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Sustainable design of a trigger sprayer suitable to e-commerce market

A case study of design for material reduction, disassembling and recycling

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Abstract

Worldwide consumption of plastics related to the production of household detergent containers was over 17 million tons in 2018, with an average annual growth over the last decade of 4.8%. Moreover, the pandemic will increase the demand for household detergents in 2020, 90% of which are packaged in plastic bottles. These are often associated with a liquid dispensing system called “trigger sprayers”. Due to its greater functional and formal complexity and due to the high number of heterogeneous materials used for the different components, the trigger sprayer often represents a critical issue in the disassembly and recycling phase of the bottle. The proposed paper aims to describe the research, development and prototyping process of trigger sprayer concepts, applicable to bottles of home care products sold through online purchasing channels, able to meet the requirements for the certification of "product suitable for e-commerce sale". The project, developed in collaboration with Aptar France, had as its further objective the optimization and enhancement of the environmental performance of the new product, through a life-cycle design approach and through the use of specific DfS strategies and tools. The new concepts developed are characterized by innovative technical-formal solutions able to increase the resilience of the product during transport, drastically reducing both the use of materials and the number of components, improving their performance. In the first phase of the project, a series of activities were launched aimed at identifying and analyzing the main environmental criticalities of traditional trigger sprayer models for domestic use. Through the photographic survey, the disassembly and weighing of the components and the identification of the materials used, it was possible to analyze the types consolidated on the market, the material and aesthetic-perceptive characteristics of the products, the ergonomic requirements and the technical and functional characteristics of the dispensing systems. At the end of the analysis phase, some new trigger sprayer concepts were generated, developed according to the DfS's design criteria and optimized to be used in bottles sold through e-commerce platforms. In the third and final phase the concepts have been prototyped to experimentally validate the strategies adopted and verify, with a special consumer test, the appreciation by the end user. The life-cycle design of the trigger sprayer with the adoption of design

strategies aimed at environmental sustainability have led to a substantial reduction of the plastic material use and to the optimization of the disposal and recycling phase. The results obtained from the project have contributed to increase the company know-how, in terms of DfS of the Aptar group, aiming to focus on the SDG 12 "Ensure sustainable production and consumption patterns" (12.2-12.5-12.6).

Keywords: trigger sprayer, sustainable design, design for e-commerce market, design for reduction, usability optimization

1. Introduction

Worldwide consumption of plastics related to the production of household detergent containers was over 17 million tons in 2018, with an average annual growth over the last decade of 4.8%¹. This figure also takes into account the quantity of recycled plastic, which is used in the production of packaging that is destined for the detergent market. The increase in the use of plastics in the household cleaning sector is a direct consequence of the constant growth, worldwide, of the market for household cleaning products, and of the replacement of cardboard packaging, with some types of polymers. In industrialized countries with a mature market, and in particular in Europe² - despite the recession of recent years - the detergent industry has taken steps to face the slowdown in the market, focusing on product innovation, communication and consumer education to a correct use of detergents, simultaneously implementing promotional campaigns for cheap products, mainly marketed through e-commerce channels. In part, these strategies have also been implemented in "emerging economy" countries, for which the gap in the consumption levels of detergent products contained in plastic bottles is expected to recover. In summary, the estimates predict that the world consumption of plastics for the packaging of household cleaning products will increase in the coming years at an average rate of 4.7%, substantially in line with that recorded in the last decade, to reach 21.3 million tons in 2022. To further support the growth in the consumption of plastics for the household cleaning sector, there is a progressive trend towards replacing powder detergents - generally contained in cardboard containers - with liquid detergents, which for obvious reasons are distributed to the consumer in plastic bottles. In the US, these detergents already account for about 80% of total consumption and in Europe, as well as in almost all emerging countries, plastic liquid detergent containers are gradually eroding the share of cardboard containers.

In the Market Monitor carried out by Assocasa-Federchimica in collaboration with Nielsen, it emerges that the sale of home care products, during the pandemic emergency from Covid-19, in the reference

¹ Il mercato mondiale del packaging per detersivi, <https://www.plastmagazine.it/mercato-mondiale-packaging-detersivi/> (accessed 14.05.2021).

² In Europa la prima richiesta di plastica, pari al 39,6%, è destinata alla produzione del Packaging. Source: PlasticsEurope Market Research Group (PEMRG) and Conversio Market & Strategy GmbH.

period 17 February - 17 May 2020, recorded an increase of 17.8% (Tarenzi, 2020). The rising figure must certainly be traced back to both the greater sensitivity and attention to the issue of personal and home hygiene and the change in habits induced by the particular period of the pandemic and to some purchasing dynamics, especially through e-commerce sales channels, which have consolidated and expanded. The numbers give a clear picture of what will plausibly be the growth trends of home care products in the coming years: the so-called "other products" related to home care, which in 2019 accounted for only 2.9%, grew by 59.8%. Leading the trend are mainly disinfectant products, with a 100% increase. Bleaches are the second fastest growing category, simultaneously in the lead, however, in the category of "washing additives", in the post-covid period, with an increase of 53.3%, equal to 18 million euros and about 60 % of the total.

