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TRIZ: INNOVATION OPPORTUNITIES FOR THE FASHION INDUSTRY

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Abstract: *Research purposes: To understand the possibility of TRIZ application in the fashion industry by analyzing several fashion inventions and apparel pro-duction techniques from the TRIZ point of view*
Key words: *TRIZ, Fashion, Apparel, Innovation, System Evolution Laws, Contradictions, Principles of Contradiction Resolution, Resources.*

1. INTRODUCTION

Innovative ways of designing and manufacturing have become more popular in the apparel industry. Contemporary fashion designers must be able to generate new ideas and come up with the most incredible solutions quickly. Various engineer invention methods help to develop creative thinking and speed up design and production process. That is why fashion designers have begun to apply these methods more often nowadays.

There are several techniques for generating new ideas that fashion designers use frequently. For example: by using the method of similarities, fashion designers find inspiration in architectural constructions, paintings, design elements from historical costumes, etc.; the bionic design method allows to find new ideas in nature with observation of animals and insects; the morphological analysis proposed by Fritz Zwicky [1] as well as the brainstorming method help to solve various problems of design and production processes.

Recently, fashion designers around the world have begun to apply TRIZ tools for design of clothes and accessories. For example, there was an attempt in Saudi Arabia to use TRIZ tools in development of contemporary women's clothes with elements of national costumes. Their main task was to preserve the country's cultural heritage of traditional costumes and national identity in the global world. Analysis of identified contradictions and application of TRIZ methods for resolving contradictions made it possible to find the optimal creative solution and re-duce production time and cost. [2] TRIZ tools were used to design a collection of handmade handbags in China. [3]

2. TRIZ TOOLS

The most of TRIZ tools can be used in design and production process of clothes, shoes and accessories. In this article we will demonstrate the following tools:

1. The Morphological analysis; [4]
2. The system development laws; [5]
3. The logic of non-standard problem solving; [6]
4. Inventive principles for resolving contradictions; [7]
5. The Su-Field analysis. [8]

3. TRIZ APPLICATION EXAMPLES

3.1 Morphological analysis for garment design

Example 1. Design of a casual dress

A fashion designer can create variety of dresses using the same base dress silhouette by screening numerous collar shapes, necklines, sleeves, stylelines, pockets, decorative elements,

and textiles. Example of the dress transformation is shown on Fig. 1

Fig. 1. Dress design options based on the same silhouette.

Table 1

Morphological analysis of various dress details based on the current fashion trends (a fragment of the morphological analysis table).

Garment Parts	Options					
	1	**2**	3	4	5	6
Waistline	Natural	**Low waisted**	High waisted	Without a waistline seam	With a drawstring	On an elastic band
Front closure	Single breasted	**Double breasted**	With a zipper	On buttons	On snaps	Lacing
Collar	Mandarin collar	**Turtle neck collar**	Without collar	Cowl collar	Turndown with lapels	Ring collar
Neckline shape	Basic with pin tusks	**V-neck**	Asymmetric	Round	Oval	Square
Sleeve	Puff sleeve	**Petal sleeve**	Drop shoulder sleeve	Bishop sleeve	Raglan sleeve	Basic set in sleeve
Pocket	Rectangular patch pocket	**Welt pocket**	Double welt pocket	Double welt pocket with zipper	Inserted seam pocket	In seam pocket
Darts or stylelines	Added fullness	**Bust darts**	Waist darts	Center front bust cluster	Princess stylelines	Armhole princess stylelines
Decorative elements	Lacing	**Frills, ruffles, pleats**	Patchwork	Waist belt	Fringe	Application
Skirt structure	A-line	**Godet skirt**	Skirt with tiers	Slightly flared to the bottom	Pegged skirt	Pencil skirt

Morphological analysis can help a designer to find the best design solution by screening only details based, for example, on current fashion trends (Table 1).

Morphological analysis, in general, can be much wider. It depends on a fashion industry task.

Example 2. Classification of clothing for morphological analysis

Clothing features:

1. Protective;
2. Informational;
3. Aesthetic.

In general, clothing is divided:

1. By body parts:
   - 1.1. Upper torso garments;
   - 1.2. Lower torso garments;
   - 1.3. Accessories:
     - 1.3.1. Hats;
     - 1.3.2. Shoes and hosiery.
2. By age and gender:
   - 2.1. Women's wear;
   - 2.2. Men's wear;
   - 2.3. Children's wear.

