Repercussions of 3D Printing in Mining Sector
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Abstract—3D printing is the process of making physical objects from a digital model using printer. The technology has footprints since decades but yet is considered in the developmental stage due its own limitations and applications. Applications of 3D printing are known in many industries like consumer products, manufacturing, healthcare, automobile, aerospace, mining etc. However, it is not fully implied on an industrial scale in many sectors, for instance, mining industry. The technology has the potential to address specific challenges of mining sector and develop multiple benefits. The biggest advantage of this technology is that it provides instant modelling to get an idea of the final product, in-hand better visualization, which can cut costs and time significantly. And perhaps the most compelling reason to accept 3D printing is that it has effective ways of communicating. The paper illustrates the concept of 3D printing and its repercussions in the mining sector.

Key words: 3D Printing, Mining, Technology, GIS

I. INTRODUCTION

3D dimensional (3D) printing is basically an additive manufacturing process in which objects are built layer by layer from a digital model. This technology allows the user to make physical objects, build real objects from virtual 3D objects. This is done by ‘cutting’ the virtual object in 2D slices and printing the real object slice by slice. This technology finds applications in many industries like consumer products, manufacturing, healthcare, automobile, aerospace, mining etc. However, the technology is not fully implied on an industrial scale in many sectors, for instance, mining where its applications are enormous. But simultaneously there are many practical challenges to implement this technology in mining sector which is quite complex and safety eccentric. The biggest advantage of this technology is that it provides instant modelling to get an idea of the final product, in-hand better visualization, which can cut costs and time significantly. In this paper, we have tried to explain the concept of 3D printing and its repercussions in the mining sector.

II. LITERATURE REVIEW

3D printing or additive manufacturing is a process used to make a three-dimensional object [1]. In 3D printing, additive processes are used, in which successive layers of material are laid down under computer control [2]. These objects can be of any shape or geometry and are produced from a 3D model or other electronic data source. 3D printing is known for decades. Since its inception during 80s, the actual process behind additive printing in a three dimensional matrix remain largely unchanged although materials used in 3D printing is somewhat changed by that time [3].

3D printable models can be generated with a computer aided design (CAD), through a 3D scanner or through photogrammetry software. 3D scanning is a process of analyzing and collecting digital data on the shape and appearance of a real object. 3D models of the scanned object can then be produced based on the data [4]. After finalizing the model, multiple errors are also examined and omitted before printing a 3D model. Several techniques are identified in the process of 3D printing. Major techniques include selective laser sintering, direct metal laser sintering, fused deposition modeling, stereo lithography and inkjet bio-printing. These are also known as ‘Rapid Prototyping’.

Fig. 1: Types of Rapid Prototyping

Fig 1 shows different types of rapid prototyping techniques, each technique has its own advantages and disadvantages and they are considered on the basis of cost, speed, material and capabilities. Different types of 3D printers are available in the market. Major suppliers are shown in the following chart (Fig 2). Depending on the type of printer capacities, possibilities are numerous to visualize and analyze objects. The applications people are finding for such machines are amazing.

Fig. 2: Major Suppliers of 3D Printers [5]

Mining sector is one of the most prolific producers of three dimensional data. Geoscientist, paleontologists are one among the early adopters of 3D technology looking for digitally extract fossils from stubborn matrices or reconstruct disarticulated specimens [6–8]. Other geoscientific uses have been reported like printing topography, Lidar, seismic data to understand stratigraphy, visualizing earthquake distribution etc. [9–12]. 3D printing helps in understanding and integration of geological data with surface and subsurface terrain. The technology also
aids in mine resource modelling, groundwater flows, aquifer structure, stockyard composition, geological structure, landscape planning in a mine operational environment.

Various features can be easily understand and identified by way of 3D printing model and data depicted on model can be extracted, digitized, and incorporated into a GIS format. The technology simplify the process and takes shorter time for resolution. 3D printers are capable of creating full colour models from digital data (Fig 3 & 4). The printers can accept the data from CAD, GIS representing various features [13]. However, it is essential to note that there are challenges in 3D printing of GIS layers. 3D printing applications in GIS is still in initial stages [14].

