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Fused Deposition Modelling-based 3D Printing: A Systematic Literature Review Employing VOS Viewer

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Abstract

Fused Deposition Modelling, also known as FDM, has emerged as a major technology in the field of 3D printing. It provides adaptability and cost-effectiveness in the process of materializing intricate designs. This paper intends to conduct a complete bibliometric analysis (BA) of 3D printing based on fused deposition modelling (FDM) in order to comprehend the trend and research field. After extracting data from the Scopus database using the titles, abstracts, and keywords, the documents have been taken into consideration for evaluation. Vos Viewer software has been used for construction and visualization of networks. The obtained network has been analyzed to find out the trending areas in the field of 3D printing, based upon the co-occurrence of keywords. VOSviewer software has been used for co-occurance analysis using bibliographic data obtained from the Scopus database. The co-occurrence analysis helped to identify keywords widely used by researchers in 3D printing. It has been found that because of its superior strength, polylactic acid (PLA) is the filament material that is used the most frequently, and fused deposition modelling (FDM) is the most popular method for 3D printing. The mechanical properties of 3D printed samples, studied by most of the researchers have been identified mainly as the tensile test, the flexural test, the compressive test, the bending test, and the wear test.

Keywords: Systematic Literature Review (SLR), Fused deposition modeling (FDM), 3D Printing, Additive Manufacturing, Rapid Prototyping.

INTRODUCTION

Manufacturing procedures that have been used traditionally are examples of subtractive manufacturing, which means that the end product is made by removing material. Additive manufacturing, in which the final thing is created by adding material, came into being as a result of the waste of material that occurred throughout the manufacturing process. One of the most common types of additive manufacturing is known as three-dimensional printing, which involves printing material in two dimensions and then printing subsequent layers on top of the one that came before them in order to get the necessary amount of dimension or design. This wonderful technique of producing 3D objects by stereolithography, with minimum wastage, was filed for patent in 1986 by Charles W. Hull (1). Since then, various methods and printable materials have been developed in the field of 3D printing. Based on state of raw materials 3D printing can be classified (2) as per Figure 1.

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PROPOSED METHODOLOGY

A systematic literature study is conducted with the purpose of providing an all-encompassing overview of the research landscape in the field of

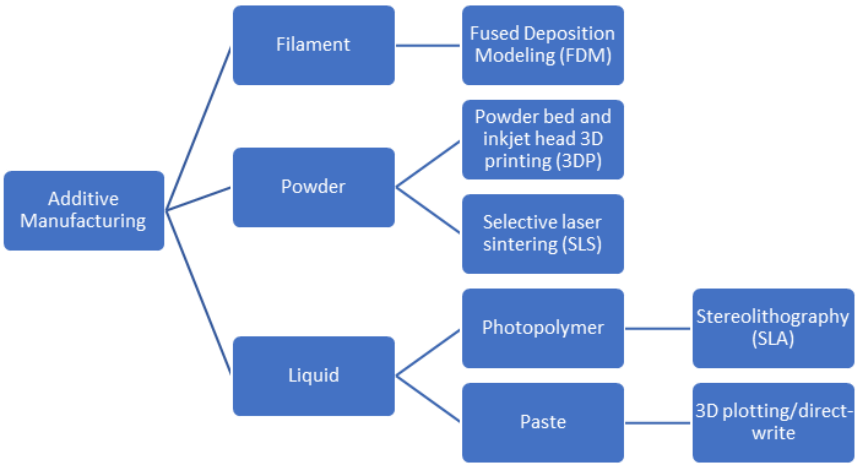

Figure 1. Classification of additive manufacturing.

Table 1. Search result for scopus database.

Search Performed for	Documents Result
"3D Printing"	45381
"3D Printing" AND mechanical	27406
"3D Printing" AND fdm	7108
"3D Printing" AND mechanical AND fdm	5858
“3D Printing” AND mechanical AND fdm AND pla	3139
“3D Printing” AND mechanical AND fdm AND pla AND tensile	1802
“3D Printing” AND mechanical AND fdm AND pla AND flexural	653
“3D Printing” AND mechanical AND fdm AND pla AND wear	338
("3D Printing")) AND (mechanical) AND (fdm) AND (pla) AND (optimization)	1598
("3D Printing")) AND (mechanical) AND (fdm) AND (pla) AND (ann)	114
“3D Printing” AND mechanical AND fdm AND pla AND ((tensile) OR (flexural) OR (wear))	1976

