Scaling Up Additive Manufacturing with Powder-based 3D Printing

Introduction

Powder-based 3D Printing is a billion dollar market. The Economist considers it to be "The Third Industrial Revolution" and Money Magazine predicts it will be the next trillion dollar industry and a key technology to bring manufacturing back to the U.S.—something that was reinforced by President Obama in his recent State of the Union Address. The purpose of this proposal is to build upon recent developments in our research, which use locally available raw powered materials, such as salt, saw dust, fly-ash and earth-based materials (clays, cement, geopolymers), to create a series of powder-based ecological materials and proof of concept prototypes for additive manufacturing in order to create large-scale structural objects that are enriched with digital characteristics in a manner such that data, material, programming and construction are interwoven—opening up 3D printing to the entertainment, automotive, aerospace and construction industries in California.

Because the process of additive manufacturing requires no dies or molds, it also allows for mass-customization, employing the flexibility of computer-aided manufacturing systems, rather than mass- produced, which allows for design parameters to be quickly changed and tested without incurring costs associated with labor and retooling. Thus, the process bypasses several of the steps involved in traditional production methods making it possible to go directly from file to fabrication. However, the high expense involved in a mass-customization production cycle makes these innovative modes of production not possible, especially for large objects.

Currently, my research has proven that the production of large-scale mass-customizable objects are possible to manufacture at a very low cost using sustainable and recycled materials, most of which are produced in California. Using previous funding ($36,000 for research and development and $16,000 in startup funds) I have developed a proprietary cement polymer material that can be used to produce large, mass-customized industrial grade 3D printed objects. With assistance of the Baker Fellowship, I would like to create

a start-up company that commercializes this powder and/or is a manufacturer of large-scale 3D Printed objects. Additionally, testing and printing large-scale prototypes which demonstrate usefulness of the materials and which will give potential investors and customs insight to the materials' structural performance and the possibility to produce large objects are an important goal to be achieved. Unlike current technologies, which are primarily geared at the production of small objects and parts that employ materials such as plastics and nylon-based powders, my patented material process is eco-friendly (producing zero waste), inexpensive and much stronger, making this a very viable material for the construction and manufacturing industries. The structural 3D-printable material has high strength characteristics—up to 4,537 psi (fig. 1) in compression in the most recent tests, which exceeds typical concrete, which is around 3,000 psi.

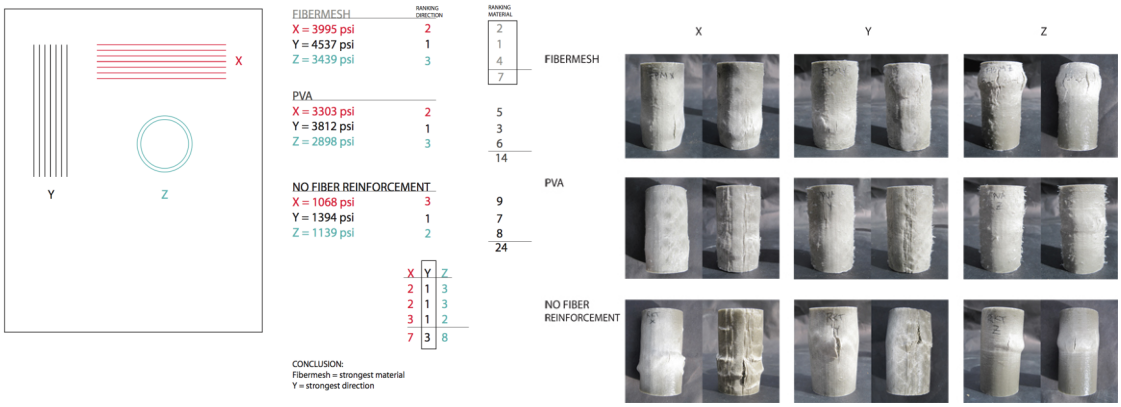

fig. 1: Structural test conducted at the University of California of fiber reinforced 3D printed objects

Further testing of the structural characteristics, as well as improving upon the material, are included in the aims of this proposal. Furthermore, I have begun to develop several other materials that include salt, harvested directly from the San Francisco Bay; recycled engineered wood power, from a company located at the foothills of the Sierra Nevada Mountains, clays from California and fly-ash, which is waste material from burning coal. Because I have published outcomes from the patented material, the phone is already ringing. I have potential customers who are interested in the technology, but there is still work to be done, before this can happen and the Fellowship would be enormously helpful in bringing more value to this endeavor.