In conclusion, the home care product market presents two significant trends, attributable to both new production-commercial models and to recent social changes and attention to hygiene. In particular, the first important data refers to the gradual replacement of traditional cardboard containers with polymer analogues. The second, on the other hand, refers to the growth of the detergency market as a response to the pandemic phenomenon caused by Covid-19, which has led to an exponential increase in the sales of sanitation and cleaning products, especially through e-commerce platforms. These two trends, therefore, translate into a significant increase in the demand for the production of polymers for the market of bottles, containers and trigger sprayers for home care. It is in fact evident that plastic is the most used material to produce both the bottles for the packaging of household detergents and the devices to allow their dispensing. The most used polymers are high density polyethylene (HDPE), low density polyethylene (LDPE) and polyethylene terephthalate (PET). The competing material is cardboard, but it is used almost exclusively for the packaging of powdered products and tablets, or to make secondary packaging intended for the transport of the bottles. In fact, the performance capabilities of these polymers in terms of durability, resistance, transformability, recyclability and containment of production costs, represent the main parameters of preference compared to other material solutions, and for many companies in the sector, it continues to be strategic to develop new plastic bottles.

At the same time, the recyclability and reduction of the consumption of plastic materials of the bottles is one of the themes of greatest interest for the development of new detergents with reduced environmental impact, especially for household care products (glass, floor and furniture cleaners, sanitary ware, deodorants, descalers, etc.) characterized by the presence of multi-material devices, both for dosing and for application on surfaces. In fact, these containers are often associated with a characteristic liquid dispensing system, called "trigger sprayer" which, due to its functional and formal complexity, and the high number of heterogeneous materials used for the different components, often represents a criticality in the recycling phase of the bottle, so much so as to require its separation and disposal in landfills. The development and production of these dispensing devices,

in recent years have evolved strongly, especially in response to the new B2B purchasing dynamics and the constant growth of the e-commerce phenomenon, particularly appreciated by companies in the home care sector, as a new sale channel. As highlighted by the consumption trends of plastic household cleaning products, many companies are investing resources and capital to optimize their products for sale on virtual commercial platforms, which require a subsequent phase of shipping the product to the final consumer. For this very reason, guidelines are being defined and standardized for the development of detergent products suitable for online sales (ISTA 6, 2016), whose final objective is to ensure the watertightness of the bottles and avoid the leak of liquids during the transport, maintaining the correct functionality of the spray dispensing system, even in case of particularly turbulent shipments. These guidelines, therefore, require a substantial formal and functional rethinking of the trigger sprayer, with a look at implementing a new set of design parameters, previously considered entirely secondary.

Therefore, the paper intends to describe the research, development and prototyping process, guided by the Life Cycle Design methodology, of a series of trigger sprayer applicable to bottles of home care products, conceived by the consulting company EcodesignLab Srl, spin-off of the University of Camerino, in collaboration with the company Aptar, studied to reduce the consumption of materials and the number of components able to meet the requirements for certification of “product suitable for e-commerce sales”. The purposes of the paper are those of bringing out the contribution of design with respect to the objectives described in the design-brief, and describing the results achieved, through the adoption of specific eco-design strategies (Giudice et al., 2006), in terms of component optimization and reduction of polymeric materials for the production of a new trigger sprayer.

2. Methodology of applied research and preliminary analyzes

The development process started from a preliminary phase of framing the design-brief, developed by the company which included: the development of a trigger sprayer, more sustainable and with a simplified design and a reduced number of components compared to a traditional one; the inclusion of a new plastic motor, developed by the Aptar company for dispensing the liquid; the use of plastic materials with a reduced environmental impact and the implementation of design solutions to make the product suitable for e-commerce sales, allowing it to pass the tests required by the protocol.

Therefore, the methodology implemented (Thiebat, 2019) to achieve the objectives listed in the brief, was divided into four macro-phases:

- technical-functional analysis of the prototype and the plastic engine developed by the R&D of the Aptar company;
- research, benchmarking and technical-functional analysis of the main home care products and related trigger sprayers;

- design and development of new trigger sprayer concepts through specific eco-design strategies;
- prototyping and ergonomic verification of an innovative trigger sprayer model.

The first macro-phase focused on the study of the trigger sprayer prototype developed and patented by the company and, in particular, on the advantages generated by the implementation of an innovative motor for dosing the single-material liquid.

The developed prototype is schematically made up of seven components, as shown in Figure 1: a dispensing nozzle (b) which, as in many traditional models, with rotation in one direction dispenses the detergent and in the other, closes the trigger to avoid accidental dripping of the liquid; an actuator (a) that allows the passage of liquid from the engine to the nozzle, designed to also perform the function of the external body of the product; a bellows motor (c); a cover (d) that binds the motor and connects the actuator with the ring nut to the thread of the bottle; a trigger (e) for operating the engine bellows and supplying the set dosage; a dip tube for the liquid (g), connected to the motor by means of an adapter and a ring nut (f) which binds the trigger to the body of the motor and connects the entire trigger sprayer to the thread of the bottle.

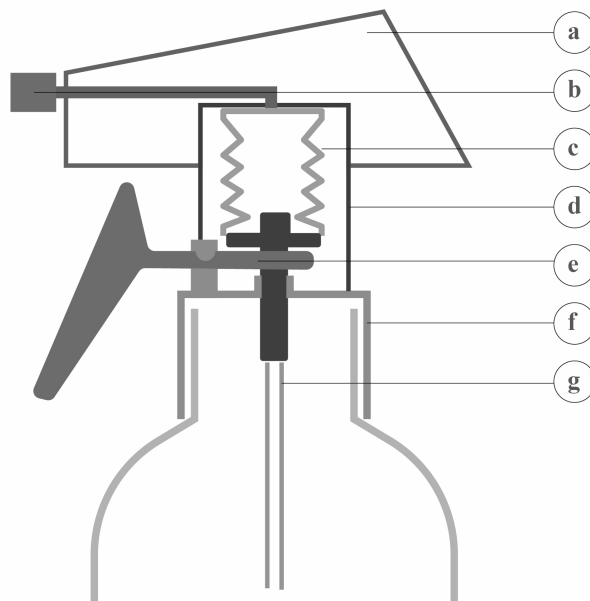


Figure 1. Aptar prototype functional diagram

The liquid is dispensed through the operation of a new type of motor, characterized by a bellows and an adapter connected to the dip tube, with a vertical layout: in the rest position, the two valves and the bottle vent are completely sealed; during the actuation and dispensing of the liquid, the trigger pushes the adapter, compacting the bellows membrane of the motor, and generating pressure inside of it. This pressure closes the internal valve, and opens the external one and, simultaneously, the vent of the

bottle opens, allowing the passage of the liquid inside the actuator and finally from the nozzle in the form of nebulized detergent.