FDM-based 3D printing. The proposed methodology intends to conduct a complete bibliometric analysis (BA) (3) of 3D printing based on fused deposition modelling (FDM) in order to comprehend the trend and research field. Documents have been evaluated after data extraction utilizing title, abstract, and keywords from the Scopus database. The largest database, Scopus, was searched for title, abstract, and keywords using the advanced search option. the search was performed for "3D Printing," and 45,381 document results were obtained. The results came down to 27,406 documents when mechanical was searched along with 3D printing The Search results reduced drastically to 7108 documents when searched for “"3D Printing” AND fdm”. It was decided to move forward with the narrowing of results obtained through "3D printing" AND mechanical means.When the string "fdm" was added to the search strings, the number of documents returned for "3D Printing" AND mechanical AND fdm" was 5858, which was reduced to 3139 when PLA was added to the search string (i.e., a search for "3D Printing" AND mechanical AND fdm AND pla).For search criteria containing “(“3D Printing”)) AND (mechanical) AND (fdm) AND (pla) AND (optimization),” it returned 1598 documents as a search result. Furthermore, when tensile strength, flexural strength, and wear were added to the search criteria, the overall search became "3D Printing" AND mechanical AND fdm AND pla AND (tensile) OR (flexural) OR (wear)," and we received 1976 documents as search results, which were considered for further analysis. Table 1 represents the number of documents returned for the strings for which the search was performed.

BIBLIOMETRIC ANALYSIS USING VOSVIEWER SOFTWARE

VOS viewer, an open-source program, available for free download that has been developed by (4) , has been used for co-occurance analysis using the bibliographic data obtained the scopus database.

The same data can be used for biblioshiny, only difference being that the data has to be exported as comma seperated values (.csv) file, which will act as input for VOS viewer. One of the options that was selected was the development of a map that was based on bibliographic data. The data that was used as input was bibliographic data that was collected from the Scopus database in a csv format. Full counting was chosen as the technique of analysis, and co-occurrence was selected as the type of analysis. This means that each co-occurrence of the keyword was given equal weightage. The author keyword and the index keyword were both taken into consideration here. The bare minimum of twenty co-occurring offences was maintained. The visualisation of the network is depicted in Figure 2, and the overlay visualisation that corresponds to it is given in Figure 3.

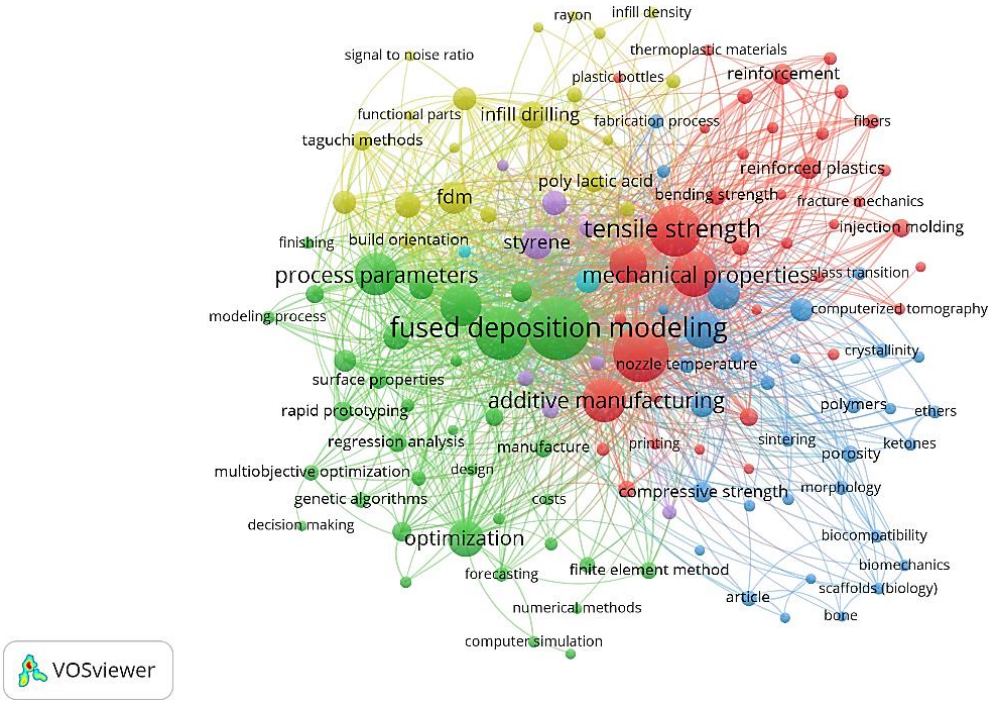

Figure 2. Visualization of the network.

