Potential of plastics powder-based 3D printing

TECH FRONTIERS

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The global market for 3D printing technology using plastics is growing rapidly. India, lagging behind in this technology, needs to exploit the potential to increase its market share and provide a boost to engineering exports

THE manufacturing sector, a vital contributor to the national GDP, has been a high priority sector in India. Several advanced manufacturing techniques like digital, distributed, flexible, customised, etc. with diverse and new application areas such as bioengineering, cell/tissue/nano fabrication, in situ applications, smart materials, etc. are of great interest for industry and academia. India is well poised to tap the strength of its IT expertise, which would immensely contribute to advanced manufacturing technologies. Additive manufacturing (AM) is among one of the interesting manufacturing techniques that has drawn

the attention of researchers and industrialists across the globe. As the name indicates, AM is a manufacturing process of adding of materials subsequently to build a part layer by layer using 3D model, raw material, and an energy source. While conventional manufacturing is subtractive in nature as they produce the final part by eliminating material from unfinished part, additive manufacturing is additive in nature as it adds on layers to produce final part.

The scope of doing relative changes in design and process as per the functional requirements of the customer makes AM a disruptive technology when compared to conventional manufacturing. It has the ability to build intricate parts with functional assemblies using adequate amount of materials and utilising less time. Hence, additive manufacturing is considered as emerging technology. 3D printing (3DP) is one of the AM technologies that is portrayed as an additive manufacturing technology for producing plastic parts mainly. It also improves product lifecycle management to greater extent in contrast to traditional manufacturing techniques. AM allows freedom to design in manufacturing complex structures with composite materials with high precision, which is not so easy in conventional manufacturing techniques sometimes. AM is also a perfect model for Just in time manufacturing.

Status of 3D printing

As per a report of Frost & Sullivan1, a growth rate of 15 percent CAGR for the period 2015-25 is forecasted in the AM sector. Global 3D printing revenues for the automotive industry, medical devices industry, and aerospace and defence industry are expected to grow at the rate of 34, 23, and 26 percent CAGR respectively for 2015-25. From the same report, the revenue generated in 2015 and expected to be generated in 2025 in different regions are given in **Table1**.

In the Asia-Pacific region, AM is expected to grow at the rate of about 19 percent CAGR for the period 2015-25. A big business share of about 70 percent among all Asia-Pacific countries is captured by China. In 2025, it is expected that different sectors will have a global market share as given in **Table2**.

Table1: 3D printing revenue expected for different regions ($ billion)

Regions	Revenue in 2015	Revenue expected in 2025
North America	2.35	7.65
Europe and West Asia	1.81	7.18
Asia-Pacific	1.01	5.56
Rest of World	0.14	1.11
Total	5.31	21.50

Table2: Global market share of different sectors in AM by 2025

Automotive	20
Aerospace	15
Medical and Dental	16
Industrial	12
Consumer Electronics	28
Architecture	04
Other	05

Source: namic.sg/wp-content/uploads/2018/04/global-additive-manufacturing- market_1.pdf

Table3: Market share of different materials used in 3D printing

S. No.	Material	Market share (%)
1.	Photopolymers	56.0
2.	Thermoplastics (solid)	40.0
3.	Thermoplastics (powder)	2.0
4.	Metal powders	1.4
5.	Inkjet powders	0.6

Source: Miller Allen et al., 3D Printing Standards and Verification Services, Technical Brief, Centre for Entrepreneurship and Technology, University of California, Berkeley, March 2015

Plastics, a dominant material for 3D printing

Polymers have been widely used in the first generation machines for making prototypes in a faster way. Plastic materials are the best suitable materials for 3D printing when compared to metals because plastics utilise energy more efficiently in comparison to metals. AM is highly suitable for polymers as they have low melting temperatures, absorb laser energy rather reflecting like metals, and are easy to handle. **Table3** shows the market of different materials being used in 3D printing where it can be noted that plastics are the dominant materials than others.

Status of plastics

As per the report of FICCI on Sustainable Infrastructure with Plastics2, the plastics processing industry in India has grown at a CAGR of 10 percent in volume terms from 8.3 MMTPA (million metric tonnes per annum) in the year 2010 to 13.4 MMTPA in 2015. A growth rate of about 10.5 percent CAGR from 2015 to 2020 would lead to volumes of about 22 MMTPA. Business in terms of value reached Rs1 lakh crore in 2015 from Rs35,000 crore in 2005, showing a growth rate of 11 percent CAGR. In 2015, per capita consumption of plastics in India was one of the lowest in the world, i.e.11 kg

against 100 kg in developed markets. Even compared to emerging markets like China (38 kg) and Brazil (32 kg), the per capita consumption of plastic in India has a long way to go. Rising incomes and growth in end-use industries, including automotive, construction, electronics, healthcare, textiles, and FMCG, are resulting in increased consumption. India is second in the world after China in the context of population; however, demand for polymers in India is only one-fifth of China's. Hence, it is anticipated that the plastics industry in the Indian subcontinent has better prospects for growth.

