Clothing development process towards a circular model

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ABSTRACT – REZUMAT

Clothing development process towards a circular model

The textile and clothing industry uses many resources. It causes a lot of environmental problems: water pollution, consuming a massive amount of raw materials, energy, chemicals, etc. The garments are produced to be worn and cleaned several times, and their lifespan is considerably reduced. Over 60% of what the consumer buys, becomes unuseful (either the consumer forgot what he/she has, or the product is not fashionable anymore, or it does not fit). It is compulsory and essential to understand the necessity of creating a new balance between the use of resources, the lifespan of the products and consumer behaviour. Closing the loop and building a new understanding of how the textile and clothing industry can exist is the key to the future – to develop and implement the circular business model. This type of business implies some changes in the production flow: the materials are recycled in several rounds, the design process has to take into account several lifecycles of the items (with the same destination or a different one), the products are designed to be re-included in a system where it is possible, and the consumer has to be educated to accept these categories of products. Each stage of the production process has to be sustainable, environmentally friendly and with a low production cost. In terms of a sustainable design process, this paper presents the main stages of the designing process of a garment (leisure sports jacket), with a versatile shape and usage (garment/ backpack). The garment is designed and manufactured to allow and the vice-versa transformation without any technological modifications. By using a creative and feasible design and manufacturing solution, the waste of worn garments will be considerably reduced, and the product lifespan prolonged, as much as it is possible.

Keywords: *circular economy, versatile garment, design for durability, prolong the lifespan, detachable garment parts*

Dezvoltarea conceptuală a produselor de îmbrăcăminte adaptată unui model de economie circulară

Industria textilă și de îmbrăcăminte folosește numeroase resurse. Din acest motiv apar multiple probleme de mediu: poluarea apei, consumul unei cantități masive de materii prime, consumul de energie, consumul de substanțe chimice etc. Produsele de îmbrăcăminte sunt realizate pentru a fi purtate și curățate de mai multe ori, iar durata lor de viață este considerabil redusă. Peste 60% din ceea ce cumpără consumatorul devine inutil (fie consumatorul a uitat ce deține, fie produsul nu mai este la modă, fie nu se mai potrivește ca mărime). Este obligatoriu și esențial să înțelegem necesitatea creării unui nou echilibru între utilizarea resurselor, durata de viață a produselor și comportamentul consumatorului. Închiderea buclei și construirea unei noi înțelegeri a modului în care industria textilă și de îmbrăcăminte poate exista este cheia viitorului – dezvoltarea și implementarea modelului de afaceri circular. Acest tip de activitate implică unele schimbări în fluxul de producție: materialele sunt reciclate în diferite etape, procesul de proiectare trebuie să țină seama de mai multe cicluri de viață ale produselor (cu aceeași destinație sau una diferită), produsele sunt concepute pentru a fi reincluse în sistem, dacă este posibil, iar consumatorul trebuie educat să accepte aceste categorii de produse. Fiecare etapă a procesului de producție trebuie să fie durabilă/sustenabilă, ecologică și cu un cost de producție redus. În ceea ce privește un proces de proiectare durabil/sustenabil, această lucrare prezintă principalele etape ale procesului de proiectare ale unui produs de îmbrăcăminte (jachetă tip sport de agrement), cu o formă și utilizare versatilă (îmbrăcăminte/rucsac). Produsul de îmbrăcăminte este proiectat și fabricat astfel încât să permită transformarea versatilă, fără modificări tehnologice. Prin utilizarea unei soluții creative și fezabile de proiectare și fabricație, se reduce considerabil cantitatea de produse de îmbrăcăminte utilizate, iar durata de viață a produsului va fi considerabil extinsă.

Cuvinte-cheie: *economie circulară, produs de îmbrăcăminte versatil, design pentru sustenabilitate, prelungirea duratei de viață, repere detașabile ale produsului de îmbrăcăminte*

INTRODUCTION

The textile and clothing (T&C) industry is a diverse and heterogeneous field of activity. It is an essential part of the European manufacturing industry, playing a crucial role in the economy and social well-being of multiple regions of the EU.

