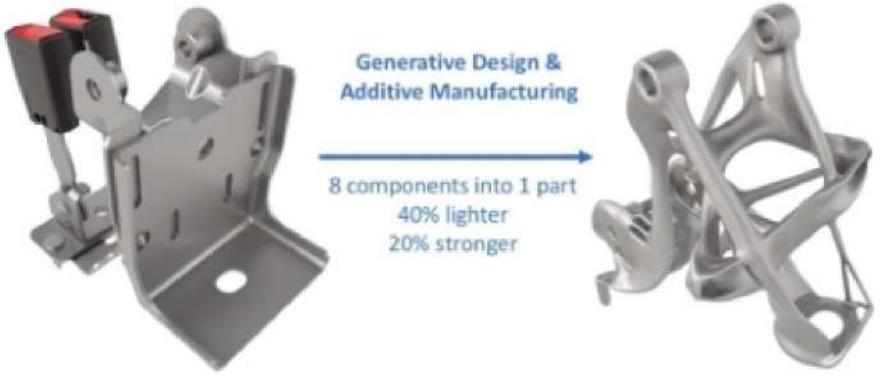
Role of 3D Printing in Advanced Manufacturing

Ganesh Babu presents an overview of how Additive Manufacturing technologies are true game changers in the industrialisation of parts and part manufacturing.



Example of unlimited design freedom. Source: Autodesk/GM

Additive Manufacturing, broadly known as 3D printing, is revolutionising and transforming how products are being designed and manufactured and enables 'on demand manufacturing' using digital data or CAD models. The process of manufacturing is simplified and parts are being made without the aid of tooling or dedicated equipment. The broad range of materials that are available for 3D printing, enables customers to have versatile outputs that are tried and tested at an initial stage in the design process, thereby enabling better products in a shorter time. With unparalleled flexibility the usage of AM across industry verticals is fast growing.

Indian industry has been showing remarkable growth in the manufacturing sector, thanks to the various initiatives by the Indian government, a nation with rich resources and skilled manpower has been on the growth ladder. Industries and R&D organisations have been at the forefront of embracing 3D printing or Additive Manufacturing and have seen tremendous benefits in their respective areas of work.

Additive Manufacturing, better known as time compression engineering, gives innovators in product development out of the box solutions, and has been encouraging to see various sectors in Indian industry adapting to use AM for lean manufacturing. With unlimited design freedom and endless possibilities, it is the evolution of design process and industrial manufacturing. It's a new way to design and manufacture for better products.

Although it has been a slow adaptation by Indian industry to come out from its conventional manufacturing practices for realising the first physical part, the last decade has seen tremendous growth of AM where many large industries as captive users are working with AM parts from design to manufacturing of industrial parts and it is very encouraging to see various verticals starting from education, automotive, aerospace, healthcare, design houses and consumer goods manufacturers having one or more 3D printers in their organisations.

Many industries have already realised the AM potential to move beyond prototyping and are printing application specific outputs with advanced materials, light weight manufacturing tools, etc., and it's been a new way of making things, which are both time and cost effective. With the advancement in newer materials and processes, industries in India have greater potential for functional evaluation and end use applications of AM parts, which in turn would enable for rapid industrial growth. From a slow and steady start in adapting to AM the Indian industry has shown greater progress in this innovative technology's adaption over the last decade. We also need to take note that AM is more of a complimenting technology and not a replacement to the traditional and conventional process of manufacturing.

Range of materials

Over the last decade companies have been investing heavily on 3D printers and are scaling up their AM usage, which in turn has created a huge demand for commonly used and specialised AM materials. Metal AM systems offer a wide variety of materials. The metal material portfolio includes various grades of aluminium, tool steel, cobalt chrome, stainless steels, tungsten, titanium alloys and precious metals. There have been newer

ULTEM 9085 is a high performance thermoplastic. Source: Stratasys

materials, which are in focus, such as metallic glasses, light weight alloys, tungsten, bronze, copper alloys and much more.

To suit custom applications, tailor made materials specific to part properties and applications are developed, validated and supplied to meet the ever expanding needs of customers. Industrial 3D printing has been established well by many industries for mass customisation and for manufacturing of spares and on demand parts.

3D printing being a highly innovative technology, there is always a need for newer materials and processes to address the ever expanding market demands, hence manufacturers and their R&D teams are far from being exhausted in their innovative space of developing new materials and processes. Besides metals and ceramics, polymers are widely employed for applications in AM. The synthetic versatility and adaptability with a wide range of properties that can be achieved using polymer materials have rendered polymers as the most widely used class of materials in AM. Generic plastics like PLA and ABS are used for all prototyping and some limited functional applications; however there is a growing demand for high end application specific materials, which are strong, highly durable and functional, that cater to industrialised and manufacturing applications. The 3D printing industry has developed high performance thermoplastics such as ULTEM, carbon-reinforced composites, PEEK and PEKK based thermoplastics, which are enabling industries to print functional parts that are tried and tested in harsh environments at elevated temperatures.

