Simulating Large Scale 3D Printer Mechanisms Using COMSOL Multiphysics® Software

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Abstract

1. Introduction
3D printing is projected as the next industrial revolution. Most of the available 3D printers are small scale 3D printers. Current need is for Large scale 3D Printers to manufacture realistic 3D Printed products effectively, compared to commercial production process. For larger scale printers, the part size and resolution are conflicting requirements. Reliable large scale 3D Printing requires in depth understanding of the functional Mechanisms. Cartesian 3D printers are dominant compared to other printers like Delta and Robotic arm because of their simple construction. Current 3D printer are having limitations in print rate and part size. The challenge for large part 3D printing are print resolution and print speed, which is governed by the printer mechanism. In this paper, brief review of available 3D printer mechanisms are given. The printer mechanisms are simulated in COMSOL® software and the add-on product, Multibody Dynamics Module. Flexible and rigid mechanism simulation are performed for evaluation of the print mechanism and structural performance. This study, in future will also include 3D printing manufacturing method simulations.

2. 3D Printer Mechanisms and Simulations
Major Types of 3D Printers are classified as Cartesian, Robotic arm and Delta 3D printers. CAD model of 3D printing Mechanisms are shown in figure 1. Cartesian printers have three different positional mechanics. Robotic arm 3D Printer with 6 dof are used due to their flexibility and powerful programming capability. Delta 3D Printer have three identical axis of movement. This reduces the number of unique parts and makes for simpler construction. Cartesian 3D printers are wided used in the industry due to its simplicity in construction and ease of operation. CAD models of Cartesian Printers are shown in figure 1.

Parametric model of 3D printer was developed. The mechanisms and structural performance was investigated using Multibody Dynamics and Structural mechanics module. The displacement results and animation of a building a square box are extracted to visualize the mechanism of the 3D printer. Simulation are made with flexible attachments and prismatic joints to guide the X Y Z movements. The effect of gravity loading, G forces along with multi body simulations are investigated. Parametric sweep node is used to extract the displacement results at different positions and Animations plots for the mechanisms. Displacements and animations results for one of the case is shown in figure 2-4.

3. Conclusion

The simulation results shows that the visualization of 3D printing Mechanisms helps in the selection and customization of 3D printer for a given product or part fabrication. Multibody dynamics simulation on a flexible body shows the deflection and stress levels due to normal working payload, gravity and g- forces effects of the 3D printer for optimization. The trade off between printer size and part print resolution can be optimized with these simulations. These parametric physics based scaling models can be used from micro to macro level printer for overall performance evaluation.

Figures used in the abstract

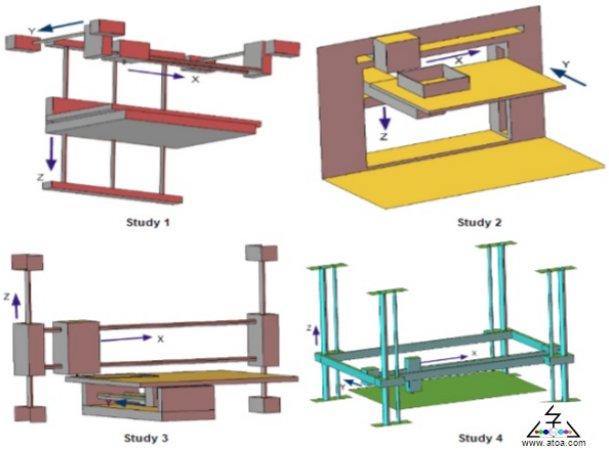

Figure 1: CAD models of different types of Cartesian 3D Printer Mechanisms.

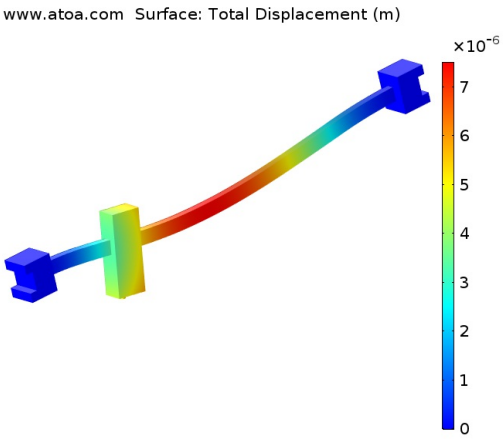

Figure 2: Displacement plot of Extruder axis.

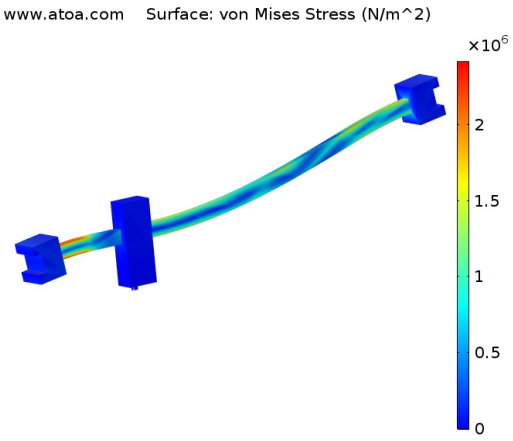

Figure 3: von Mises Stress plot of Extruder axis.

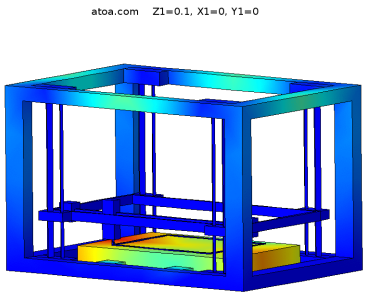

Figure 4: Animation plot for Cartesian printer (Study 4).