In 2019, the entire EU-28 T&C industry represented a € 162 billion turnover. According to the Euratex Key Figures of the Textile & Clothing Industry 2019, the EU T&C industry is formed by 160.000 Textile & Clothing companies, most of which are SME's [1, 2]. The European Commission recently identified the significant potential of this sector to become part of

the circular economy, calling out textiles (apparel and fabrics) as a priority for future development [3].

EURATEX and European Technology Platform developed (October 2016) the document "Towards a 4th Industrial Revolution of Textiles and Clothing – A Strategic Innovation and Research Agenda for the European Textile and Clothing Industry" [4]. According to this document [4], the first seeds of the 4th Industrial Revolution are currently being shown in the European textile and clothing industry. However, significant investments in research and development, and worker education will be necessary for the coming years to achieve the goal of having truly smart textile and clothing factories.

One of the significant Strategic Innovation Themes and corresponding Research Priorities for the next years is Circular Economy and Resource Efficiency, along with:

- Novel flexible process technologies for saving water, energy and chemicals
- High-tech textile recycling for circular economy concepts
- Sustainable substitutes for hazardous and restricted textile processing chemicals or biochemistry based textile processing
- Bio-refinery concepts using European biomass or waste for textile fibres
- Greater use of EU-origin natural fibres.

Recently, the European Commission issued the novel "Industrial Strategy for a globally competitive, green and digital Europe", which mentions three key priorities: maintaining the European industry's global competitively and a level playing field (both locally and globally), making Europe climate-neutral by 2050, and shaping Europe's digital future [5].

In this context, innovation and market potential of the European textile and clothing industry are intimately related to what is known as "Circular Economy". The latter provides a guideline for making investments in production technology (cleaner and less resource-consuming), product development (more sustainable products, focus on recyclability, prolonged lifespan), and for the selection of textile materials (more focus on the use of sustainable fibres).

However, the industry still faces tough challenges in the transition from a traditional linear production and consumption model (take – make – dispose of) to a circular one. In this case, cooperating with all stakeholders in production, retail and waste processing is essential.

Forward, this sector is going to operate according to a globalised and efficient circular economic model (figure 1) that maximises the use of local resources, exploits advanced manufacturing techniques and are engaged in cross-sectoral collaborations and strategic clusters. It is also going to implement profitable and inclusive business models and attract skilled and talented entrepreneurs and employees [6].

Euratex is developing a successful EU Textile Strategy for Circular Economy as a solution for both

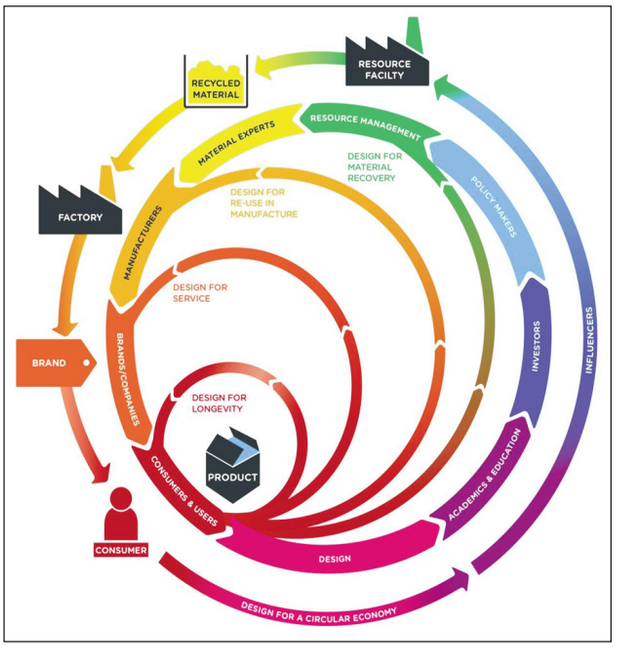

Fig. 1. Globalised circular economic model [7]