One of the major innovations of this type of motor is that it is made entirely of plastic, without the use of traditional steel springs. In fact, the elasticity of the bellows system is exploited to generate, together with the trigger, both the pressure and the release of the adapter that closes and opens the vent of the bottle. In environmental terms, this single-material device becomes particularly advantageous for the disposal and the recycling phase of the entire bottle, allowing it to be disposed of in the appropriate bins for plastics, with the trigger sprayer still screwed to the bottle.

In fact, in most of the traditional models that still have the system with metal springs, the user should - for a proper disposal - separate the bottle from the trigger sprayer placing the former in the collection of plastic packaging while the latter in the unsorted collection.

After studying the technical and functional components of the new prototype in detail, an ergonomic analysis and usability analysis of the product was started, with the aim of identifying any critical issues and defining the outcoming improvement strategies. Through a photographic survey process, the anthropometric relationships and user experience in the detergent dispensing phase were documented, and the critical issues identified during the analysis were briefly described.

Once the study phase of the initial prototype was completed, we moved on to the second research activity, aimed at mapping and analyzing the main trigger sprayers on the shelf, in supermarkets and in stores that are specialized in household products. As it was done for the prototype study, an analysis sheet divided into five main sections was also developed:

- photographic survey of the product;
- main dimensions and overall weight;
- orientation of the engine layout (diagonal, horizontal or vertical);
- materials used for the main components;
- identification of project criticalities.

The benchmarking study, led to the development of 15 product sheets - some of which are shown by way of example (Figure 2) -, a summary sheet of the levels of usability noticed on the trigger sprayers (Figure 3) and two summary sheets with the design observations and the main critical issues relating above all to the experience of using the products (Figure 4).

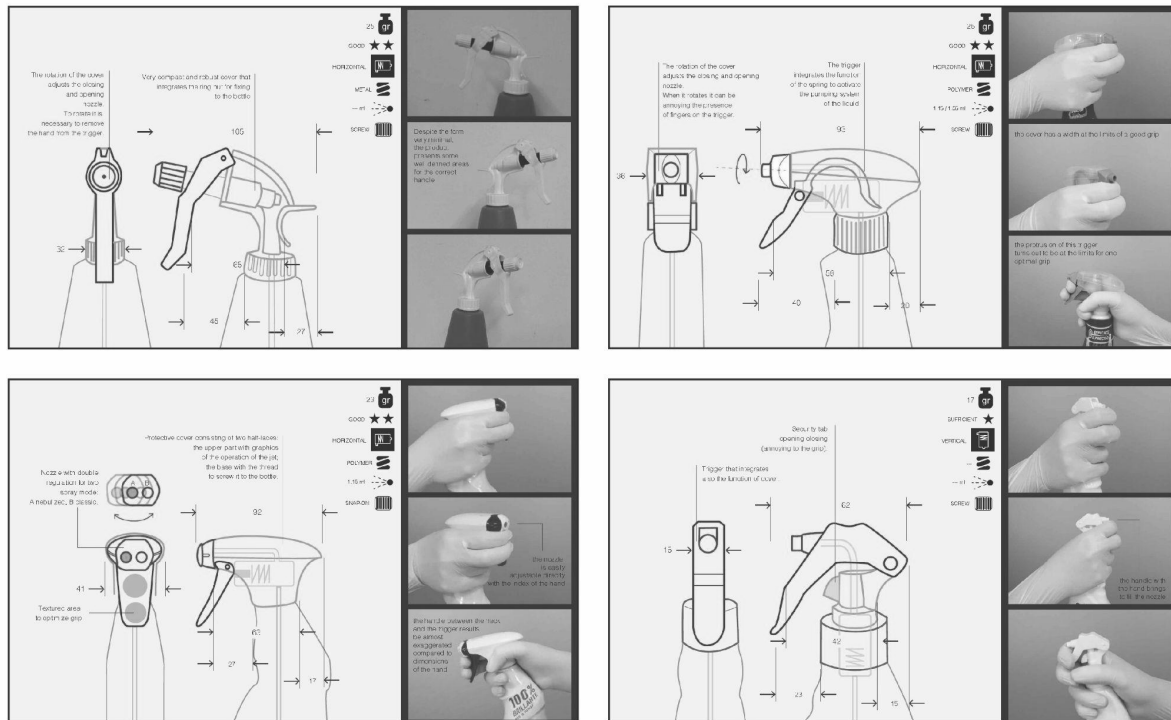


Figure 2. Examples of trigger sprayer filing, available on the shelf analyzed.

