NOVEL DEVELOPMENTS IN ACTUATOR DESIGNS FOR FLASHING HOUSEHOLD AEROSOLS

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Abstract

With increasing legislation on volatile-organic-compounds, there is interest in either reducing the hydrocarbon content in aerosol cans or removing it completely, ie. using inert compressed gas propellant. However the latter gives relatively poor atomisation. There are also motivations for achieving control of the size distribution produced by flashing atomisation, for example to reduce the inhalable fraction of droplets in some applications. This paper describes experiments that have been carried out to explore the effects of flow control devices on the flashing flow and the quality of the spray and which are leading to new generation of household aerosols.

Introduction

Because of the ease of atomizing 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 and an internal flow passage. The exit orifice 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 and encouraging research in this area[1].

The key performance parameters of an aerosol are the discharge rate, the particle size and the cone angle. Safety is also a key requirements.[1].

The aims of this investigation are

- to develop improved, aerosol actuators using a new manufacturing technology:
- to reduce VOC content of existing aerosol cans, e.g. butane reduction
- to achieve spray performance at least matching the characteristics of existing aerosol air fresheners, deodorants, hair spray and body sprays
- to gain improved understanding of internal flashing flows

New Actuator Manufacturing Method

The practical utilization of more complex designs of nozzles in household aerosols is made possible by a new manufacturing procedure. Figure 1 shows a typical aerosol can where the "actuator" is that part that fits on the valve[2].. Most actuators are in two parts, the main body and the exit orifice insert. A new injection moulding technique for caps, allows the complete actuator and exit orifice to be made as one part, as illustrated in Figure 2 [3].

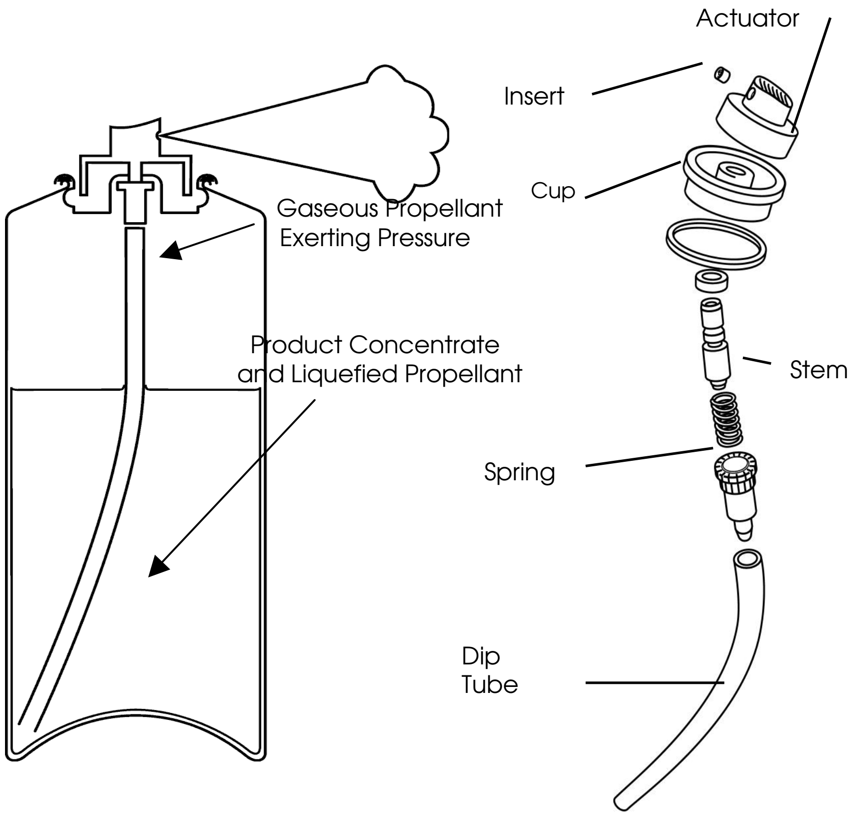

Figure 1 Typical aerosol can and valve system (courtesy BAMA, London)

Figure 2, New actuator technology design [3]

This is achieved by moulding a hinged cap as one unit that folds 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.

Apparatus and Procedure

An experimental programme has used transparent actuator caps, as in figures 3 and 4 with high speed video recording, and droplet sizing using a laser diffraction instrument. 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 internal passages and flow control devices may be tested systematically. Figure 3 shows an example of one of the assembled units and figure 4 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.