social and economic problems. It also aims at reconciling the Environmental-Social-Economic sides of sustainability in the sector and at providing resources for resource-decoupled growth, especially for the European SMEs and the employment they provide. 12 specific points were identified as necessary for making the EU textile circular economy a reality: partnerships between buyers (fashion brands/authorities) and makers (from fibres to finished products) needs, demand lowers cost, product design (or designed for circularity, which includes: i) design for recycling or ii) design with recycled or regenerated materials or iii) design for longevity), consumers, life cycle assessment (LCA), standards, collecting and sorting, green public procurement, the legacy of chemical, national barriers, public-private funding, and new services.

The principle of the circular economy is to minimise waste through cycles of reduction, reuse, and recycling with limited leakage and minor environmental impact [8, 9]. Even though the benefits of the circular economy are relatively well understood, there are still very few examples of companies that have implemented this paradigm [10]. Recent studies observed and analysed the circular economy business model of Eileen Fisher (EF), New York [11]. The study explored how the company had developed its take-back programme and how this programme led to the development of recycling operations at EF. Results were summarised in an analysis of the strengths, weaknesses, opportunities and threats (SWOT) to highlight the advantages and challenges the company faced when it adopted the circular economy concept. The results indicated that a circular economy approach in the luxury fashion industry is possible and is beneficial to extended business, and while both generating revenue and reducing environmental degradation.

PECULIARITIES OF THE DESIGN/MANUFACTURING PROCESS IN THE CONTEXT OF THE CIRCULAR BUSINESS MODEL

The clothing development process is defined as one which turns a concept/idea into a physical item with a specific destination. This process involves several stages of transforming textile materials by using different categories of textile equipment, IT tools, and trained labour force.

Traditional clothing manufacturing processes incur costs determined by the use of raw materials, force labour, energy, water supplies, and other sources.

The producers in the field of clothing, like any other goods manufacturers, must always be aware of the pulse of the market, its financial potential and resources. They should adapt their strategies to the new requirements of nowadays by adopting the circular business model, with a rethinking of the design and production processes, and extending of the product lifecycle, usage flexibility, and diversity.

Some manufacturers have already adopted some of these new measures; they collect the used products from the customers and turn them into raw materials and other final products.

Consumers must be aware of all of these issues; they have to learn to prolong the lifespan of textile products, which means that the latter must also be designed for this purpose. This goal can be accomplished by adhering to the following principles: a design for durability, design for long-lasting style and design for disassembly [12].

The first principle requires textile products to be manufactured in a way that enables them to be resilient to the usual wear and tear and to withstand abrasion and washing. The choice of durable, high-quality fabrics and other components is vital for this purpose, along with how seams are executed (so that they can withstand tearing) [13].

The second principle refers to the users' sensitivity to style and the changes in fashion trends. By carefully selecting colours and styles that are regarded as timeless and appealing to a wide range of customers, designers prevent the items from being perceived to be out-of-fashion and dispose of. Moreover, timeless items retain a higher value on the second-hand market, further encouraging prolonged use and reuse.

Finally, how a textile product is assembled determines how easily it can be disassembled to facilitate maintenance, component reuse and/or recycling. For this purpose, design-for-disassembly strategies choose to stitch over gluing, avoid fusible interfacing by using blind hemming and use low-density stitching.

DESIGN FOR DURABILITY

Its purpose and consumer habits influence the lifespan of a garment product. The lifespan of the product is variable and is determined by:

- the type of product: usual, for special occasions, sports, protective or with a particular destination (medical, technical, etc.)
- the shape of the customer's human body, which can be: standard (in terms of proportion, conformation and posture), particular (characterised by asymmetries or peculiar proportions, conformation, or posture), or with disabilities [14];
- how often is the product used;
- the quality of materials used in the production process and the technical accuracy of the operations involved;
- the storage, usage and maintenance conditions;
- the user's habits and background: level of education, financial resources, social status, purchasing habits (some customers might tend buying more frequently than necessary).