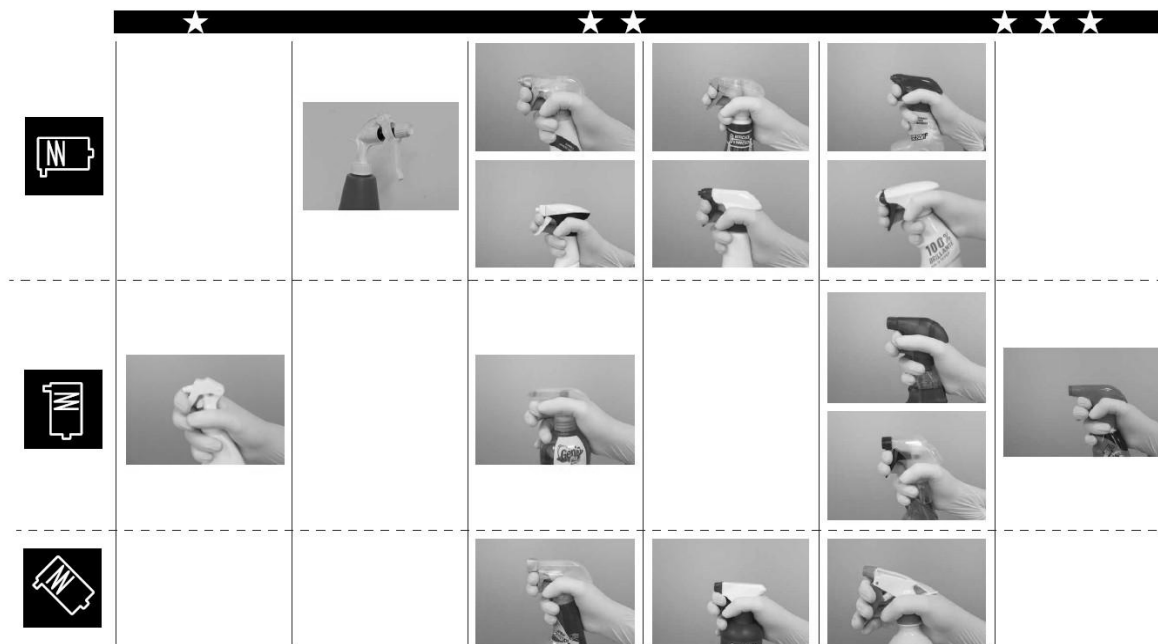


Figure 3. Summary sheet of usability level of the analyzed products.

The analysis of the products on the shelf, from an aesthetic-communicative point of view, has made it possible to develop design considerations with respect to the methods of preparation and the distinctive elements of the product. First of all, two main categories can be distinguished: trigger sprayers for home care use and trigger sprayers for professional use. In the first case - relevant to the

project - the characterizing element is a standard uniform layout for all products, consisting of a cover and a trigger. Through a careful observation, it is evident that the aesthetically relevant elements for the type of product examined are, above all, the shape and graphics of the bottles, mainly due to their large usable surface; at the same time, however, it is noted that the trigger sprayer, while being able to contribute to the general communication of products, does not have any area dedicated to the application of information labels. Another important observation is that most trigger sprayers are not coordinated with the shape or general aesthetics (texture, graphics, etc.) of the bottles to which they are applied; in fact, there are only few examples of trigger sprayers with styles and shapes in line with the bottle. The range of chromatic finishes detected is limited to 6 recursive colors (orange, green, red, gray, white and transparent), generally used in two-color mode. After studying the aesthetic and communicative identity of the products on the shelf, we moved on to a detailed analysis of the functional performance and components of 15 different types of dispensers for house cleaning, marketed under as many different brands. From this activity, features emerged in terms of practicality and usability of the product, which improve the user experience and represent crucial characteristics for the generation of new concepts:

- an external cover that prevents access to the pumping system;
- a morphology of the grip point that highlights the practicality of use and increases the general ergonomics of the product, especially in terms of weight balance;
- texturing of the surfaces, to highlight the correct position of the hand and fingers and to increase the grip;
- the safety closure nozzle usually integrates a sort of retina for the nebulization mode;
- the trigger is generally shaped to be pressed with only two fingers and its length influences the pressure required to nebulize the liquid (in products for professional use the trigger is longer to give greater strength and stability);
- in trigger sprayers for professional use, the body performs as both the function of trigger and actuator;
- the optimal dimensions of the trigger sprayers detected are between 92-94 mm in length and 30-34 mm in width and a variable distance between 52 and 54mm between the trigger and the shell that is screwed to the ring nut.

In addition to identifying the main aesthetic and functional characteristics of the products analyzed, some critical issues concerning the design were highlighted, which emerged in particular following the dispensing systems tests. The above-mentioned tests involved several operators, and focused above all on the user experience, evaluating both the ergonomic performance - such as the comfort of the grip and the ease of activating the trigger - and the functional performance of the dispensing system, when it is directed downwards, horizontally and finally upwards. From the tests carried out, it emerged that:

- it is difficult to rotate the nozzle to close it or change the dispensing mode if the product is held at the same time, since the fingers, which wrap the trigger, can block its rotation;
- if the size of the nozzle is too short, it is easy for "dripping phenomena" to occur during use, since the fingers can clog the dispensing hole and cause an annoying dripping on the hand;
- some triggers, have sharp edges and corners, that cause discomfort when using the product;
- often the coupling lines of the covers, are protruding and sharp, affecting both the ergonomics and the feeling of general comfort of the gripping point;
- the correct placement of the two fingers on the trigger and the distance of the latter from the back of the cover are crucial to define a good affordance of the product.