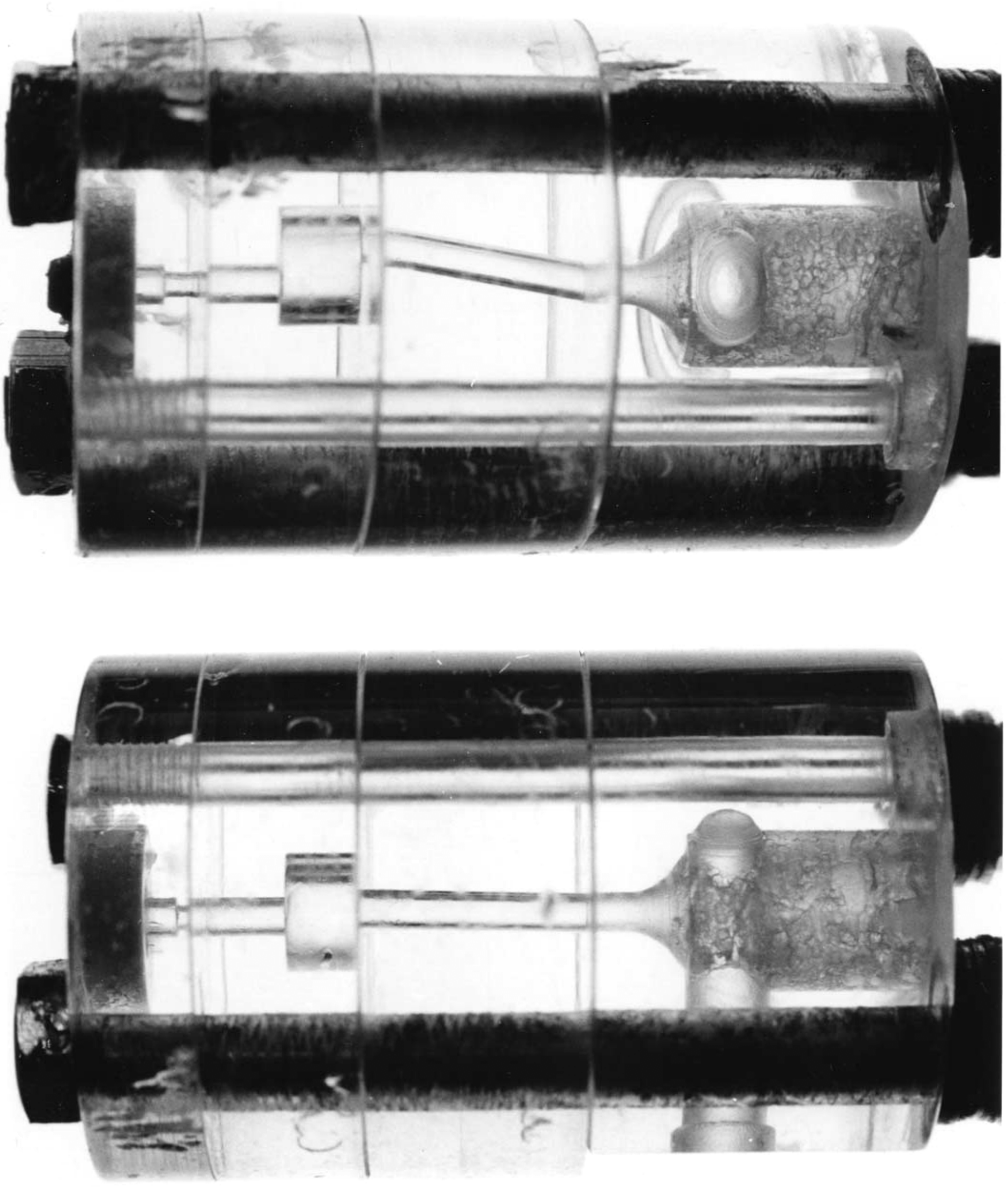

Figure 3, Top and side views of new anti-perspirant atomizer

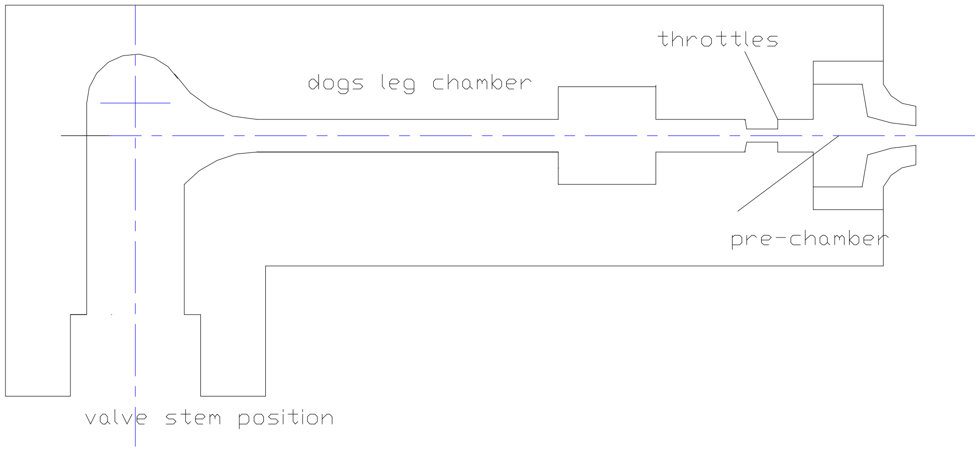

Figure 4. A typical design developed for anti-perspirant sprays

Discussion

Considering first anti-perpirant sprays, these contain complex combinations of powder, 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 3 and 4 illustrate some of the 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 inhailble fraction of droplets. This is achieved by producing a near-homogeneous two-phase mixture in the prechamber 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. Figure 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.

