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PRODUCTION WITH 3D PRINTERS IN TEXTILES [REVIEW]

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Abstract: *3D printers are gaining more attention, finding different applications and 3D printing is being regarded as a 'revolution' of the 2010s for production. 3D printing is a production method that produces 3-dimensional objects by combining very thin layers over and over to form the object using 3D scanners or via softwares either private or open source. 3D printed materials find application in a large range of fields including aerospace, automotive, medicine and material science. There are several 3D printing methods such as fused deposition modeling (FDM), stereolithographic apparatus (SLA), selective laser sintering (SLS), inkjet 3D printing and laminated object manufacturing (LOM).*
3D printing process involves three steps: production of the 3D model file, conversion of the 3D model file into G-code and printing the object. 3D printing finds a large variety of applications in many fields; however, textile applications of 3D printing remain rare. There are several textile-like 3D printed products mostly for use in fashion design, for research purposes, for technical textile applications and for substituting traditional textiles suchas weft-knitted structures and lace patterns. 3D printed textile-like structures are not strong enough for textile applications as they tend to break easily and although they have the drape of a textile material, they still lack the flexibility of textiles. 3D printing technology has to gain improvement to produce materials that will be an equivalent for textile materials, and has to be a faster method to compete with traditional textile production methods.

Key words: *3D printing, additive production, textile-like printed materials, 3-dimensional printed objects.*

1. INTRODUCTION

3D printers are gaining more attention, finding different applications and 3D printing is being regarded as a 'revolution' of the 2010s for production [1, 2]. 3D printing is a production method that produces 3-dimensional objects by combining very thin layers over and over to form the object. Traditional production methods are substractive production methods which result in huge material losses, while 3D printing is an additive production method.

The 3D-printed car 'Strati', which was produced in 44 hours, and announced in 2014 [3], 3D printed guns [4] and 3D printed buildings [5] are among 3D printed examples.

3D printing (3DP) technique is being researched in many areas ranging from material science to medicine. Stent prototypes [6], production of pelvic models having fractures for surgical management [7], production of 3-dimensional bone support structures for lesion sites [8], production of bone tissue scaffolds to mimic the physical structure of bone [9, 10], ceramic implants [11], fabrication of individual tablets [12], production of biomaterials [13] and regenerative medicine [14] are among several studies of 3DP in medicine area. Production of auxetic metamaterials [15], printing Cu, which is highly viscous metal in molten state, 3D structures [16], particles having Cu core and Ag shell [17], production of composite membrane structures [18], and chip production [19] are among applications of 3DP in materials science. Research studies are conducted to ensure precise printing to measure thickness [20] and to enable remote controlling [21].

2. 3D PRINTING

3D printing process involves three steps: production of the 3D model file, conversion of the 3D model file into G-code and printing the object. Production of the 3D model file might be done using 3D scanners or via softwares either private or open source. The conversion time depends on the object size; and the conversion time takes longer as the object has asymmetries, complex surfaces or hollow surfaces. The conversion time takes minutes for a 0,2m x 0,2m x 0,1 m object while it takes more than 1 week for a 1m x 1m x 0,8m object [22]. There are several 3D printing methods such as fused deposition modeling (FDM), stereolithographic apparatus (SLA), selective laser sintering (SLS), inkjet 3D printing and laminated object manufacturing (LOM).

The fused deposition modelling (FDM) technique uses a plastic filament which is pushed through a heated extrusion nozzle that melts the material, most inexpensive 3D printers use the FDM process [23].

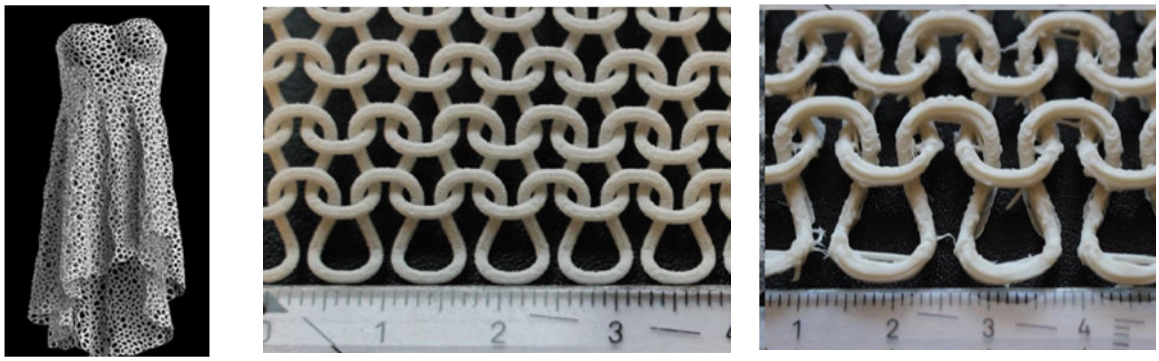
Stereolithographic apparatus (SLA) has a UV laser which cures the liquid polymer used and prints parts layer by layer [24]. Selective laser sintering (SLS) uses a variety of materials including polymers, ceramics and metal materials; SLS forms parts layer by layer from bottom to the top using a laser beam which selectively sinters the powdered material layer [25, 26].

In inkjet 3D printing, layers are formed by depositing a powder and selectively solidifying the powder with a liquid sprayed through the inkjet printhead to print the object [27].

Laminated object manufacturing (LOM) is capable of producing objects at a large variety of materials such as paper, cellulose, plastics, metals and fiber reinforced materials. LOM produces 3D objects by stacking layers of sheet material using a deposition tool; layers are bonded on top of the previous layers and then cut to a specific shape according to the cross-sections of this layer from the software model [28].

3. 3D PRINTING FOR TEXTILE MATERIALS

There are several textile-like 3D printed products mostly for use in fashion designs [29, 30, 31] and for research purposes [32, 33]. The printed dresses are more like a plastic, do not have the textile structure which is flexible and durable [29, 30, 31]. For technical textile applications, wearable technology applications [34] and flexible heating systems developed by Mangre et al [33] are examples; and for 3D printed traditional textiles, examples are weft-knitted structures and lace patterns produced by SLS and FDM printing methods [23]. The printed weft-knitted structures were produced in larger size than traditional knitted fabrics to obtain a thickness that holds the structure in one piece; and the lace produced was not flexible after printing, a second process of soaking in water was applied to give the lace flexibility [23]. Figure 1 shows a 3D printed gown [29] and weft-knitted structures produced by Melnikova et al [23].



(a) *(b)* *(c)*

Fig. 1: *(a) 3D printed gown [29], (b)Weft knitted fabric produced by SLS method[23], (c) Weft knitted fabric produced by FDM method [23]*

4. CONCLUSIONS

3D printing finds a large variety of applications in many fields; however, textile applications of 3D printing remain rare [23]. Although 3D printing looks like a new breath in production as it makes it possible to produce prototypes of almost any product, 3D printing needs improvements to make it a faster and more versatile method to produce flexible textile materials. In literature, we could not find any research on the comfort properties of 3D printed textiles.; therefore, comfort properties of

3D printed materials are opportunities for future research studies.

There are some applications of 3D printed fabrics mostly used for fashion designs and research [23, 30, 31, 32]. Still those structures are not strong enough for textile applications as they tend to break easily and even though they have the drape of a textile material, they still lack the flexibility of textiles. 3D printing technology has to gain improvement to produce materials that will be an equivalent for textile materials; and yet has to be a quick production method since traditional textile manufacturing methods are already in mass production stage. However, 3D printing seems to be a promising method for producing prototypes of textile materials such as medical textiles, which will save time and money to predict the properties of the end-product.

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