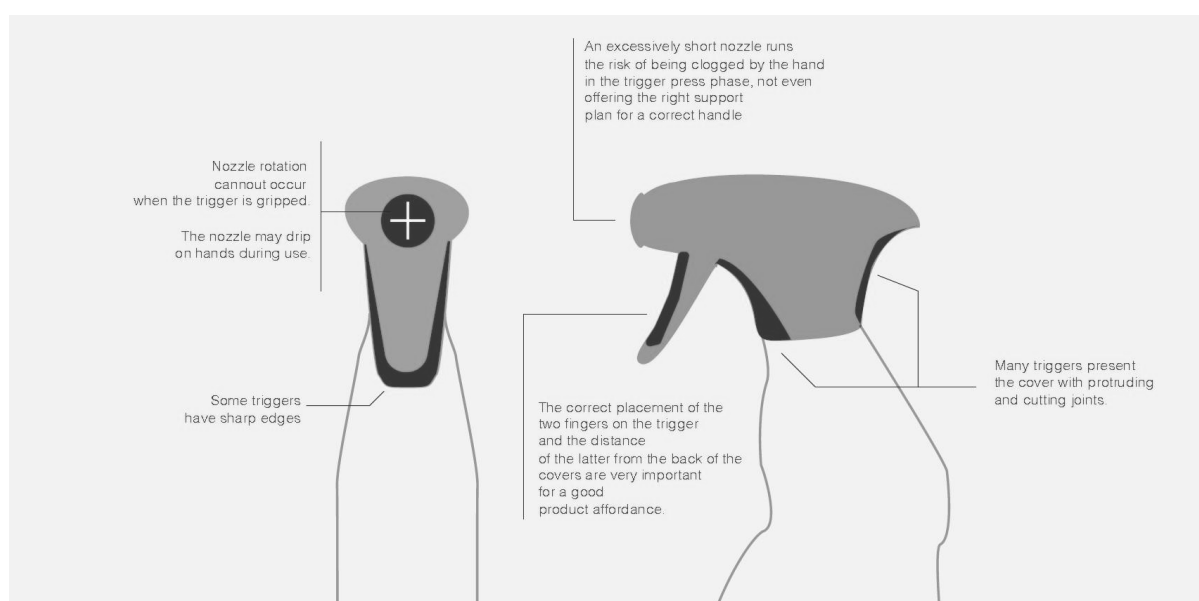


Figure 4. Summary sheet of the main criticalities and observations detected by the analyzes.

Following these activities, a third phase of design research was launched, divided into two main activities: the definition of the design strategies for the optimization and reduction of materials and components (Vezzoli and Manzini, 2007); the development of new trigger sprayer concepts with reduced environmental impact and suitable for e-commerce sales.

3. Macro-strategies to increase the environmental performance of trigger sprayers, for the home care sector.

The main macro-strategies identified for product improvement and optimization, are focused on the layout of the engine and on the possibilities of lightening the bodies, to reduce the consumption of plastic material. With respect to the possible optimal arrangement of the engine, three layouts have been conceived: vertical, at 45 °, and horizontal, as shown in Figure 5.

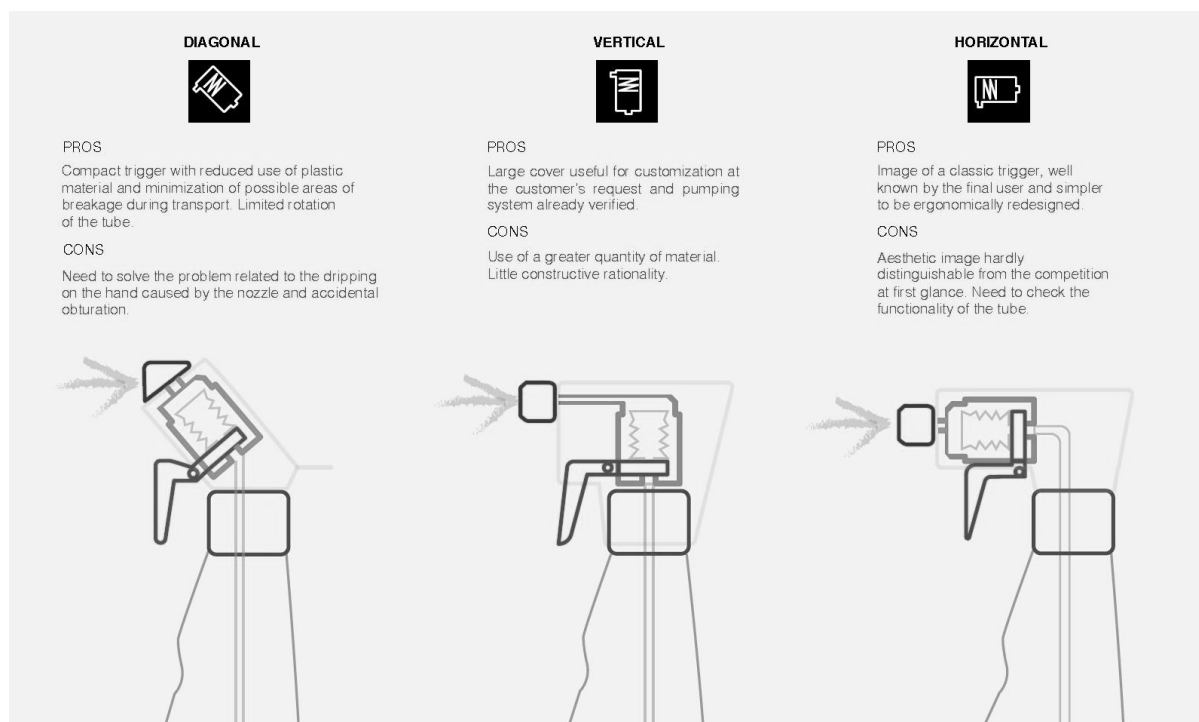


Figure 5. Summary sheet of the design benefits and criticalities in relation to the possible engine layouts.

The hypothesis of a layout with a vertical motor, would have allowed the use of an already tested pumping system, together with the advantage of having a large cover, functional to personalize the product and to accommodate in an optimal way - in ergonomic terms - the user's hand. However, this solution demands a greater use of material, and a poor constructive rationality, having to transform the horizontal movement of the trigger of the thrust system of the bellows motor, into a vertical one.

