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Mechanical System for Wire Arc Additive Manufacturing

Krum Petrov
Technical University of Sofia,
Institute of Metal Science, equipment, and technologies with Center for Hydro- and Aerodynamics "Acad. A. Balevski" at the Bulgarian Academy of Sciences – (IMSETHC-BAS)
Sofia, Bulgaria
kpetrov@tu-sofia.bg

Evgeny Tongov
Technical University of Sofia,
Institute of Metal Science, equipment, and technologies with Center for Hydro- and Aerodynamics "Acad. A. Balevski" at the Bulgarian Academy of Sciences – (IMSETHC-BAS)
Sofia, Bulgaria
niton_et@abv.bg

Abstract. **This article discusses the reassembly of a mechanical system for 3D printing plastic parts to be used for plasma arc additive manufacturing. The main issues in converting an existing 3D printer designed for plastic additive to used for producing metal parts are: control of the welding power source; installation and realization of the movement with the welding torch; set the height of the zero layer; setting up the program software to generate the control file.**

Keywords: plasma arc, additive manufacturing, 3D printer, mechanical system.

I. Introduction

Additive manufacturing is the process of creating an object by building it up one layer at a time. This is the opposite of subactive manufacturing, where it is created by cutting a solid object out of material until the finished product is complete. Technically, additive manufacturing can refer to any process where a product is created by building something, such as molding, but it always applies to 3-D printing [1], [2], [3], [4].

Additive manufacturing was first used to develop prototypes in the 1980s - these objects are not functional. This process was known as rapid prototyping because it allowed people to create a scale model of the final object quickly, without the typical setup process and costs associated with creating a prototype. As additive manufacturing improves, its use extends to rapid tooling that is used to create molds for finished products. Additive manufacturing (AM) — has formidable potential across the manufacturing [1]. It enables products to be made on demand, at point-of-use, and with very efficient material usage. AM's primary use to date is in rapid prototyping, tooling, and production of replacement parts. 3D printing, or additive manufacturing (AM), is highly suited to high precision manufacturing in a wide range of details [5], [6], [7], [8].

3D printing is a technique that "prints" an object, thus displacing traditional technologies for the production of details. This method uses a wide range of materials such as photopolymers, thermoplastics, paper and others [9], [10], [11]. Since these materials in most cases do not have good mechanical and technological characteristics, they are not suitable for direct installation and loading in industry.

In this paper we present "printing" process that uses metal as a raw material. The process involves the use of selective metal fusion plasma remelting and an adapted torch drive from a commercially available 3D polymer printer modified by us, which deposits successive layers of metal in such a way as to form a 3D solid. This process can also be considered a low volume production process.

II. Materials and methods

In order to reduce the cost and time of making our 3D printing system by selective plasma remelting, we decided to use a ready-made 3D polymer printer Wanhao brand model Duplicator 12 D12/500 D12-500 Double Extruder the following technical fig.1 with features:

500mm X 500mm X 500mm Build Area, Product Name: D12/500, Max Printing Area :500*500*500mm, Max Print Speed: 150mm/s, Software: CURA, Filament Diameter: 1.75mm, Material Support: PLA, PETG, any filament melt =<260 C , Machine Size: 67*81*78cm, Extruder System : MK14 Single / Double together;

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Fig. 1. Wanhao Duplicator 12 D12/500 D12-500 Double Extruder.

The main goal we set ourselves is:

To modify and adapt the mechanical drive of the printer to work with different types of plasma (welding) torches.

In order to achieve the set goal, we had to solve the following tasks:

- Build a 3D CAD model of the printer so we can experiment with different drive modifications.
- To move the height sensor "3D Touch" mounted on the print head so that it works normally without being in danger of damage due to the effect of the plasma arc.
- To ensure reliable grip of various plasma torches.

III. RESULTS AND DISCUSSION

1. Building a 3D CAD model of the printer.

After a detailed dimensional capture of the existing printer, in a SolidWorks environment we built a 3D CAD model of the printer, which allowed us to test different drive modifications and choose the most suitable combination to implement in practice. Fig.2 a and b shows the 3D model of the printer.