In addition to the various grades of engineering and composite materials, there are advanced materials such as graphene, which is one of the strongest materials known to man, 200 times stronger than steel. This material will revolutionise product manufacturing from consumer products, aerospace, energy, medicine and many more. Graphene has high electric and thermal conductivity and is already being used in technology products and consumer goods. Industrial innovations built around graphene is already a game changer and developments on the graphene based composite materials for Additive Manufacturing will further strengthen the use of AM in aerospace, automotive, consumer goods, battery manufacturing and other high end verticals for industrial applications.

In today's industrial scenario with Industry 4.0, a variety of industries are already considering to complement their manufacturing capabilities with additive manufacturing. To face current challenges in business, integrating additive technologies in an organisation with the right selection is a must, at times there are some unfortunate choices made in haste.

Multiple technologies

There are multiple technologies in the AM portfolio to support every industry needs, suitable to one's product line and their manufacturing applications organisations have to select the right AM technology. There are industry experts and consultants who are well versed in both traditional and additive manufacturing processes, whose consultation would help in selecting the right choice of 3D printers.

The cost of 3D printers is a factor that needs to be clearly examined, the returns on investment (RoI) factor has to be taken into consideration, based on the utilisation of AM systems. The major cost factors that are associated with additive manufacturing are on the machines and materials. In comparison to traditional manufacturing the lead time reduction and achieving complex parts in quick turnaround time is a great value add, but you also need to have considerable projects for additive manufacturing to realise the RoI.

There are quite a lot of low end professional printers that come at low costs between a few hundreds to a few thousand dollars, but the returns are limited as the outputs will have quality issues and cannot be used for demanding industrial needs. Repetitive failures and constant tinkering with the printers leads to delay and poor quality outputs that are not meeting to the expected standards. Low end 3D printers are more suitable for hobbyists and educationalists needs.

Industrial printers are built for performance and are classified as desktop, production series systems. These polymer printers are available at an affordable price range that cater to more reliable and repetitive outputs that meet more stringent design and manufacturing requirements. The metal AM systems are considered to be expensive but the value in realising complex parts, with custom materials for

Prototype of multi-coloured bike helmet. Source: Stratasys

parts and products, which are more application specific that are produced in a shorter lead time with minimum efforts pays for itself.

Any investment on a 3D printer should be clearly evaluated in terms of utilisation and better understanding of using the 3D printer beyond prototyping. Applications such as jigs and fixtures, patterns, conformal cooling inserts, checking gauges and templates would all add value for an earlier return on investments.

While a whole lot of AM job shops or service providers are running to packed shifts, they own multiple technologies and are focussed to meet client needs in terms of providing 3D printed parts as a prototype or as a finished end use part. They also cater to meeting batch production using rapid tooling. Parts are delivered as finished goods with all the necessary post processing carried out. Many industries who are yet to invest in their own AM systems are often using the service model and are benefitting by outsourcing to the expertise of the job shops. End-to-end services are provided by many of the job shops, design to prototyping and pilot quantities are handled by professionals who understand both traditional manufacturing and additive manufacturing. With all the value adds that the job shops provide the factor of confidentiality is still a question in one's mind while sharing data for services. Additive manufactured parts require post processing and it is an essential stage in the additive manufacturing process. Starting from support material removal, surface quality improvement, heat treatment, vapour smoothing, sealing and bonding, finishing and painting, plating and coating, electromechanical etching, shot blasting, shot peening and machining are some of the post manufacturing processes. By post processing, additive manufactured part quality is improved to meet the design specifications. Quality prototypes and sample part mean the difference in business to win or lose orders and for production parts the post processing process readies them to be used as end use parts in a product.

Additive Manufacturing technologies have been true game changers in the industrialisation of parts and part manufacturing. For Industry 4.0, the seamless integration of digital data to physical part manufacturing is a great transformation tool. Global value chains are reshaped with this seamless integration that are enabling various highly complex geometries for mission critical projects in space research or aerospace component manufacturing of turbine blades and engine parts are manufactured as a consolidated design with better performance and light weighting of parts that are efficiently manufactured with minimum skill sets, with minimum time that are cost effective. Jet engine parts are today manufactured lighter in weight and in a shorter time when compared with traditional manufacturing, there is a minimum cost saving of 25% to 30% of individual parts. With stockless supply chains industries have eliminated large manufacturing capabilities.

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