In the case of a motor positioned at 45°, the trigger would be more compact with the double advantage of limiting the risk of breakage during transport and obtaining a drastic reduction in the plastic material during the production phase. In addition, the inclined position of the motor would also limit the twisting of the dip tube, during the release of the liquid, a drawback detected in the prototype analysis phase. This arrangement, however, risks generating the undesirable dripping-on-the-hand effect, due to a possible obstruction of the nozzle by the fingers, and the consequent and necessary oversizing of the object itself.

The third hypothesis, the one with a horizontal position of the engine, would have allowed a classic layout, well known by the end user, and easier to be ergonomically redesigned, based on the knowledge acquired during the analysis. This solution would have needed a particular connection though, between the motor and the dip tube, to be designed ad hoc.

With regard to the second macro-strategy, to reduce the quantity of plastic material, three different lightening solutions have been developed, each related to a specific arrangement of the engine: the

first, with the motor in a vertical position, described in the subsequent concept "A", involves the design of a series of holes and slots capable of reducing the plastic material and generating textured surfaces to favor the grip of the product during the use; the second with the engine in a diagonal position, proposed in the concept "B", is characterized by both the reduction in volume and the compact design of the cover, responsible for the protection of the engine; the third solution, the most innovative with the motor in a horizontal position, assumes a grouping of numerous parts of the product and proposes a new mode of interaction that allows the general dimensions of the object to be reduced.

Therefore, the main results achieved - in terms of environmental sustainability and product usability - from the design development of the three new concepts of trigger sprayers suitable for sale through the e-commerce channel, will be discussed in the next paragraph.

4. Three concepts of trigger sprayers with reduced environmental impact and suitable for e-commerce sales for the Aptar company

The preliminary research phases and the aesthetic-functional analysis of the products were fundamental to frame the technical-production context and to set up strategies for the optimization and environmental improvement of the new design proposals. The main results, achieved by the methodological process and the adoption of the eco-design guidelines, are the development of three new concepts of trigger sprayers, summarily called: concept "A", concept "B" and concept "C".

The concept "A", features a vertical motor, as already foreseen in the initial prototype provided by the company, and is characterized by the development of a trigger which, in addition to fulfilling the function of cover, has a series of slots and holes, to reduce the use of plastic material and at the same time favor the grip in the main grip points of the product. The concept, shown in Figure 6, consists of four main components: a ring nut connecting the bottle, which integrates the large, visible hinge; a trigger locking device, which is activated by rotating it around the ring nut, and guarantees the watertight seal of the product, preventing the detergent from spilling out during the transport phase; a trigger that completes the visible hinge, and integrates the pressure piston of the engine bellows and the liquid outlet nozzle. The peculiarity of this model is certainly the shape of the trigger, which replaces the traditional plastic cover shells. Furthermore, compared to the models proposed on the market, which are very thin and not very functional, solutions have been studied to increase performance, in terms of ergonomics and usability. In fact, the surface of the trigger has been sized to accommodate the fingers of the hand in an optimal way, but without adding any plastic material. To further reduce the use of the material, the trigger has been lightened, thinking of two different excavation layouts: the first, which allows a reduction of the polymer used by about 12%, involves the creation of a series of micro-perforations in the designated areas in contact with the fingers, thus also obtaining a pleasant grip, to improve the use of the product with wet hands; the second is configured

in four large slots, three to highlight the areas where to insert the fingers on the trigger and one in the upper part near the hinge, to lighten the product overall. This second solution leads to an estimated polymer reduction of around 16%. In conclusion, Concept "A" is the result of a design process, which has adopted multiple ecodesign strategies: the first was to incorporate the function of the cover into the geometry of the trigger, so as to avoid the production of another component; the second was to provide micro-perforations or slots to reduce the material used, emptying the non-functional areas of the product and at the same time improving the user experience and comfort, through the generation of a surface with greater grip.

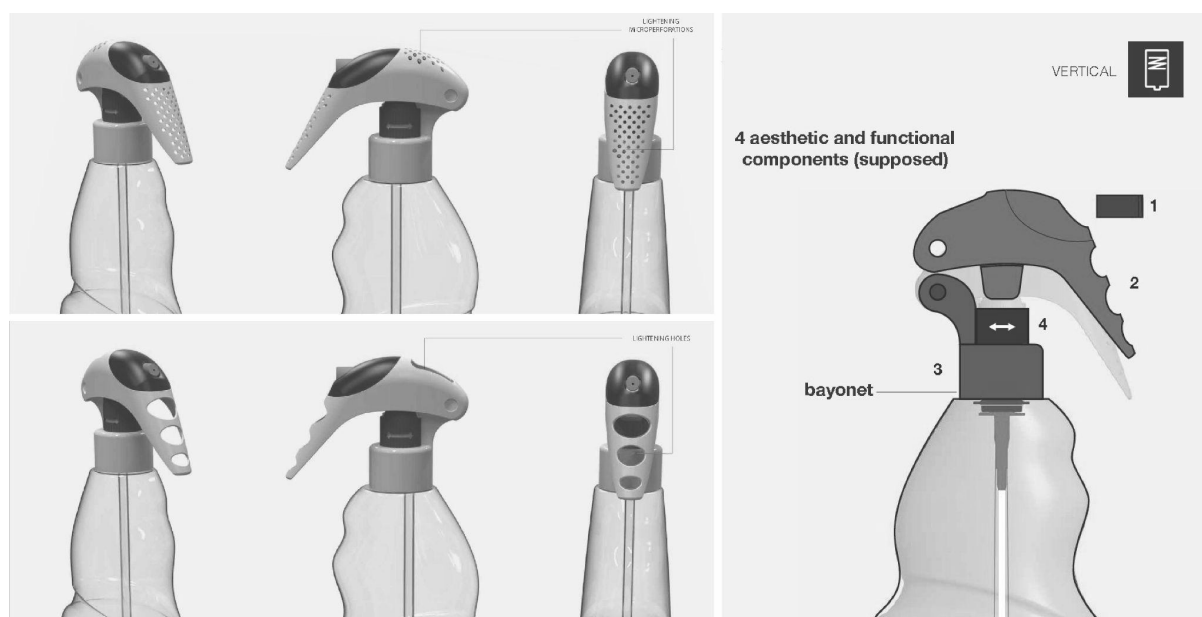


Figure 6. Concept "A".