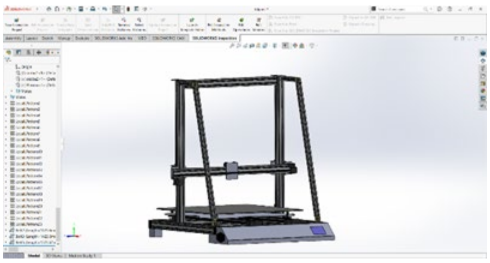

Fig. 2a. 3D model of the printer.

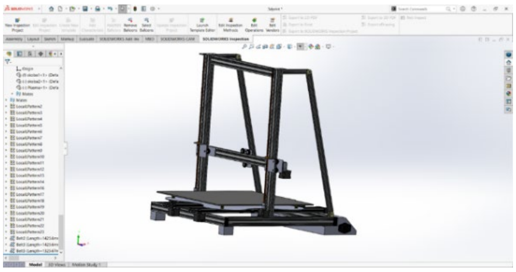

Fig. 2b. 3D model of the printer.

2. Moving the “3D Touch” height sensor.

In order to drive the plasma torch from the 3D printer, we first had to move the "3D Touch" height sensor, which is mounted on the printing head fig.3. This was necessary for the following reasons:

- "Fooling" the electronic unit, that the sensor moves together with the original print head, to ensure normal operation of the drive;
- Protection of the sensor from the effects of high temperature and metal splashes during the operation of the plasma torch.

Fig.3. Printhead with “3D Touch.

After trying several combinations, which we checked on the 3D CAD model of the printer we made, we chose to mount an angle plate on a vertical fixed beam from the printer frame fig. 4.a and b. The angle plate plays the role of the printer's work table. In this way, we "fool" the sensor that it is in contact with the mass and it gives information to the control unit that everything in the system is fine. Thus we ensure smooth and reliable operation of the drive.

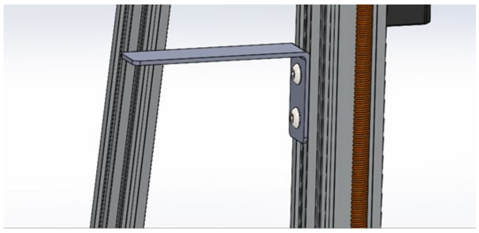

Fig. 4.a.” Angled Plank 3D Model”.

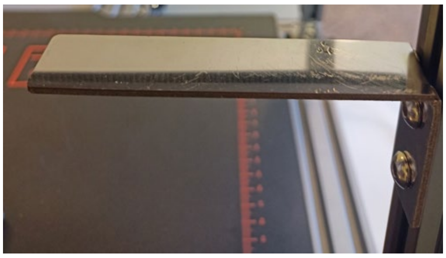

Fig. 4. b.” Angled Plank”.

We mounted the "3D Touch" itself on the horizontal movable beam of the printer so that the sensor is located above the corner plate fig. 5 a and b. For the installation of the sensor, we used an intermediate plate made by us fig. 5. b.

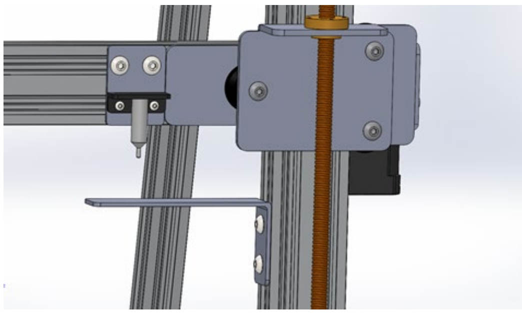

Fig. 5. a. 3D model "3D Touch".

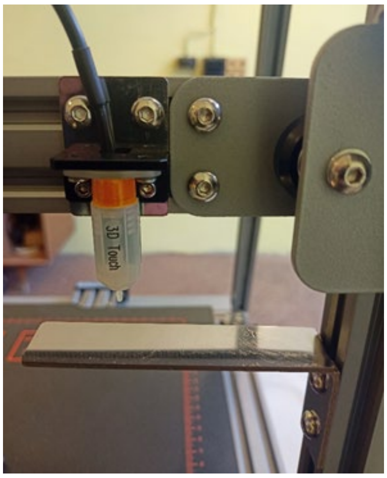

Fig. 5. b. "3D Touch".