Table 2

Clothing categories.

By age and gender:	Women's wear	Men's wear	Children's wear
By size range:	1) Junior; 2) Missy; 3) Petite; 4) Large.	1) Short; 2) Regular; 3) Long; 4) Big.	1) Newborn; 2) Infant; 3) Toddler; 4) Girls; 5) Boys.
By style:	1) Dresses; 2) Attire for special occasion; 3) Suits; 4) Outerwear; 5) Sportswear; 6) Activewear; 7) Swimwear; 8) Lingerie.	1) Designer styling; 2) Traditional styling-classic suits; 3) Outerwear; 4) Traditional sportswear; 5) Contemporary.	1) Infant; 2) Toddler; 3) Young children; 4) Older children.
By price range:	1) Couture; 2) Designer; 3) Bridge; 4) Contemporary; 5) Missy; 6) Junior.	1) Custom-tailored; 2) Designer; 3) Bridge; 4) Moderate; 5) Popularly priced.	1) Better; 2) Moderate; 3) Budget priced.

This is a superficial classification. In addition, for morphological analysis must be considered the following:

1. Type of material:
   - 1.1. Fabric:
     - 1.1.1. Fabric content;
     - 1.1.2. Fabric weight;
     - 1.1.3. Fabric finish and so on.
   - 1.2. Findings:
     - 1.2.1. Notions type;
     - 1.2.2. Notions material.
2. Contemporary fashion trends;
3. Colorways.

Protective equipment and uniform, such as arctic, police and military clothing, can be also added to the classification above. In general, a multidimensional matrix with embedded submatrices is formed. The more details we add, the more submatrix nesting levels there are.

3.2 System development laws

The history of clothing is a great source to study changing clothing trends from the system development standpoint.

It is believed that the first clothes appeared with the loss of hair on the human body. At the beginning, people hunted and used animal skins as a protective clothing. Then people have learned how to sew skin of several animals together with tendons and hair. Further, the materials for making clothes, and manufacturing technology have changed. Goats and sheep were domesticated approximately 10,000 years ago and since then people began to make wool garments. Later, cotton and linen were developed. Synthetic fabric was invented only in the 20th century.

Example 3. Change of clothing shape

Let's consider how forms of clothes has changed starting from Ancient Egypt.

Egyptian clothing for many centuries remained unchanged, constant and monotonous. There were only two types of clothing: male and female. Clothing of various social classes was different only in its decoration and materials. But exact laws and geometrical forms also acted for them. A major garment for men was an apron and a wraparound skirt (schenti). Women's clothing covered the body much more. Slaves walked almost naked (Fig. 2).

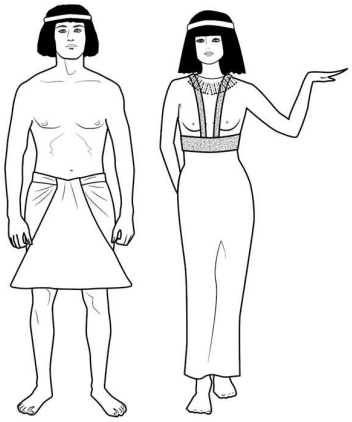

Fig. 2. Clothing of Ancient Egypt.

Later clothes have become more complicated. A dress with the crinoline is one of complex design examples. The crinoline was fashionable from 1851 to 1867 (Fig. 3).

Fig. 3. Crinoline.

Subsequently, dresses have begun to simplify, and their volume decreased. Women started wearing pant in the 20th century. More fitted garments are in fashion today. Clothing has become much lighter and more comfortable. The general trend is shown in Fig. 4.

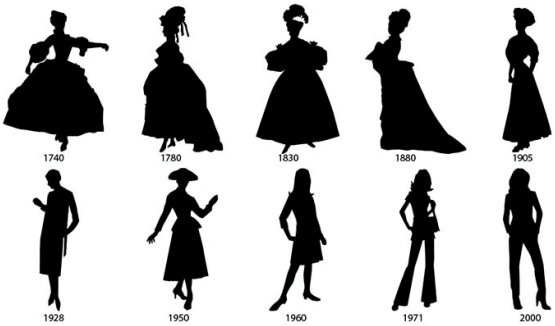

Fig. 4. The evolution of women's clothing.