Market Opportunities

Our market assessment has demonstrated that there is a substantial need to scale up current 3D printing processes, however, current technologies do not make this economically viable. I have arrived at a technology to meet the current billion-dollar market that is almost entirely devoid of large-scale 3D printing, and employing this technology in the State of California could potentially situate the state as a leader in additive manufacturing technologies and center emergent manufacturing processes, rather than overseas. The new materials that I have developed can be sold at a lower cost than currently available powder-based materials (which have no structural capacity), and substantially less than currently available 3D printable structural materials. Thus, what once seemed financially unrealistic, the printing of large objects, is now a reality and large-scale objects can be produced with commercially available 3D printers. This has important consequences in the construction industry. For example, California's construction industry has shed nearly 100,000 jobs, according to the Wall Street Journal, who cite this loss in jobs as an important barometer of the state's economy. Innovation that is both cutting edge and ecological would be positive contributions to an industry that is critical to the State's economy and moreover, to an industry is seen as deeply responsible for producing waste in landfills and for producing CO2 emissions. Tesla Motors, California's newest automobile manufacturer relies heavily on 3D printing, but employs some of the most expensive 3D printing technologies that exist, in the manufacturing of their prototypes. Hollywood also employs expensive additive manufacturing for the construction of its sets and effects. In both cases, the work is outsourced abroad or uses foreign technologies. The development of 3D printing powders and technologies that come from California sourced raw materials and fabricated in California would go a long way towards continuing California's legacy of an innovator in ecology and technology in the additive manufacturing market.

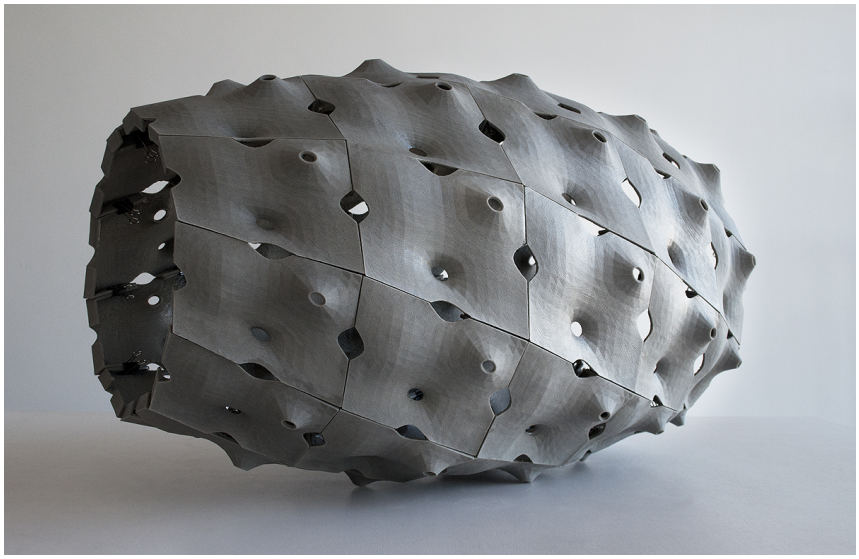

fig. 2: Two-foot-long cantilevered and sand-blasted cylindrical beam

The small objects that we have produced thus far with the material, which include assemblies of various sizes (fig. 2 and at http://www.emergingobjects.com) and a bench (fig. 3), which represents one of the largest-to-date pieces of furniture ever produced with a commercial powder printer, have brought much attention to the work in the form of outside interests, exhibitions and publications and potential customers. However, these objects do not realize the full potential of the research, which is to suggest that the material could be used to produce large objects, such as a house, for example.

fig. 3: 11’ long bench designed to support the weight of several individuals.

Recently, the United Kingdom named 3D printing a national technology priority and recognizes the way that 3D printing will impact the UK economy. California is the epicenter of digital technology and maker culture on the planet. The innovation of a start-up company that responds to the emergent potential of additive manufacturing in the State of California through the licensing of powder formulas for 3D printing and the fabrication of large-scale structural 3D printed objects, which would in turn, drive more sales to 3D printed powders, is the economic aim of this project. This would also have the potential to transform the building and manufacturing industry in California by putting forward the first large-scale building materials to be mass customized anywhere. The sale of the powder technology could spurn others to start companies in other manufacturing fields as well, from restoration, transportation, design, construction, or any entity wishing to employ additive manufacturing into their existing workflow in a way that allows for making parts bigger, faster and less expensive than previous methods of 3D printing allowed.

Milestones

In order to move towards commercialization of these materials, there are several goals that I would like to achieve within the timeframe of the fellowship. One is to develop a software tool alongside the material develop that would assist I creating aggregated assembly structures. Because currently available 3D printers have limited bed sizes, it would be important to develop a software tool alongside the powders that would enable design and manufacturing workflows that maximize material efficiency as well as the number of parts able to be produced per print job. In addition, printed objects using the array of materials would be tested for structural capabilities, fire rating, water resistance and weathering and would also be further developed and refined to meet industry standards. Additionally, new materials would be further developed and tested. Finally, large, proof-of-concept large-scale objects would be fabricated.

Timeline

In the first two years I anticipate:

- Refining materials not-ready for market
- Development of software tool for large-scale aggregation
- Production of large scale proof of concept using cement materials
- Licensing current material technology that has been patented and/or creating a startup company
- Development of new materials
- Production of large scale proof of concept using salt material
- Licensing of current material or acquisition of license by startup company
- Acquisition of large format 3D printer

In the subsequent 3 years I anticipate:

- Further material development
- Filing of patent for new powder material processes
- Production of large scale proof of concept using wood material
- Licensing of current material or acquisition of license by startup company
- Full formation of startup-company that commercializes powders and produces large scale objects or continued licensing of all powder materials.