Figure 2 explains the circuit that a garment undergoes during its lifespan:

– branch A → using/cleaning (these actions are repeating), and disposal (when the item does not meet the consumer requirements);
– branch B → using/cleaning (these actions are repeating), transformation, reuse/cleaning (repeating), and disposal (in the end).

Branch A corresponds to a linear circuit, whereas branch B contains a loop that extends the lifespan of the product. The latter describes a circular model, in which the item is re-introduced in the usage circuit (with the same destination or with a different one) and used to the greatest extent possible.

The garment transformation process is conditioned by how the garment was designed and manufactured. Thus, several aspects have to be carefully considered:

- the structure and the complexity of the model (number of layers, pieces, category of accessories);
- the shape of the style lines (curvature, length, number, etc.)
- the properties and characteristics of the materials (physical, mechanical and surface properties, colours, types of structure, colours, motifs, etc.)
- the manufacturing technology (the type of stitches, assemblies, number of layers in an assembly area);
- the garment destination and style: casual, streetwear, ethnic fashion style, formal office wear, business casual, evening black-tie, sportswear, haute couture, modest fashion, etc.

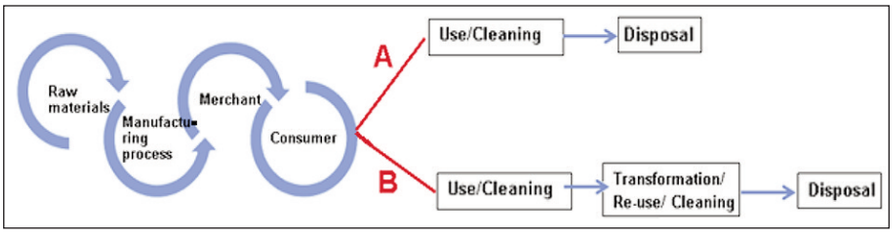

Fig. 2. The lifespan of garment products

- the category of consumers for which it is intended: children (all growing and development phases, teenagers), adults (different ages), etc.
- variants of design and manufacture solution to obtain the garment.

A garment transformation process can be carried out by either keeping the initial intended purpose of the object or by altering it:

- keeping destination → some parts or layers of the garment are replaced or removed;
- changing destination → the garment is used in different ways, without affecting its structure. In this case, we can say that the garment is flexible or versatile one: its transformation can last for a long or a short time, according to the user's preferences.

DESIGNING A VERSATILE GARMENT

In what follows, we are going to present a model of a versatile leisure sports jacket. This type of jacket can be used in two different ways: as a garment or as a backpack.

The design and manufacturing processes are approached to ensure its durability:

– the garment must have some detachable parts whose position can be changed;
– the materials, accessories and manufacturing process ensure the use of the item in both variants;
– the transformation process does not involve technological modifications.

The garment patterns and manufacturing process have to be developed while keeping in mind that the consumers should be able to transform the item by themselves by following precise and simple instructions.

The selected model is presented in figure 3. Because it is a leisure sports jacket, it can be made from fabric which contains cotton fibres. It is also meant to have different accessories placed in different positions to allow its uses. The model has-zippers, pockets with flaps, straps and special pressure staples.