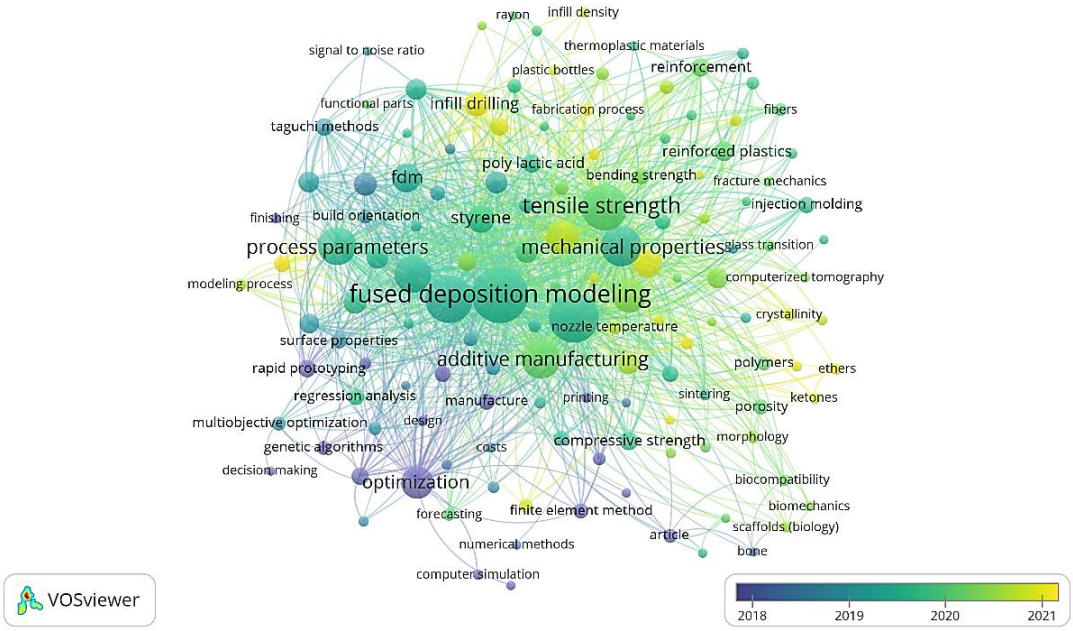

Figure 3. Overlay visualization.

RESULT AND DISCUSSIONS

There were a total of six clusters across the network. The phrase "3D printers" could be used to refer to Cluster 1, which has the highest prevalence of 571 inside the cluster. The overall number of keywords was 38, with tensile strength, mechanical characteristics, and additive manufacturing being some of the most prominent ones (5–7). The second cluster contained a total of 36 elements, with the highest frequency of fused deposition modelling (FDM) being associated with it (8–10), whereas the other keywords that were most frequently used were optimisation, regression analysis, design of experiments (DoE), and process parameters. The cluster had a number of fascinating terms, including neural networks, genetic algorithms, multi-objective optimisation, and modelling processes; however, the frequency with which these phrases appeared was extremely low, which suggests that not a great deal of previous research has been conducted on these particular keywords. The greatest number of instances of fused filament fabrication (fff) was found in Cluster three, with 464 incidents (11,12). Compressive strength had an occurrence of 80, and some other salient keywords that were observed were nozzle temperature (13–15), flexural strength, printing speed (16–18), and mechanical testing. Given that it has the greatest occurrence value of 197, cluster four has the potential to be referred to as "fused deposition modelling (fdm)." Layer thickness, analysis of variance (ANOVA), polylactic acid (PLA), Taguchi methods, experimental investigations, build orientation, impact strength, infill density, and hardness were some of the other significant keywords that were observed. Additionally, it was found that the co-occurrence for wear of materials was twenty, which serves as evidence that not an enormous amount of work has been made to it. When it comes to cluster five, there were just seven keywords that were involved, and the occurrence value for acrylonitrile butadiene styrene (ABS) was the highest among all of them. Additionally, it included the design, methodology, and approach, as well as the ultimate tensile strength and the strength of the materials. Extrusion and extrusion temperature were the only two elements that were included in the last cluster, which was cluster number six. The occurrence values for these two particular elements were 114 and 36, respectively.

CONCLUSIONS

In conclusion, this systematic literature study, which makes use of the features of VOSviewer, provides a full overview of the current state of research surrounding FDM-based 3D printing. Clusters, trends, key writers, and new areas that have been discovered all contribute, collectively, to a nuanced perspective on the changing landscape of FDM technology. It is possible for researchers, practitioners, and policymakers to make use of these findings to guide their efforts in advancing FDM-based 3D printing. Through the application of the co-occurrence analysis, we were able to obtain the terms that have been utilized to a significant degree by the researchers. Polylactic acid (PLA), which is a substance that is widely utilized for the filament, was found to be the material that is used the most frequently due to its greater strength. This was the first discovery that was made. Fused filament fabrication (FFF), sometimes referred to as fused deposition modelling (FDM), was identified as the prevailing 3D printing technique. This was another discovery that was made. Following that, the parameters of the printer, which had been the subject of a substantial amount of research, were determined. The temperature of the nozzle, the orientation of the build, the layer thickness, the printing speed, and honeycomb structures were some of the factors that were identified. It was observed that Taguchi orthogonal arrays were used widely in order to reduce the number of tests that were carried out. This is done in order to save time and reduce the material cost. The most common sorts of experiments that were carried out by the researchers on the samples that were produced through the technique of 3D printing were the tensile test, the flexural test, the compressive test, the bending test, and the wear test.

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