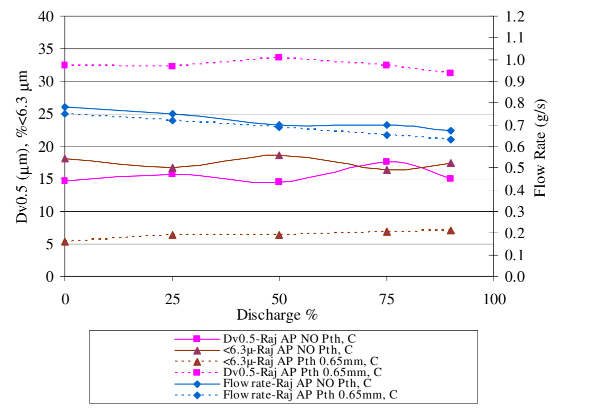

Figure 12: Anti-perspirant, Product C

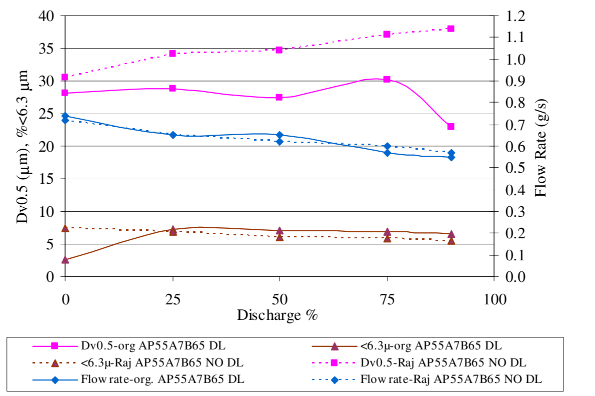

Fig 13: Effect of dog-leg on break up droplets-prod G

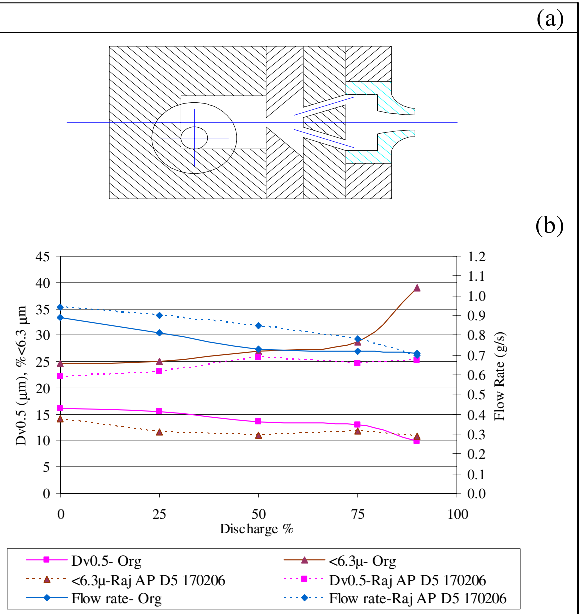

Fig 14a, b: Anti Persp, Prod C Org v Raj D5 170206

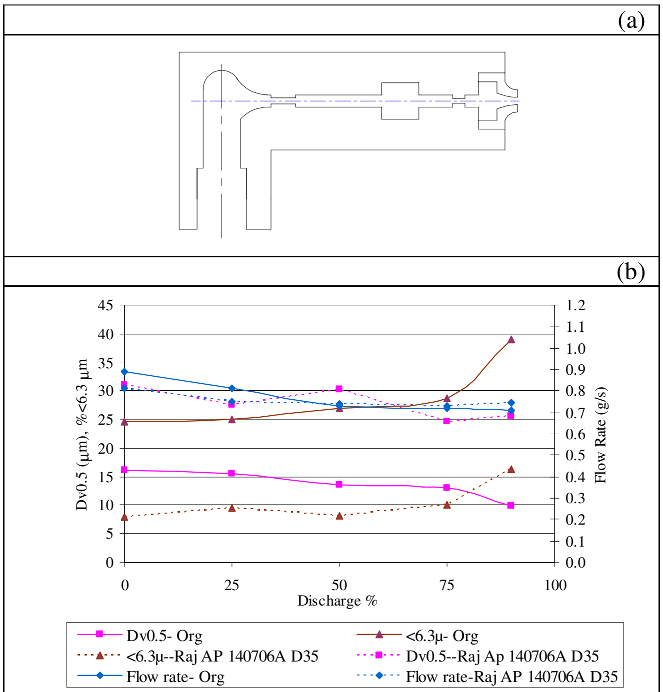

Figure 15a, b: Anti Persp, Prod C Org v Raj D35

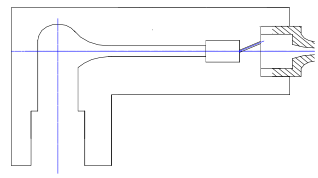

Figure 16a: Anti-perspirant Design 55A7EX3

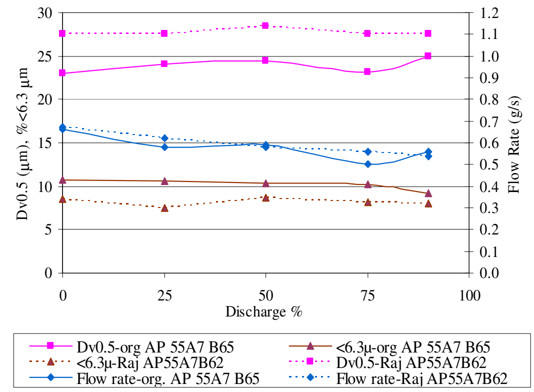

Figure 16b: Anti-perspirant, Product G

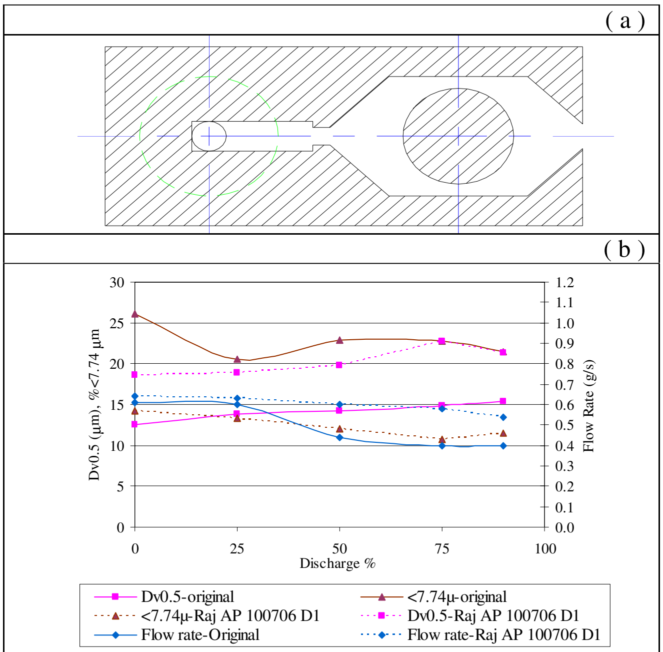

Figure 17a, b: Raj AP Original vs D1 product Q

