[[1]](#footnote-1)

A Review of the State of Mechanical Systems in Additive Manufacturing Machines

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*Abstract*— Current methods for the construction of chassis, enclosure, and motion control for additive manufacturing machines are compared from the perspective of a photopolymer additive manufacturing system aimed at the open source hobbyist market.

# INTRODUCTION

With the proliferation of additive manufacturing and computer numerical controlled machining in the hobbyist sector many solutions for mechanical systems have been proposed or used. There are now several commercial additive manufacturing machines (AMMs) targeting the hobbyist market [1]. This includes photopolymer additive manufacturing (PAM) systems [2].

The community nature of this market has led to focus on freedom of use similar to the free software movement [3]. This has created open source designs for chassis components [4] [5] [6], motion control [6] [7], and full AMMs from small and inexpensive to large [8] and feature rich [9].

This has created a broad and varied basis for developing the chassis, enclosure, and linear motion of an AMM.

# Discussion

## Chassis

The chassis of an AMM is used to support components, axes of motion, and maintain rigidity and geometry during the manufacturing process. Many designs for chassis have been implemented for AMMs.

Many utilize proprietary enclosures which also function as the chassis [9] [1], while some chassis designs focus on maximizing accessibility to hobbyists by utilizing CNC laser cut sheet as the structure of the chassis [10]. Some designs have integrated motion control into the chassis structure utilizing OpenBuilds V-Slot extrusions [11].

## Enclosure

The enclosure of an AMM separates the build volume, motion control, and electronics from the environment. Some fused deposition manufacturing (FDM) AMMs forego enclosures entirely [11] [10]. It is of much importance in a photopolymer additive manufacturing (PAM) system. Unlike FDM, PAM requires light isolation to prevent unwanted polymerization of the photoresin. This necessitates a complete enclosure for the build volume.

## Linear Motion

Most AMMs use toothed belts [8], synchromesh cable [11], or lead screws [2] for linear motion control. Z axis motion is almost exclusively handled by lead screws [11], usually in tandem [1], while X and Y axis motion is implemented with a toothed belt [10] or synchromesh cable [11].

While most AMMs use round-slide plain bearings [2] [1] [10] [9], dovetail slides have been implemented in elegant ways [11] [7] [6]. Flat slides could also be implemented inexpensively, though precision may suffer.

# Conclusion

PAM systems offer a unique combination of needs and allowances which can be leveraged to produce an inexpensive and accessible AMM for the hobbyist market. Current AMM practices allow the merger of many system components, such as chassis and linear motion bearings [6] or chassis and enclosure [9].

FDMs reliance on mechanical motion for deposition requires precision in the chassis and linear motion systems. Current PAM system designs only rely on mechanical precision for Z axis travel, allowing more design flexibility in the chassis. The combination of these two factors does not lend itself to many of the current open source chassis solutions [5] [4], including those which incorporate linear bearings [6].

The necessity of a PAM system to have an enclosure lends credence to combining the chassis and enclosure. The lack of need of much mechanical precision allows for the use of a structurally weaker chassis/enclosure. Maintaining accessibility to hobbyists would suggest a chassis/enclosure manufactured from laser cut wood sheet and fastened with M3 hardware, similar to the Printrbot and MakerBot version 1 designs [10] [1].

With linear motion being divorced from the chassis, linear motion becomes a blank slate system, with the only caveats being price, maintaining perpendicularity, and precision in motion. It is therefore suggested that round-slide plain bearings and a lead screw be implemented in the Z-axis motion control.

# Acknowledgment

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