The Impact of Utilizing 3D Printing Techniques on the Production of Plastic Packages

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Summary

Introduction

3D printing has revolutionized the industrial technology by manufacturing a three-dimensional, tangible and concrete product by designing it on a computer and printing it (manufacturing it) with 3D printers. The uses of three-dimensional printing in many areas, including space, medicine, entertainment, education, manufacturing and packaging, and the uses of three-dimensional printing in the Egyptian packaging market are limited to the production of prototypes (models that are made to test a specific design and try it in doing a certain job before requiring a large amount of it). Relying on 3D printing in the production of prototypes and packaging packages is intended to take advantage of the many advantages that 3D printing provides, including lower initial cost, and thus has provided a solution to the problem of lack of available resources with small investors, a feature that encourages many to invest, which in turn increases the production wheel and reducing the time needed for the manufacturing process, which helps to increase the speed of the production cycle and freedom to design and produce packages with a complex structural composition in addition to getting rid of problems and restrictions imposed by traditional methods such as injection and molding. Represented in the difficulty of producing complex prototypes, wasting time, high cost of labor, and molding tools.

Key words:

3d printing – prototype – fused deposition molding

Research problem

• Not to benefit from the use of 3D printing techniques in the production of prototypes and personalized models and the limited quantitative production of packaging packages.
• Failure to determine the technical effectiveness of 3D printing technologies in the Egyptian market.

Research hypotheses

• The application of 3D printing in the field of packaging creates a different and unique competitive environment that will achieve the desires and needs of the consumer in line with the technological development of that technology in the field of producing prototypes and personalized packages on a larger scale in the future and determining the ways to benefit from them.

Objective:

• Determining the three-dimensional printing techniques and materials that achieve the highest degree of simulation of the prototype of the shape of the final packaging (for different types of packages) by classifying these different technologies and materials.

• Determining the technical suitability for using 3D printing in the field of prototyping and personalized production and the limited production of packaging packages locally.

Importance of the Research:

Maximizing the utilization and optimum utilization of the various technologies of 3D printing in developing the production of packaging packages, while studying the appropriate materials and the technical and economic aspects of each technology in line with the shape of the product to be manufactured.

Research Methodology

• The research depends on the use of both the descriptive and analytical approaches, and the experimental method to reach the goal of the research through study and observation, collecting and analyzing data, and conducting practical experiments and measurements.

3D printing:

3D printing is a technology of making a hundred years of 3D model data. The process consists of printing successive layers of materials that are formed on top of each other. 3D printing technologies vary in the Egyptian market to accommodate different purposes and applications.

Classifications of 3D printing according to the nature of the raw material used:

The different methods can be classified according to the raw materials used in these methods as follows:

1- Liquid base methods 2-Powder based methods 3-Solid-base methods

The most famous 3D printing techniques used to produce plastic packaging in Egypt:

FUSED DEPOSITION MOLDING: It is one of the most important 3D printing techniques that can produce complex geometric parts through the processes of smelting, sedimentation and hardening of thermoplastic layer by layer.

The applied study

The production flow of the prototype of corn packaging

1-The technical specifications of the package

(A) Product type: sweet corn (B) Packed weight: 230g

(C**) The material used** : Polylactic Acid (PLA) is a thermoplastic polymer and safe for use with foodstuffs.

2-Specifications of the machine used the Creality Ender 3 Pro, a 220 X 220 X250 mm FDM Fused Deposition Modeling Machine.

3-Packaging design The third-place winning package was chosen in the STARPACK 2018 competition designed by Dina Khattab, where the package was designed on the most famous SolidWork 3D design program.

Pic. No. 1 indicates to the structure of the package to be produced

4- Converting the design into a code that the printer understands (G-Code)

5- Preparing the printer and sending the G- code to the printer: connecting the printer to a computer and transferring the G-code file to the printer driver.

6- The printing process

(A) Printing the inside (yellow) part of the package: Printing the inner part of the package which is divided into three parts begins where the printer first determines the frame in which you will work, then you print the first layer and then fill in the following layers until you reach the last layer.

(B) Printing the three parts of the package : The printer is equipped with a green PLA reel and the printer first draws the outer frame of the remaining three parts of the package, then forms layers one by one until we reach to form the remaining three parts of the package.

7- The finishing phase The support parts were removed from the package and sanding was used to get rid of some excess and smooth the edges of the package.

8- Stage of linking the parts of the package This stage depends on the use of adhesive materials between the three parts of the package to make the package appear in its final form.

Economic cost of producing prototype packaging

3D printing cost calculation = gram cost x package weight in gram =5 x 170 gm = 850 l.e.