India has a shortage in production of plastics and it imports plastics for fulfilling domestic requirements. Saudi Arabia, Korea, Qatar, UAE, Germany, USA, Singapore and Thailand are among the main countries from where plastic materials are being imported into India. However, India also exports some plastics materials to other countries. As per the report of the Plastic Export Promotion Council (Ministry of Commerce & Industry, GoI), India's total export of plastics for the year 2017-18 was $8850.18 million with a growth of 17.1 percent including export of raw materials of $3272.97 million and value added products of $5347.49 million. The country-wise share of exports from India for 2017-18 was USA (12.51), China (8.23), UAE (4.98), Italy (4.56), Germany (4.15), Turkey (3.78) and UK (2.91) percent respectively. But countries like China, Taiwan, Indonesia, and other South Asian countries pose tough competition for exports.3

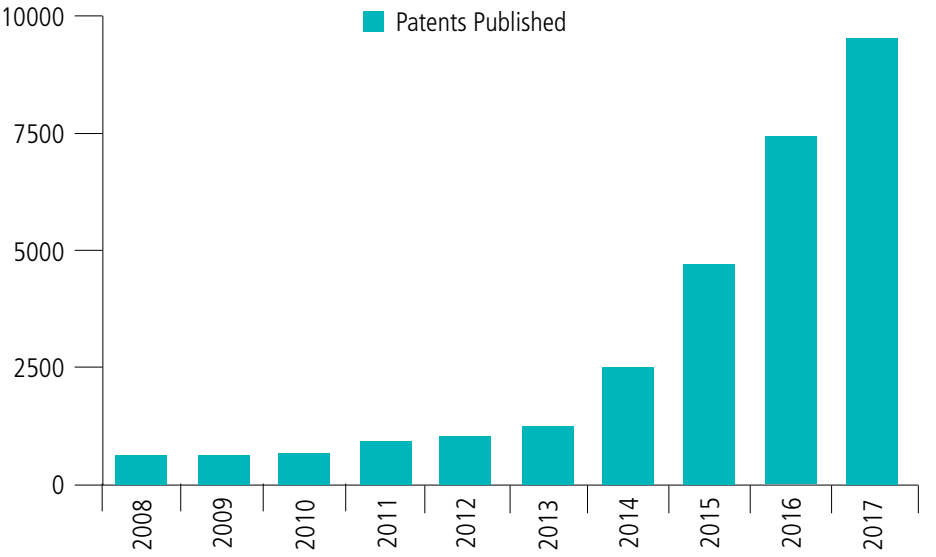
Nevertheless, seeing the expected revenue generation from 3D printing in the Asia-Pacific from **Table2** and the share of polymers and plastics in 3D printing from **Table1**, plastics can be usefully deployed 3D printing.

Patent analysis

Patent analysis will also be an interesting way to understand future prospects of 3D printing technology. Patent analysis is a forecasting technique where patent statistics is used to indicate the technological change and diffusion of any new technology. The WIPO (World Intellectual Property Organisation) database4 is used to collect data/patent details using keywords such as additive manufacturing, stereolithography, plastic, 3D printing, etc. A logical syntax was formulated using these keywords to perform prior art search in the database. Covering all the technologies related to plastics 3D printing, around 36,000 patent publications were found for the period 2000-17. It has been noticed that over 2000-08, there was less growth in patent publications. However, it increased after 2008. **Figure1** shows the number of patents published from 2008 to 2017. This figure signifies the interest of researchers towards 3D printing technology after 2010. **Table4** gives year-wise publications of the top 10 regions for the last 10 years. It clearly shows rising trends in recent years. Publications in the USA, PCT (Patent Cooperation Treaty), China, etc. are far more than publications in India.

Figure2 depicts the regional patent publications in percentage terms for the period 2000-18. This also indicates that significant research work is going on in the USA, China and Australia among others in comparison to India and Japan.