3D printing is also very useful in developing prototypes of machinery/tools across the mining value chain. The case of 3D printing in the mining sector is compelling. Because most of the mining operations are located in remote areas, companies would be able to make their own parts on site in a fraction of the time it takes to get parts sent in. For instance, mining equipment manufacturer major Sandvik recently announced to boost research spending on 3D printing to expand capabilities in a market that is expected to grow to $21 billion in the next 10 years [15].

III. RESULTS AND DISCUSSION

3D printing is an emerging technology and has the potential to address specific challenges of mining sector and develop multiple benefits. Perhaps the most compelling reason to accept 3D printing is that it has effective ways of communicating. The process enables faster production, increased flexibility and the ability to shape difficult designs from standard methods. Here we have considered two generic cases, one of exploration maps and another of mining equipment, to explain efficacy of 3D printing in the mining sector.

A. Case 1:
Maps are an integral component of mineral exploration and mining. They provide the first and foremost visual information of the terrain or location. Hitherto comprehensive 2-dimesional maps are primarily used in mining world for complete visualization of exploration areas and mining sites. This technique is in practice since ages and provides most efficient and safer way to access a location on or underneath earth surface [19]. But there are still flaws in it and having its own limitation. Better-quality maps are required nowadays for quicker navigation, accessibility and understanding of the exploration areas/mining sites. By applying this technology, 3D printed models of topographical and geological structures can be prepared by using existing data and photos (Fig 3). These models are capable to add more visual impact to the maps.

B. Case 2:
Machinery of all types is necessary to run mining operation smoothly. In mining industry tooling, prototyping and manufacturing is long, expensive and wasteful. Mining processes are in need of a significant overhaul. Besides crucial is that many parts used in mining operations are made with one-off production runs and with traditional manufacturing methodologies. It is an extremely inefficient use of resources, both material and financial. This clearly suggests developing prototype parts/tools at site and is a necessity which can save time, cost and uninterrupted production. 3D printing is having edge in designing and generating models of tools on-site.

In conjunction with aforementioned cases, there are several advantages and disadvantages associated with the 3D printing technology. We attempt to narrate few of them in this paper.

Fig. 3: From Model to 3D Print

Fig. 4: Sample - 3D Printers [16 – 18]

C. Advantages:
3D printing technology can render following solutions:
- 3D maps of geological, topographical and infrastructure by using survey data and photos.
- 3D printable models for better visual impact of the geological structures like subduction zone, lineament etc.
- 3D maps of exploration areas, mining sites, mills.
- 3D printed models of the correlated data with digital photogrammetry and 3D modeling.
- High end visualization to understand geological terrain and structures.
- Data elevation model, geological formations, and sub-surface geophysical model.
- Develop prototypes of machinery/tools across the mining supply chain.
- 3D printing of parts/tools on site.

D. Disadvantages:
- 3D printing is not a low-cost-process; therefore quantity of material involved should be taken care-of.
- The resolution and accuracy of a 3D print can be high but at the same time small details can be lost.
- 3D printer consumes lot of energy. And also may pose health risk due to unhealthy air emissions [20].
- Bulk of plastics is consumed in building 3D printers and it can generate non-degradable plastic waste [20].
- 3D printers are still slow, sometime takes several hours to days to print [20].
IV. CONCLUSION

3D printing technology is still in the developmental stages but yet it has the potential to revolutionize the mining industry. The technology has the potential to transform productivity levels at multiple levels in the mining value chain ranging from early stage exploration to mine closure. It can assist in improving supply chain and logistics at remote mine sites. The technology leverage rapid solution to physical assets of mining sector and benefits of on-site, on-demand and custom production capability are added advantages. If 3D printing technology can overcome its barriers, that would be certainly a boon to the mining and other industries.

V. ACKNOWLEDGMENT

Authors are grateful to the management of the organization for giving the permission to publish and providing valuable support. Authors greatly acknowledge the help of all colleagues in preparing the manuscript. Views referred in the paper are solely of the author not of the organization.

REFERENCES