3. Grip the various plasma torches.

To hold the plasma torches, we designed and manufactured a special bracket that we installed in place of the original print head. Thanks to the samples we made in advance with the 3D CAD model of the printer, the bracket was designed so that during installation there would be no changes to the original construction of the printer fig. 6 a and b.

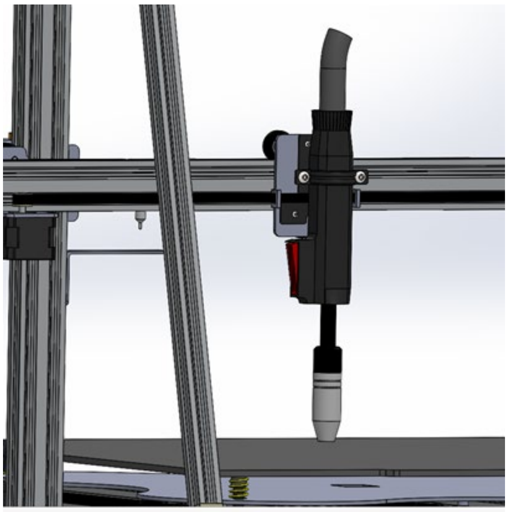

Fig. 6. a. Bracket for holding the torch 3D.

Fig. 6. b. Bracket for holding the torch.

Figure 7.a and b shows the modified printer based on the 3D CAD model.

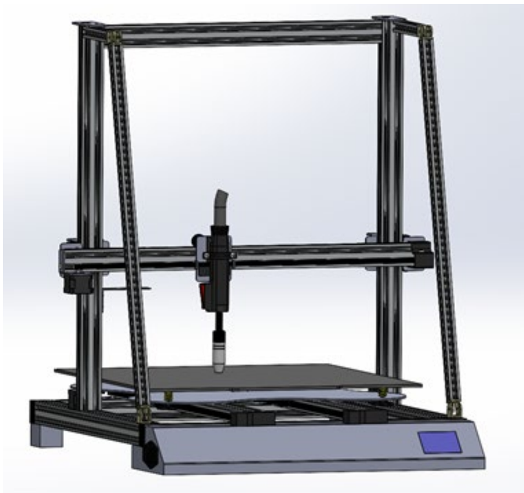

Fig. 7.a. 3D CAD model.

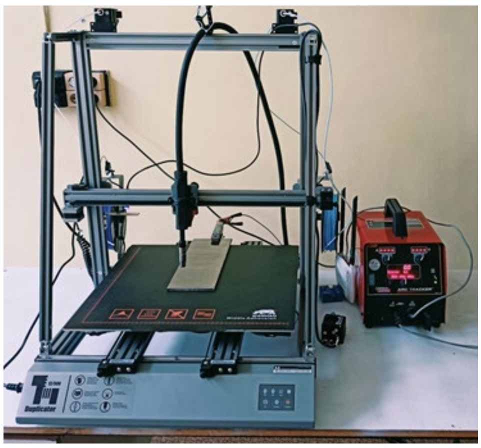

Fig. 7. b. 3D selective plasma remelting.

IV. Conclusions

Based on 3D model of printer end the parts we designed and built, we successfully converted an existing 3D printer designed for plastic additive hu be used of produce metal parts. We realized a stable grip on the welding torch. We ensured a smooth and steady movement of the welding torch. We have achieved full synchronization between the 3D printer and the welding power source. We have adjusted the software to generate the control file so as to obtain a sustainable 3D printing process of metal products with selective metal fusion plasma remelting.

This is the work that we did in the first stage of the contract. At the next stage, we envisage the creation of details with different geometries, which will be thoroughly investigated by performing mechanical tests, flaw detection, microstructure research, etc.

V. Acknowledgments

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