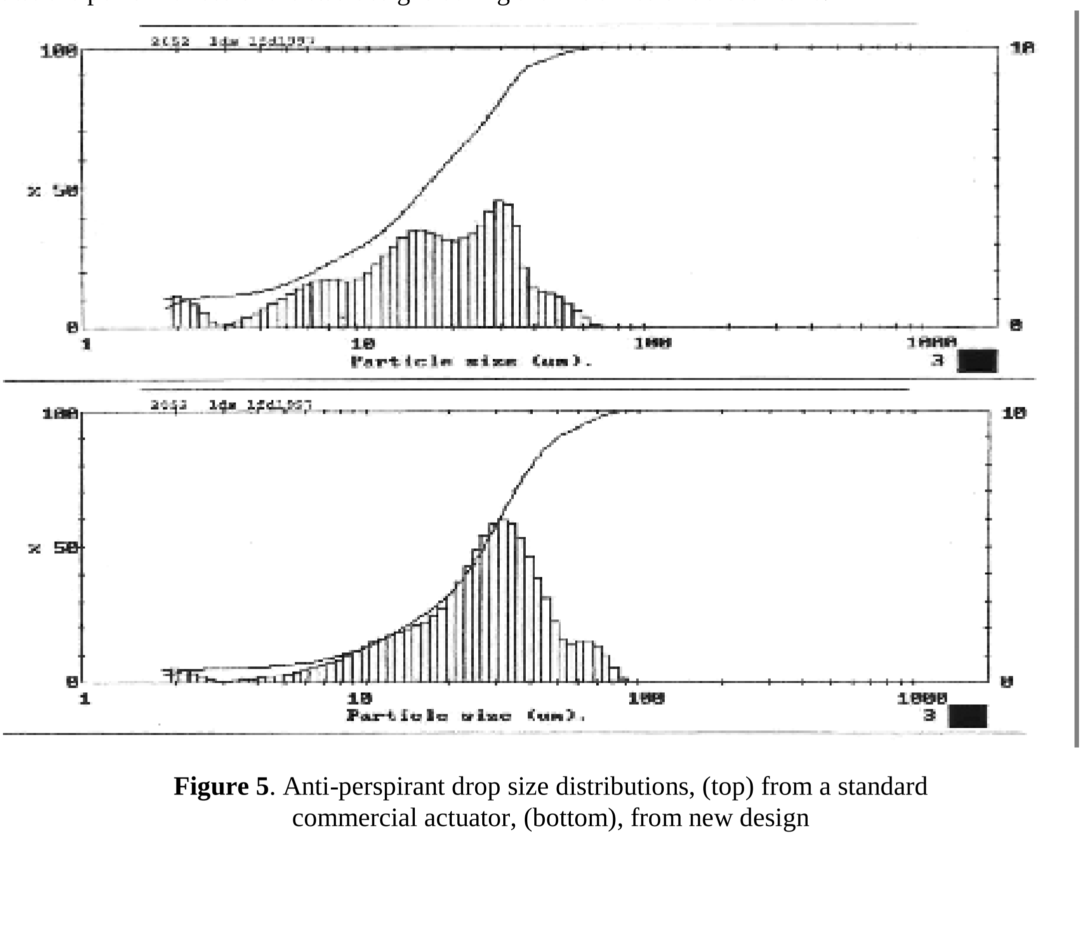

Figure 5. Anti-perspirant drop size distributions, (top) from a standard commercial actuator, (bottom), from new design