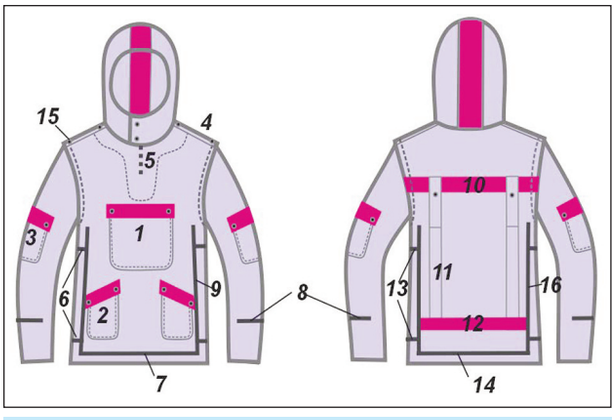

Fig. 3. Leisure sport jacket: *1* – central pocket; *2* – lateral pockets; *3* – sleeve pocket; *4* – shoulder strap; *5* – middle zipper; *6* – front longitudinal zipper; *7* – front longitudinal zipper; *8* – sleeve zipper; *9* – front vertical zipper; *10* – band; *11* – straps; *12* – band; *13* – back longitudinal zipper; *14* – back longitudinal zipper; *15* – pressure staples; *16* – back vertical zipper

Description of the front side

The front side is composed by one main piece with three pockets: one central (1/3 of the central pocket is above the bust line, and 2/3 below) and two other ones placed below the waistline (figure 3). The pockets have rounded corners, and they are also equipped with flaps at the opening line (rectangular-shaped for the upper pocket and parallelogram-shaped for the others). The jacket has a zipper, placed on the middle line, whose purpose is to dress and undress the garment. The facing corresponding to this area is shown in figure 3.

The jacket is also equipped with a hood, well-shaped around the head and the neck, which is made of three pieces (the central one has a rectangular shape). The hood is buttoned with two pressure staples.

The jacket is equipped with zippers covered by pleat facings at the shoulder level. The shoulder area is attached with two pressure staples (one on the right-hand side and one on the left-hand side).

The front is equipped with two vertical zippers (9) and other longitudinal ones (6 and 7), whose purpose is to allow the jacket to transform into a backpack.

Description of the backside

The backside consists of one piece that is equipped with two straps (11), placed symmetrically to the middle line of the backside. Each strap has a loop fixed with a pressure staple. The backside has also got two bands (10 and 12), whose purpose is to reinforce the vertical straps of the backpack. The band (10) is placed at the shoulder blades level, whereas the other one (12) is placed at the hip level. For fashion reasons, these two bands, the pockets flaps, and the central piece of the hood have the same colour.

The backside has zippers: two vertical one with the same length as the front side (16) and horizontal ones as well – the two zippers (13) (symmetric, placed on both the right and left-hand sides) are at the same level as the ones on the front side (6), and the zipper (14) is placed at the same level as the one on the front side (7).

The zippers (7 and 14) are detachable because they are meant to play a role in forming the bottom part of the backpack.

The description of the sleeves

Each sleeve consists of one piece and is equipped with pockets. The latter is placed on the middle line of the sleeve, and they have rectangular flaps. The sleeves are attached to the jacket with zippers and, covered by pleated facings.

The outer material contains 35% cotton and 65% PA, while the reinforcing bands and the middle piece of the hood are entirely made of PES (pink neon colour to ensure excellent visibility, figure 3).

Designing the patterns of the model

The shapes of the pieces of the jacket are designed by first drafting the patterns of the main elements (front, back, and sleeves) and by doing the same for

the patterns of the other pieces afterwards (hood, pockets, flaps, straps and facings).

The 2D shape of the pattern blocks are drafted in the Modaris software environment (LECTRA Systems). The shape of the patterns is drawn using specific values. These values are calculated with mathematical relations, whose structure is determined by several factors: the size and shape of the garment (numerical values of lengths and widths), the shape of the human body (dimensions of the body, conformation, proportions), model cut lines, and ease allowances (see figure 4).