The time taken to produce the prototype package

The time taken to print the whole package is 18 hours,

The process of producing the package with personalized production

The treatment and coverage phase with epoxy is added by immersing the packaging in the material to make it safer for food packaging.

Comparisons	3d printing			Traditional methods		
	Prototype	Personalized	Limited production	Prototype	Personalized	Limited production
Production Workflow of corn package	1-Package design stage 2- The STL design files are converted to a Gcode file 3-printing process 4- finishing process 5- Connecting parts of the package	Covering with epoxy by immersing the package in the material.	1-treatment process of package 2- Production of Package Molds 3-vacuum casting process 4- Oven treatment	1- The stage of designing the shape of the molds. 2- The stage of producing molds First mold: The inner part of the package (yellow). The second mold: the outer part of the package (green). The third mold: the package cover. 2- Installing the first screw (for the inner part of the package) on the injection blow molding machine. 3- Installing the first mold in blow molding machine. 4-Installing the second mold (cap on the package) on the injection molding machine. 5- Production of the inner part of the packaging cap on injection molding machines. 6- The parts of the inner and outer packaging are linked with each other through the presence of overlapping parts in each part.		
Time taken to produce the packages	Time to print the entire package = 14 hours.	We need 2 days to print the personalized package.	Time taken to produce 40packages = 22 days.	The time it takes to produce prototypes and personalized packages and custom production by conventional methods, depends on the time required to produce the packaging molds which is one month.		

The final cost	Cost of 3D printing = cost per gram x package weight in grams = 5 x 170g=850 l.e.	3D printing cost + epoxy treatment cost 850 + 100 = 950 l.e.	**The cost of 40 packages =(Cost of 2 cast parts per package x 40 (475+515)x40 = 39,600 l.e.**	The cost of prototypes, personalized models and limited production depends on the total cost of the molds. The total cost of the molds = 90 , 000 l.e.

The economical cost of producing the customized packaging

The cost of 3D printing + the cost of treating with epoxy = 850 + 100 = 950 pounds.

The time taken to produce the personalized packaging

It takes two days to print the personalized package.

Production dedicated to producing limited quantities of the packaging goes through an additional stage after the completion of the 3D printing process, which is the vacuum molding process.

Workflow of package limited production: Producing limited quantities of the packaging goes through an additional stage after the completion of the 3D printing process, which is the vacuum casting process.

Package treatment process: The treatment depends on the package produced by 3D printing (the original piece) through the use of sandpaper and the use of a filler (then paste and spraying Doku to get the final surface smooth.

Production of molds for the package: To produce the first mold of the package, the silicone material is poured at a temperature (20-25) on the inner part of the package (the yellow part) consisting of two hollow parts for an hour and a half to turn into the rubber form and produce the second mold in the same way, then comes the stage of cutting the mold and taking out the package.

The vacuum casting process: Each mold is placed inside an airtight sealed body so that the propylene material (the package material) is weighed (shape), mixed with the coloring pigment and poured through a hole inside the silicone mold to take the shape of the original piece and get engraved inside the mold.

Oven treatment: The curing stage in the oven for the mold of the package for 3 hours and after removing the mold and removing the parts of the package, they are placed again in the oven for 4 hours.

Economic cost of custom production for packaging

The cost of the 40 packages = (the cost of the two parts of the packaging x 40) =
(475 + 515) x 40 = 39600 pounds.

Results:

1- The use of 3D printing techniques has provided wide opportunities for producing complex structural shapes from different packages.
2- 3D printing can solve the problems of producing prototypes and personalized models using traditional methods such as injection molding and blow molding, such as wasting the used raw materials, tools and molds and wasting time and cost of labor.
3- 3D printing technologies have their own simple operation paths, which is not available when using traditional methods of packaging production.
4- The materials used in 3D printing techniques vary to suit all uses.
5- The possibility of making changes to the design of the package on CAD programs at any time and printing them with the required change, unlike traditional methods.

Recommendation

1-Expanding the use of three-dimensional printing in the production of prototypes and personalization due to the advantages achieved.
2-The necessity to increase awareness of the economic and technical advantages of 3D printing machines within the major industrial enterprises and packaging factories in the Egyptian market to avoid the problems of traditional methods of production.
3-Paying attention to the expansion of the local manufacturing area of 3D printing machines to create a competitive environment that works to meet all the requirements of the Egyptian market.
4-The necessity of utilizing the prototypes produced by 3D printing in the production of limited quantities of packages using vacuum casting technology at a lower cost and time than traditional methods.

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