Figure1: Patent publication year wise, 2008-17



Potential of 3D printing

The patent landscape report explains the dominance of the US in 3DP technology compared to other nations. The US established several research organisations and industrial training programmes dedicated to additive manufacturing, whereas India is still in a nascent stage in this technology. Nevertheless, India has great opportunity to grab the global market share; electronics, automotive, medical, industrial aerospace, architecture, and so on are potential application areas. This requires more advancement and research by conducting technology development trainings and programmes that help industries to develop the expertise. Patents related to 3DP technology in the field of biomedical industry have come to light where human body parts can be tailored according to the patient body conditions. In future, 3DP will make all surgeries simple to operate, giving a big relief to surgeons.

In today's world of engineering, the applications of 3D printing help to build several

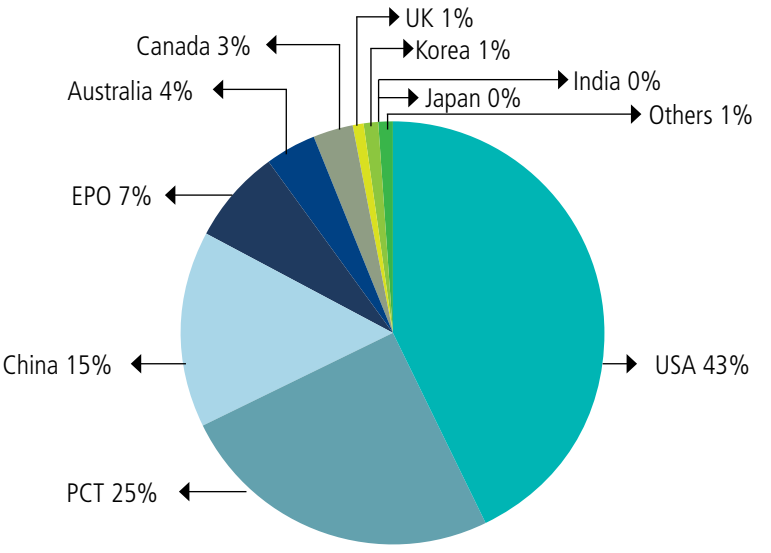
Table4:Year-wise regional patent publications, 2008-17

Year	USA	PCT	China	EPO	Australia	Canada	UK	Korea	India	Japan
2008	325	187	6	74	27	47	2	3	-	3
2009	356	152	10	77	25	54	1	7	1	-
2010	451	162	6	79	26	61	-	5	2	6
2011	504	203	9	105	44	55	6	8	1	4
2012	569	255	-	114	51	36	12	9	-	5
2013	710	325	44	109	80	32	19	14	2	6
2014	1193	697	364	158	86	34	8	14	6	2
2015	1943	1245	942	222	147	82	20	45	10	15
2016	2662	1810	1678	417	428	134	127	128	25	4
2017	3551	2463	2189	626	262	153	157	17	45	3
Total	**12264**	**7499**	**5248**	**1981**	**1176**	**688**	**352**	**250**	**92**	**48**

products/components encompassing a wide range of simple structures used in day-to-day life to complicated components in applications like aerospace. 3DP is a quick and efficient process for creation of prototypes. Fused deposition modelling (FDM) is deployed to build products from thin layers of extruded filaments of a semi-melted thermoplastic. 3D printers can generate parts previously considered difficult to achieve with conventional manufacturing processes. This exposes a completely new horizon in the design level, which can lead to more effective and better output.

Reliability to produce very complex and precise components and simplicity of 3DP technology make it a very important part in manufacturing industry. 3DP enables mass customisation which makes it possible to produce parts with high degree of adaptation and at a cost that is comparable to a mass produced product to the customer. Generation of mechanical components is another beneficial use for 3D printers as these components can be sold for industrial as well as for personal repairs. 3DP has made it far easier to reproduce parts for machines that might no longer be in production or that would take too long to arrive. Various components/parts manufactured by 3DP are not sold directly to customers but are manufactured by companies as parts/components in a larger project. 3D printing is enabling industries to manufacture more and more innovative products, satisfying the precise needs of customers in a cost effective manner.

Figure2: Regional patent publications 2000-18



While 3DP manufacturing is suitable for low volumes, recent advancements in this field make 3DP a viable option of higher volumes as well. As 3D printing becomes viable for volume production, it opens up tremendous possibilities for industries for domestic as well as export production. Industries must keep a tab on research and development in the area of advanced 3D printers that are not only efficient but are also cost effective. Deployment of smart 3D printers and efficient workforce, adept in operation of these machines can assist manufacturing industries in boosting their exports.

Notes

1. Source: namic.sg/wp-content/uploads/2018/04/global-additive-manufacturing-market_1.pdf
2. Source: http://ficci.in/spdocument/20872/report-Plastic-infrastructure-2017-ficci.pdf
3. Source: ficci.in/spdocument/20396/Knowledge-Paper-ps.pdf
4. www.wipo.int