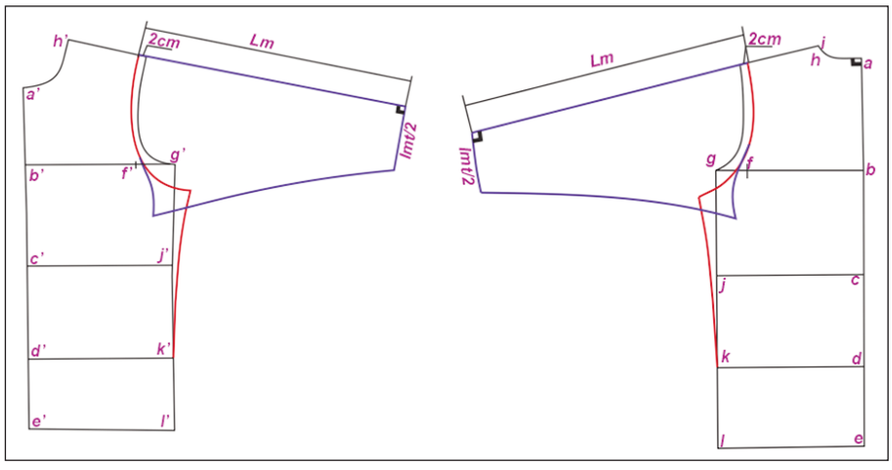

Fig. 4. 2D shape of the pattern blocks

The initial data used to draw the patterns are the body height (l_c), the bust perimeter (P_b), the jacket length (L_{pr}), the sleeve length (L_m), the sleeve width (l_{mt}), and bust ease allowance (A_b).

To be able to draft the hood pattern, one needs to know: the height of the head area (including the neck), the head perimeter neck and the characteristics of the desired hood model. The block starts from point (a) by drawing a rectangular angle.

Mathematical relations:

$(a-b) = P_b/10 + k_1$, k_1 = the value is influenced by the posture of the human body and by the structure of the garment;

$(a-c) = l_c/4 + k_2$, k_2 = the value is determined by the posture of the human body, the structure of the garment, silhouette and cutline;

$(c-d) = l_c/10 + k_3$, k_3 = the value is determined by the posture of the human body, the structure of the garment, silhouette and cutline;

$(a-e) = L_{pr}$ = initial data

$(b-f) = (P_b/8 \pm k_4) + c_1 * A_b$, k_4 = the value is determined by the posture and conformation of the human body, the structure of the garment, silhouette and cutline;

c_1 = a fraction of the bust ease allowance intended for the backside; it is determined by the posture and the conformation of the human body, the structure of the garment, silhouette and cutline;

$(f-g) + (f'-g') = (P_b/8 \pm k_5) + c_2 * A_b$, k_5 = the value is determined by the posture and the conformation of the human body, the structure of the garment, silhouette and cutline;

c_2 = a fraction of the bust ease allowance intended for the armhole; it is determined by the posture and the conformation of the human body, the structured garment, silhouette and cutline.

$(f'-b') = (P_b/4 \pm k_6) + c_3 * A_b$, k_6 = the value is determined by the posture and the conformation of the human body, the structure of the garment, silhouette and cutline;

c_3 = a fraction of the bust ease allowance intended for the armhole; it is determined by the posture and the conformation of the human body, the structure of the garment, silhouette and cutline;

$(a-h) = P_b/20 + k_7$, k_7 = body posture and conformation of the human body, the garment structure, silhouette and cutline influence this parameter.

$(h-i)$ = constant value (2.5 cm)

The vertical distance between points (b') and (h') = $= (a-b) + 3.5$ cm.

The sleeve patterns are drafted in the blocks of the back and front, as it is explained in figure 4.

The chosen model implies the following changes in the main garment elements:

– change the position of the bust line (decreases by 3–5 cm), figure 4;
– increase the backside and frontside width, each by 2–4 cm, figure 4 (red line);
– lift the shoulder point by 2 cm.

Figure 5 shows the new armhole and sideseam lines (front and back). The style lines and design features (for the pockets, hood, facings, straps, flaps, and everything else that is necessary to ensure that the garment can be used for its intended purpose) are marked on the patterns.