The concept "B", shown in Figure 7, unlike the prototype analyzed in the preliminary research, has a diagonal motor orientation with a 45 ° inclination. This model is characterized by its compact design and a directional nozzle, for a more effective dispensing of detergent, even in the most critical areas of the house (corners and high surfaces). The architecture is mainly made up of five parts: a half-cover designed to protect the engine and characterized by a special fin designed to balance part of the weight of the product on the back of the hand; a second half-cover that closes the shape of the cover and integrates the thread to screw the trigger sprayer to the bottle; a trigger for dispensing; a safety pin, to guarantee the sealing of the detergent during the transport phase and a directional nozzle through its rotation.

The peculiarity of this concept is certainly the development of a compact cover, with greatly reduced volumes and high storage density. In fact, with respect to the architecture of the initial prototype, an attempt was made to rationalize both the number of components - reducing them to four - and the distribution of the material to produce the bodies. This process of optimization and rationalization of volumes has led to a reduction in plastic material, estimated to be at around 18%. Furthermore, a new

dispensing method has been hypothesized to direct and optimize the jet, even in the most critical points, since from the preliminary analyzes it was observed that to spray the detergent on surfaces placed in angles or at a certain height, it is necessary to rotate or overturn the bottle. This dynamic results in poor dispensing efficiency, because the dip tube is unable to pull out the needed quantity of detergent from the bottle. Therefore, a solution that provides for the rotation of the nozzle has been conceived, in order to direct the jet towards the critical points and, at the same time, keep the bottle vertically, to facilitate the flow of the detergent into the dip tube. In conclusion, the concept "B", is the result of a design process that adopts the strategy of rationalizing functional parts and optimizing volumes, in order to reduce the largest possible amount of plastic material for their industrial production.

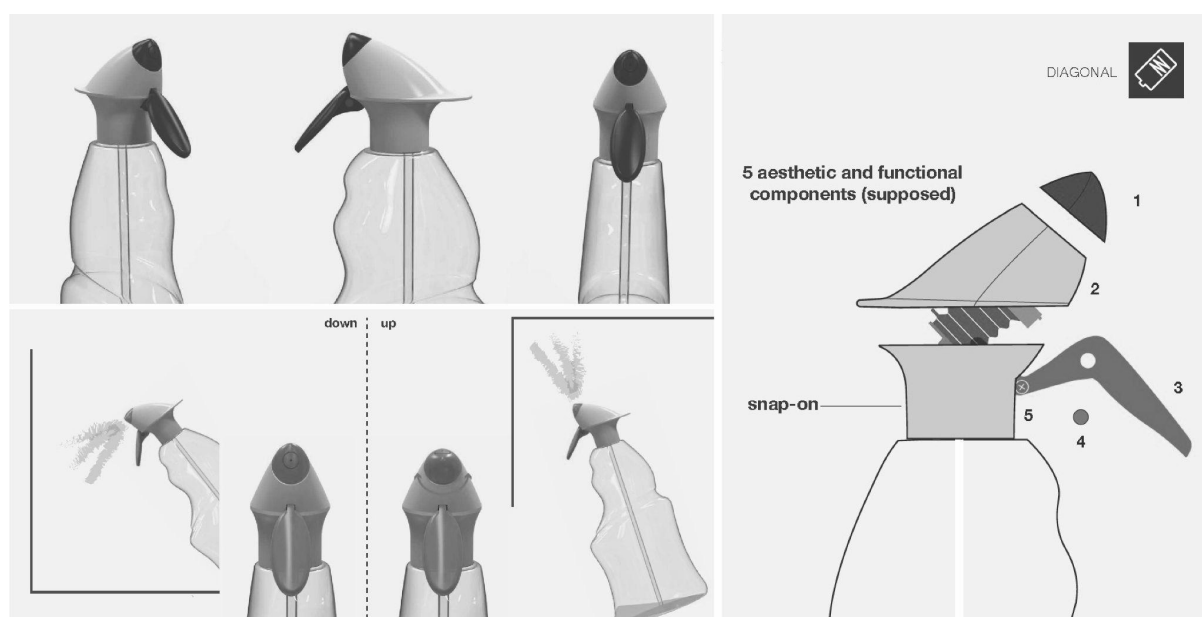


Figure 7. Concept "B".

The concept "C", shown in Figure 8, unlike the two previous design solutions, presents a horizontal engine layout, and differs from traditional delivery methods, taking inspiration from nasal nebulization systems. The solution proposes a typological innovation, having - although atypical compared to other consolidated types on the market - the great advantage of optimizing the efficiency of the engine and ensuring the safety of the product during transport. The architecture of this model is mainly made up of 3 components: two half-shells, one of which has the ring nut for fixing to the bottle, suitably assembled to protect the motor and designed to facilitate the grip of the product through soft shape and textured areas, and a new component that integrates trigger and nozzle. The operating principle is very similar to that of the established nasal spray dispensers: gripping the product with the trigger/nozzle inserted between the index and middle fingers of the hand, it is possible to press and compress the bellows motor, which generates the jet and the nebulization of the detergent. Compared to both traditional models and the two previous concepts, this solution has no

center of rotation of the trigger, as it axially pushes the bellows of the motor, increasing the general efficiency of the liquid dispensing and eliminating one of the major problems of the product during transport, that of the breaking of the trigger at its weakest point: the hinge. For the design of the handle and the development of a shape capable of guaranteeing the ergonomic performance required by the customer, various hypotheses of geometries were made, and prototyping activities started, supported by preliminary tests and focus groups, aimed at optimizing and refining the three models developed.

