



A REVOLUTION IN MANUFACTURING

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Manufacturing of complex shapes in advanced machines has been an expensive and demanding task. The difficulty of manufacturing precisely machined parts that fit together perfectly has always presented a challenge. This fine tolerances required as well as complexity of shapes to be manufactured inevitably has led to increased cost of design and manufacture. This escalating spiral appears ready to be broken through application of the relatively new technology of 3D printing.

Background

Manufacturing has traditionally involved designing component parts that comprise the whole. These component parts are then machined in factories using complex tools that involve metal casting, machining on lathes or other metal cutting tools to very precise specifications followed by assembly of the component parts to make the entire object initially designed. Such manufacturing technology has evolved over the years to move from simple relatively machines controlled by the worker (accuracy and precision of the output being dependent upon the skill of the workman) to advanced computer controlled machines. The latter technologies are able to ensure that the output from the same design is near identical in specifications. While much more expensive than conventional machine tools, computer controlled machine tools are able to give higher quality output with lower reject, manufactured items that are outside specifications, rates. The latest advances in manufacturing have centred around “decentralised manufacturing” through the use of three dimensional (3D) printing of parts. Initially 3D printing was taken to be a fad and

assumed to be limited to relatively simple items made out of soft materials more amenable to additive manufacturing. Additive manufacturing is a process wherein an item is built up through laying progressive layers of material one upon the other in required shapes. On solidifying the material forms the desired shape. It was assumed that given the nature of materials basically plastic items would be made through the process of 3D printing. Plastic raw material be stored in liquid form in inkjet printer cartridge analogues relatively easily, this liquid raw material could then be sprayed on in the additive layering process to build the item. Metallic items it was assumed would not lend themselves to this process given the difficulty of maintaining metals in liquid state, which requires heating them to very high temperatures. However, in an earlier piece on this website I had written about the potential of 3D printing to break the logistics shackles for military forces after it was reported that a British Royal Air Force (RAF) fighter aircraft had been successfully flown with 3D printed parts.ⁱ The 3D printed parts used on the RAF fighter reportedly involved printing through use on metals in solution form using suitable solvents. Then it had been opined that further developments would possibly improve upon this technology delivering a disruptive effect on traditional manufacturing and in the process reducing logistics problems for end users.

Reports have now emerged that NASA has recently successfully tested complex fuel injectors, with 40 individual spray elements in a ground test of a rocket engine. The fuel injector concerned was manufactured in a mere two pieces and through 3D printing. If the same part had been manufactured using conventional manufacturing technology it would have involved making 163 individual parts that would then have been required to be assembled. NASA has reported that the process of 3D manufacturing has enabled more complex shapes to be designed than was feasible through conventional manufacturing techniques. This fact leads to the reasonable assumption that 3D manufacturing could lead to increases in efficiency of machines using 3D printed parts. Moreover the rocket motor test conducted by NASA has proved that 3D printed parts can function successfully in the extreme conditions of temperature and pressure found in operating rocket engines. The 3D printing technique used in making the 3D printed parts tested by NASA reportedly involved layering a fine powder of material successively that was fused with the earlier layers through use of a laser, a technique known as laser fusing.ⁱⁱ

Analysis and Implications for India

The latest ground test of the rocket motor incorporating 3D printed parts conducted by NASA as well as the reported successful flight of the RAF Tornado fighter aircraft in January 2014 bring out clearly that 3D printing is not a novelty but an emerging revolutionary new technology. In common with all such revolutionary technologies it is likely to have a disruptive affect on the nature of current manufacturing. A quick look at history brings out the disruption caused by steam-powered machines on the ten traditional manufacturing using human muscle power. Steam powered machines gave the world the industrial revolution. In a similar manner 3D printed manufacturing has potential to make manufacturing infinitely customised and decentralised. The shortfalls assumed to be showstoppers in terms of the ability of manufacturing complex metal parts have been resolved in at least two ways already. The first is through using metals in solution form in suitable solvents and the second through laser fusing technology. As human ingenuity is applied further it is inevitable that more innovative methods will be found to overcome problems as they emerge. Already as early as 2013 a 3D printed gun had been printed and actually fired successfully.ⁱⁱⁱ This was followed in January 2014 by the successful flight of a RAF Tornado fighter that had 3D printed parts on board. Now the latest is the NASA ground test of the rocket engine using 3D printed injectors.

The trend is clearly towards further advances in and acceptance of 3D printing techniques even in equipment that has absolutely ^{iv} zero error tolerance. India missed the first industrial revolution. Today India has a relatively robust information technology (IT) sector. 3D printing relies to a large extent upon rendering the object to be printed in software codes form for the printer to understand and execute. This is an area of Indian strength. India would do well to invest in 3D printing technologies in a big way. The shortfall as discernible is the lack of IT hardware manufacturing expertise in India. India would do well to build up the capability to build 3D printers and their required control software on a war footing in order to capitalise upon the coming 3D printing revolution and thus to ensure that the country is able to fully gain from the new manufacturing revolution. The India armed forces, given the wide and varied regions in which they are deployed could consider giving a push towards development of these capabilities in the country in order to reduce their logistics problems.

Conclusion

Recent advances in 3D printing technology have seen progressively more complex items bring manufactured through these techniques. These have involved firing of a 3D printed gun, flying a jet fighter aircraft with 3D printed parts and ground test of a rocket engine incorporating 3D printed parts. The trend is clearly towards 3D printing as the type of manufacturing of the future. It behoves India to invest in this technology to gain from the possible economic as well as operational efficiency advantages this technology is likely to offer

(Disclaimer: The views and opinions expressed in this article are those of the author and do not necessarily reflect the position of the Centre for Air Power Studies (CAPS))

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- ⁱ Vivek Kapur, "Three Dimensional (3d) Printing in Aviation: Hope for Breaking The Logistics Shackles",
ⁱⁱ "Sparks Fly as NASA Pushes the Limits of 3-D Printing Technology", http://www.space-travel.com/reports/Sparks_Fly_as_NASA_Pushes_the_Limits_of_3_D_Printing_Technology_999.html, accessed on 02 Sep 2014.
ⁱⁱⁱ N-1