The manufactured item has to ensure the use in both ways; from this reason, the category of accessories, sewing threads, sewing parameters and manufacturing stages were attentively established:

– the sleeves are attached with zippers, covered by pleat facings and fixed with special pressure staples;
– the jacket is equipped with zippers on the shoulder line (to attach the front and the back sides), covered by straps and fixed with pressure staples;
– the jacket is equipped with vertical and horizontal zippers (placed on the front and the back sides) to cover some folded parts of the jacket;
– the zippers placed on the sleeves are meant to cover some of their folded parts;

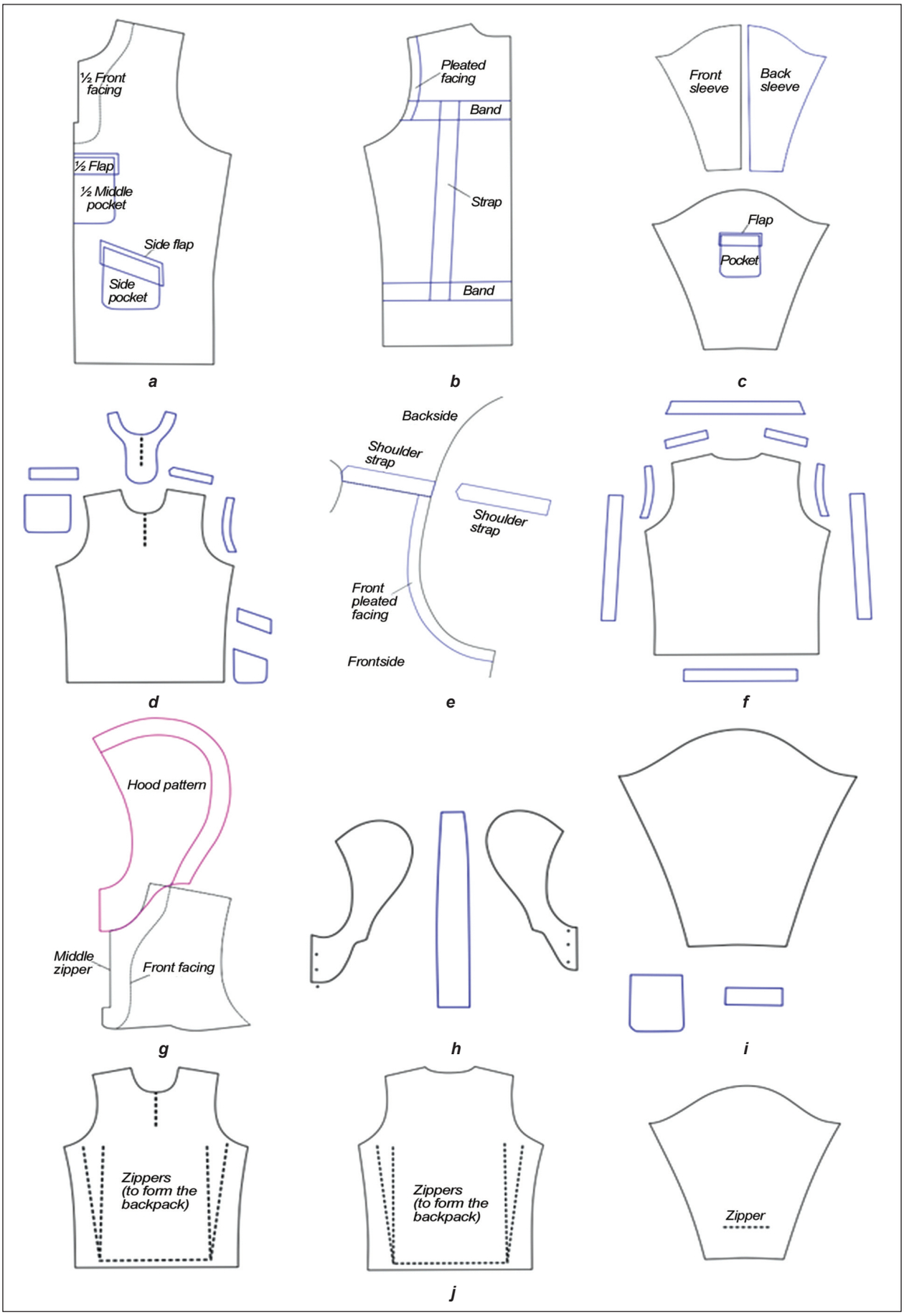

Fig. 5. The final 2D shape of the pattern blocks *a* – frontside; *b* – backside; *c* – sleeve; *d* – pieces of the frontside; *e* – designing the shoulder strap; *f* – pieces of the backside; *g* – hood positioning; *h* – pieces of the hood; *i* – pieces of the sleeves; *j* – placement of the zippers

a *b* *c* *d*

Fig. 6. Jacket transformation into a backpack: *a* – front; *b* – back; *c* – lateral side; *d* – cover

– the hood is folded so that it can become a backpack cover.

Figure 6 shows some stages of the process which transforms the jacket into a backpack.

The customers can use the garment for its initial destination (leisure sports jacket). However, they can also transform it into a backpack by executing a set of simple instructions described below:

– open the pressure staples of the shoulder straps and then open the zippers which fix the front and the back sides on the shoulder lines;
– open the zippers attaching the heads of the sleeves (the ones sewn on the armholes);
– fold the sleeves and fasten them by closing the removable zipper: one side on the middle line (14 cm from the hemline) and the other side on the lateral part, above the zippers attaching the bottom of the backpack;
– close the vertical zippers (front and back);
– close the zippers attaching the sides of the bottom of the backpack;
– close the detached zipper;
– fold the remaining part of front side inside the backpack;
– close the two pressure staples on the folded lines of the front and back sides;
– fold the hood inside the backpack;
– fold the remaining part of the backside to obtain the cover of the backpack;
– close the pressure staples of the pleated facing on the shoulder line and the front fold line;
– open the pressure staples placed on the straps (backside).