Example 4. The swimsuit evolution

The first women's bathing suit was a dress. In order to prevent this dress from floating up in the water, special metal weights were sewn to the hem of this bathing suit.

Afterward, women's bathing suits began to decrease. The general trend is shown in Fig. 5.

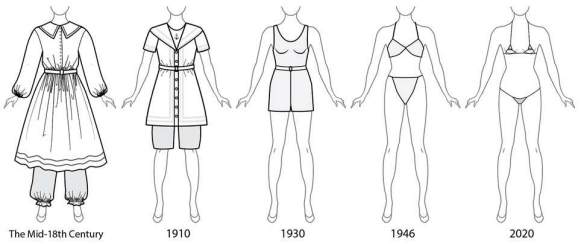

Fig. 5. The evolution of a swimsuit.

3.3 Logic for solving non-standard problems

Problem 1. A corset

Problem Condition

Women want to be seen with a slim waist, but they do not always have it physically at any age.

A corset was invented for this purpose. A corset pulls the body around the waist and gives the impression that a woman has a smaller waist and an hourglass figure. However, the internal organs are compressed in a tight corset, and this adversely affects human health. How this problem can be solved?

Problem analysis

Superficial contradiction (SC)

SC: A

SC: Women want to be seen with smaller waists (A), but do not always physically have a slim waist.

Contradiction requirements (CR)

CR: A – anti-B

CR: A woman can demonstrate a slim waist (A) by wearing a tight corset. However, a corset compresses woman’s internal organ and harm her health (anti-B).

Ideal Final Result (IFR)

IFR: A, B

IFR: Women show smaller waists (A), but do not harm their health (B).

IFR is approximation to an ideal system.

An ideal corset is a corset that does not exist but its function is performed. A missing corset does not reduce the physical waist size, but gives an impression of a smaller waist.

Contradiction of properties (CP)

CP: C→A, anti-C→B

CP: The waist size should be reduced (C) in order to demonstrate a smaller waist (A), and should not be reduced (anti-C) in order do not compress the internal organs and do not harm the health (B).

Analysis of CR and CP

Let's identify what CR requirement is mandatory (it cannot be changed), and what requirement is not mandatory (it can be changed).

Mandatory requirement is not to harm the health. It means that we can change a requirement to show a smaller waist. Let's analyze CP requirements.

According to the CR analysis, the waist size should not be reduced in order do not harm the health. It is also necessary to find out why the use of corset (Fig. 6) is harmful for the health (Fig. 7).

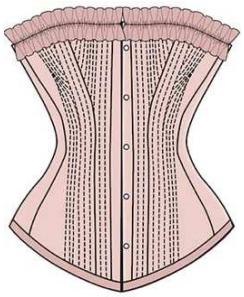

Fig. 6. A corset.

The corset was made of fabric. Boning channels (casing) were stitched on the corset surface. Wale, iron or wood bones were inser-ted into each channel. That is why the corset construction was very rigid.

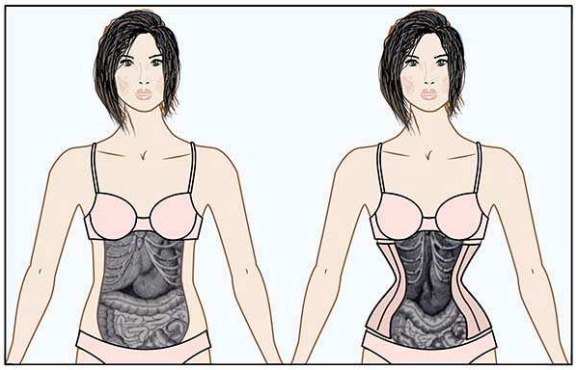

Fig. 7. The impact of a corset.

Resolution of CP features:

Opposite (contradictory) features can be separated:

- In space;
- In time;
- In structure;
- By condition.

Problem solution

Separation in structure.