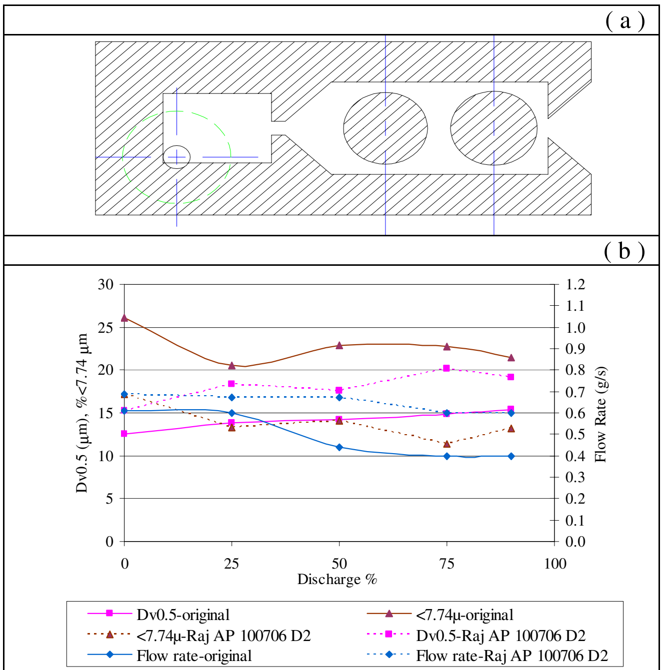

Figure 18a, b: Raj AP Original vs D2 product Q

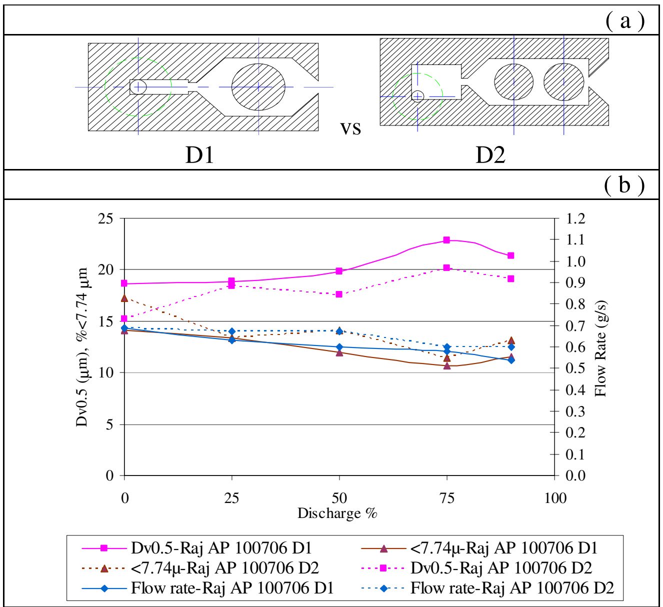

Figure 19a, b: Raj AP D1 vs D2 product Q

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 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 Design 35 on several products, 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. These designs improved the inhalables on anti-perspirants.

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.

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 most of the household can aerosols.

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