The consumer can transform the backpack into the jacket and vice-versa, anytime he wants, or the situation requires.

CONCLUSIONS

The novel circular business model is an incentive for finding proper solutions of reducing the input of primary resources and the production waste, and of cutting down on the environmental impact and quantity of disposal.

The product design stage is essential in developing soft goods with an enhanced lifespan through reuse, maintenance, and recycling.

A longer active lifespan of the item is ensured by proper maintenance and repair services. At the end of their lifecycle, textile products can be used as materials for new fibres/yarns/fabrics and other products.

Clothing development process towards a circular model requires creativity, flexibility and diversity. The customer needs and behaviour, the sources of materials (recycled materials), and the designer knowledge, skills and competencies have to meet together to produce original and fashionable items, with lower productions costs. By integrating the customer in the garment design process, suggesting him different details, understanding his profile, the designer can think to multiple or versatile usage of the product. He can convince the customer about his achievement: with one investment, he gets more than one useful product, without disassembling or destroy it.

The designer has to have the ability to visualise the same item with new possible usages, to understand which materials and technology are necessary to use for producing it and try to exploit its physical characteristics to achieve its versatility.

Designing and producing textile products with an enhanced lifespan (with initial or different destination) will raise awareness and loyalty among consumers. By making a change in their education and habits (which consists of starting to use the same product for more extended periods of time), the consumer will be more responsible. This approach could also be beneficial for the customers, as they will better understand the manufacturing stages of the desired product, the resulting amount of waste, energy, water, and chemicals involved in this process.

By closing the loop of “garment travel”, the clothing industry will become more sustainable, it will be able to have a positive impact in terms of economic competitivity, dependence on natural resources and waste reduction.

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