1. Elastic textiles can be used in order to make corset structure less rigid.
2. Illusion of a slim waist can be achieved with use of visual effects.

2.1 A fabric insertion of contrasting color can be used in a dress design. This insertion should narrow toward to a figure center front at the waist line.

2.2 A smaller waist illusion can be created with backlight and a stage background.

Separation in space (see clause 2.1).

A fabric insertion of contrasting color can be used in a garment as a center front panel. This insertion should narrow at the waist line.

Separation in time.

Dynamic changes, such as appearance of a full waist at first, and then a slim waist after, can be used for a stage performance. This effect can be achieved by using inflatable clothes, clothes made from memory shape material, and by applying an illusion of light and color.

Separation by condition.

A small waist or a full waist can be created when needed using all the above methods.

Separation in system. Parts of a garment or all clothing are made as needed in a particular place, at the right time, according to the relevant condition.

Problem 1. Knight armor

Problem Condition

Knight armor (metal plate armor) was very heavy and its mobility was limited. It was very difficult to fight in such armor. How this problem can be solved?

Problem analysis

SC: How to improve knight mobility and lighten armor?

CR: A contradiction arises between protective armor features, its weight, and comfort of movement.
IFR: Armor has protective features; it is lightweight and comfortable to wear.

CP: Armor should be lightweight and flexible for convenient movement, and at the same time, it should be inflexible and heavy in order to have good protective features.
It means that the armor must be created from a single piece of metal (armor is not flexible) and at the same time from many pieces of metal (armor is flexible). Method of resolving CP is separation of opposing properties: in the structure.

Problem solution

A chain mail garment was invented. It consists of individual rings connected together. Each ring is rigid, and all rings together are flexible. In addition, there is no metal in the middle of the ring, so its weight is significantly reduced (Fig. 8).

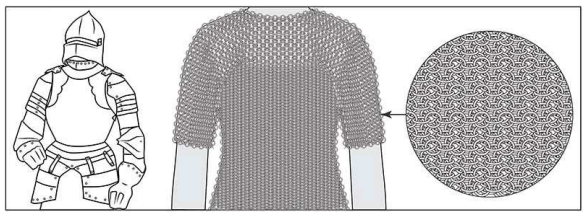

Fig. 8. A metal plate armor and a chain mail garment.

3.4 Using inventive principles for resolving contradictions

Example 5. The principle of universality (inventive principle 6)

1. Designer Ryan Mario Yasin has created clothing that grows with a child. The development of corrugated fabric is based on the negative Poisson's ratio, which is used to characterize the elasticity of various materials. When an object is stretched, it lengthens, and its cross section expands.

2. Fashion designers very often create garments that can transform and become universal. Pants-transformers are one of the examples of universal garments. These pants can turn into “capri” pants or shorts if necessary.

Example 6. The principle of "nesting dolls" (inventive principle 7)

We are oftentimes dressed according to the principle of a nesting doll. Periodically layering in clothes becomes a fashion trend, and designers can recommend to wear a short garment over a long one. Several layers of clothing help to keep the body warm, as an air layer forms between layers of clothing. Some garments, such as a jacket or a coat with an underlay, consist of several fabric layers.

Example 7. The principle of preliminary action (inventive principle 10)

Innovative materials are frequently used in today’s fashion industry. For example, fabric with memory shape or smart textiles (glowing, aromatic, etc.). One of the smart textile examples is Luminex textile, which is a complex system involving a combination of optical fibre fabric and electronics. Light emitting diodes illuminate the optical fibres, which distribute the light over the surface of the fabric. Lumalive textile glows with light-emitting diodes (LEDs) fully integrated into the fabric. This fabric can shimmer in various colors, as well as broadcast images.

The "Rami Kadi Maison de Couture" company developed a collection of dresses "Lucioles" with innovative features. The dresses glow in the dark (Fig. 9).

Fig. 9. Dress from the “Lucioles” collection designed by Rami Kadi

Example 8. The inversion principle (inventive principle 13)

A striking example of this principle is the creation of the bikini swimsuit in 1946 by the French designer Louis Rear. This swimsuit was

created contrary to traditions and the public opinion. In those days, such frankness was considered as unheard-of insolence, so a terrible scandal flared up around the designer and his model Micheline Bernardini. The swimsuit was named “bikini” by the name of the island after the first test of an American nuclear weapon at the Bikini Atoll. Introducing the bikini was similar to a nuclear explosion by the effect on public opinion (Fig.10).