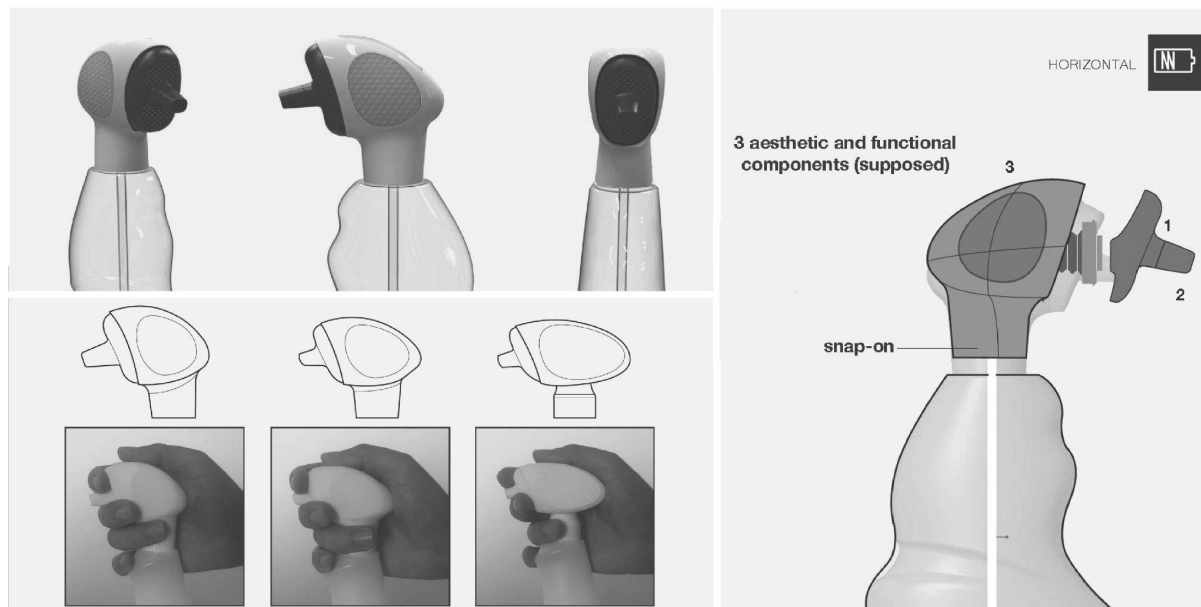





Figure 8. Concept “C”.

The conception of this delivery system designed around the horizontal arrangement of the engine has made it possible to generate an unprecedented concept of trigger sprayer, compact and rationalized in the components, capable of optimizing its industrial production process. Adopting a strategy of integration of functions, through the development of the cover with the integrated ring nut and the innovative trigger, which incorporates the geometry of the nozzle and makes it compact and safe for the transport phase without the use of special safety rings, it is possible to hypothesize a fair reduction of the plastic material, estimated at around 7%.

In the next page, Table 1 shows the main estimated results achieved by the development and design process of the new trigger sprayer concepts.

Table 1. Summary of the main results achieved through eco-design strategies.

| concept trigger sprayer developed | n° COMPONENTS (supposed) | % MATERIAL REDUCTION (supposed) |
|---|--------------------------|---------------------------------|
| A  | 4 | 12-16 |
| B  | 5 | 18 |
| C  | 3 | 7 |

5. Conclusions

As discussed in the paper and briefly shown by the numerical values in the previous table, adopting the methodology set out in the preliminary research and analysis phases and applying the DfS criteria to the development of a new trigger sprayer "suitable for e-commerce sales", it was possible to obtain significant benefits, compared to the main commercial types analyzed and to the initial prototype by the Aptar company, in terms of:

- rationalization of the basic components of the product;
- optimization of the technical-production aspects of the individual components;
- design of new formal and functional strategies to make the trigger sprayer product more compact and resilient to the transport phase;
- proposing new dynamics of user-product interaction, centered on both the efficiency and effectiveness of the expected action and the result obtained;
- creation of a new type of trigger sprayer, in reference to the concept "C", unpublished for the reference commercial segment.

The strategies of the DfS transversal to all the concepts developed - aimed primarily at rationalizing both the material used and the number of product components - have shown that it is also possible to reduce the number of steel molds and the material used for their production. Furthermore, the elimination of the traditional metal spring - made possible by the great technical innovation of the plastic bellows motor developed by the Aptar company - has allowed the product to be reconfigured, in the key of an extreme integration of the components, consistent with the new expected "end-of-life" of the trigger sprayer, which can be completely disposed of in the plastic recycling bin.

In conclusion, the tools and methodologies adopted, typical of a design process guided by Design and the adoption of eco-design strategies and guidelines, have allowed the development of three highly eco-efficient trigger sprayer concepts, capable of responding in an innovative way, to the emerging e-commerce market. In addition, they have proved to be a strategic and supportive lever for the R&D group of the Aptar company, towards an environmental, functional and aesthetic innovation of this specific type of product. The further advancement of this design experience has led the company to develop a new mono-material product, both in the internal functional components and in the external aesthetics, completely recyclable at the end of its life, which will be marketed by the main international markets in the coming months.

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