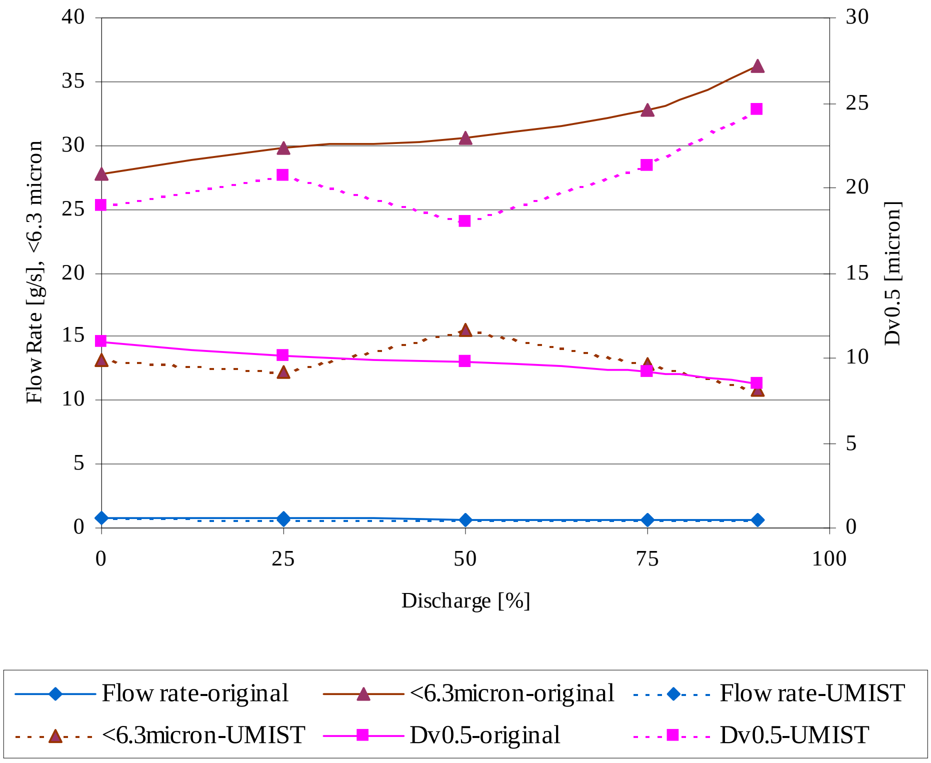

Figure 6, Performance of present and new actuator designs during lifetimes anti-perspirants

A Second example of application of the new actuator technology is the achievement of a major reduction in hydrocarbon content for air-freshener 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.

Figure 7 shows a design which provides a very significant reduction below the typical current level of around 30% VOC. Reduction in can VOC content is obtained without worsening the drop size distribution (volume and median diameter is around 40 micron for air fresheners). It can be seen that the multiple sprays, produces by the multiple small exit orifices soon combine downstream. The multiple throttles act as turbulence generators, whilst also producing vapour release.

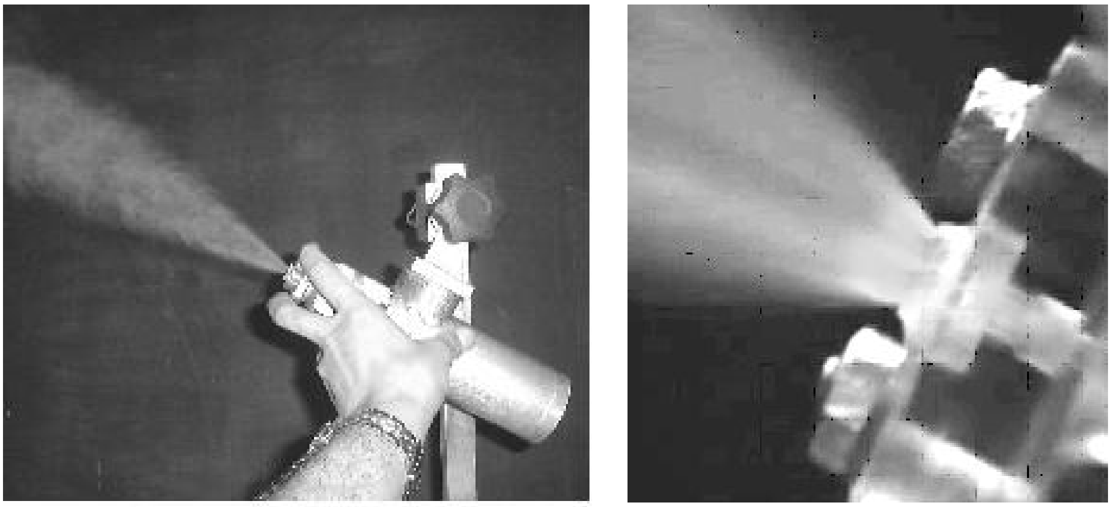

Figure 7, Multi exits multi throttle model for air freshener with reduced VOC.

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, 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 two very different types of spray: anti-perspirant and air-freshener.

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.

Acknowledgement

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References

[1] BAMA, "Scoping study: the futures of aerosols". British Aerosol Manufacturing Association, London, Nov. 2001.

[2] Nasr, GG, Yule, AJ, and Bendig L, Industrial Sprays, Springer Verlag, August 2002.

[3] www.Tencate.com, Ten Cate Plasticum, Netherlands, 2002.