Fig. 10. The “bikini” swimsuit.

Example 9. The principle of transition to another dimension (inventive principle 17)

Printing clothes on a 3D printer is a perfect example of this principle application. The “Ministry of Supply” company prints clothes without seams on a 3D printer.

Example 10. The principle of continuity of useful action (inventive principle 20)

1. The “Ministry of Supply” company has designed a self-heating jacket that responds to changes in temperature and creates an individual “microclimate” for its wearer.

2. Gloves with a built-in headset phone were created recently. A glove has a built-in speaker in the thumb and a microphone on the wrist, so phone calls can be easily answered in cold weather with a telephone remaining in a pocket.

3.5 Using a combination of inventive principles

As a rule, the most powerful solutions are achieved with a combination of various methods. We can illustrate the application of some inventive principle combinations in the examples below.

Example 11. The principle of segmentation and the principle of merging

A patchwork technique allows to create a unique garment design by sewing together fabric swatches into a larger piece of fabric. Garment pattern pieces, such as front, back, sleeve, yoke, can be divided into several parts. Each part is copied as a separate pattern piece with seam allowances. Small pattern parts are used to cut out different fabric pieces. Then all fabric pieces are sewn together to form a garment detail.

Example 12. The principle of preliminary action and the principle of merging

A crochet technique called the “Irish lace” based on the preliminary production of motifs that afterwards are combined into a seamless garment. Garment designs created with this technique are unique and cannot be duplicated.

4. CONCLUSION

Innovative way of thinking is extremely important for a contemporary fashion designer. TRIZ should take a leading role in development of inventive thinking [10] and speed up the apparel design process. This innovation methodology does not contradict other existing design methods rather embodying them as a part of professional knowledge and fostering systematic problem solving. We believe that TRIZ can make significant contribution to developing state-of-the-art fashion materials and inventive ways of apparel design and production.

The fashion industry professionals can begin their journey to systematic innovation by using TRIZ principles and ARIZ (Algorithm for Inventive Problem Solving).

5. COPYRIGHT

We acknowledge with sincere appreciation "Rami Kadi Maison de Couture" per-mission to present in this paper the photograph of the dress from the “Lucioles” collection (Fig. 9).
Images (Fig. 1, 2,3, 4, 5, 6, 7, 8 and 10) were created by Helen Solodkina.

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6. REFERENCES

[1] Mankovskaya, O. V., *The concept and methods of designing clothes based on TRIZ (Theory of Inventive Problem Solving)*, Admiralty Needle - 2018, 93-97 (2018). (in Russian)

[2] Shafeeand, W. H., Feda, L. A., *Innovative solutions for traditional Saudi Arabian costumes using TRIZ principles*, International Journal of Systematic Innovation 5(3), 47-61 (2019).

[3] Lin, C. M., Wang, Y. C., Liu, Y. L., *Innovative Design of Customized Fashion Handbags*, International Journal of Systematic Innovation 2(4), 01-19 (2013).

[4] Petrov, V., *Methods of activating the creative process: TRIZ*, Publishing Solutions (2018). (in Russian)

[5] Petrov, V., *Laws of Systems Development: TRIZ*, 2nd.edn. Publishing Solutions (2019). (in Russian)

[6] Petrov, V., *Solving Non-Standard Problems*, TRIZ, Paperback. Independently published *(2019).*

[7] Petrov, V., *Universal Inventive Principles TRIZ: Inventive Principles for All Fields*, Paperback, Independently published (2019)

[8] Petrov, V., *Structural System Analysis*, Su-Field Analysis, TRIZ. Paperback. Inde-pendently published (2019)

[9] Petrov, V., *Talented thinking: TRIZ*, Publishing Solutions (2018). (in Russian)

TRIZ: Oportunități de inovare pentru industria modei

Rezumat: Scopuri de cercetare: Înțelegerea posibilității aplicării TRIZ în industria modei prin analizarea mai multor invenții vestimentare și tehnici de producție de îmbrăcăminte din punct de vedere TRIZ.

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