CHAPTER 5

PROTOTYPING

The fidelity of the formulated design explained in earlier chapter is refined and validated with this prototyping stage. The two different manufacturing methods, 3D printing and conventional manufacturing are preferred. In order to reduce time and cost, a small scale design (i.e. conceptual design) is selected for prototyping.

5.1. Prototype 3D Printing of a TRS Assembly

The designed thermionic regenerator is 3D printed in the first step of prototype to check the assembly and avoid machining at an early stage. PLA is the substance used in 3D printing. PLA (Polylactic acid) is a thermoplastic made from renewable resources such as maize starch or sugarcane that is biodegradable (given the right conditions). It's one of the most widely used bioplastics, with uses ranging from plastic cups to medical implants. This manufacturing is done in 3D printing lab of School of Computing Skills, BSDU. The manufactured components are shown in Fig 5.1.

Fig. 5.1. 3D Printed Prototype

- FDM 3d Printer (Max 300 & Max 500) Specifications;

- Model: Fdm 3d Printer (Max 300 & Max 500)
- Technology: Fused Filament Fabrication (FFF)
- Material: ABS, PLA, HIPS, NYLON
- Build Volume (WXDXH): 300*300*300 mm & 500*500*500 mm
- Manufacturer: 3idea Technology
- Units: 1 (Max 300), 1 (Max 500)

- **Time Required:** 4hours 31 Minutes
- **Material Consumed:** 15.87 Meter, 47g
- **Approximate Cost:** 132.57 Rs.

The 3D printing is done to develop a prototype of a small scale thermionic regenerator. The inter-electrode spacing and interference of mating parts were analyzed. It was observed from the 3D printing that, for manufacturing of TEC components the machining accuracy must be kept very high achieving 10μm tolerances.

5.2. Prototype Manufacturing and Assembly of TRS

- Material and equipment selection-

- Mild steel, aluminium, brass, tungsten, molybdenum, and beryllium are used as emitters and collectors. M.S., Al, and brass are among the materials produced. Because they are less expensive and more readily available than other materials.
- Insulator: A borosilicate glass tube with an outside diameter of 192 mm (diameter x thickness) that is commonly used in chemical labs as a measuring cylinder is cut to the desired size and utilized as an insulator.
- Heating- cartridge heater of dimension 12×70 mm (diameter × length) with thermocouple for emitter temperature measurement.
- Copper connectors
- High precision voltmeter

- Conventional turning and drilling operations were performed in school of manufacturing skills for manufacturing of a prototype as shown in Fig 5.2.

Fig. 5.2. Turning

Turning is the most common lathe machining technique for cylindrical rods and shafts. During the turning process, a cutting tool is used to remove material from the outside diameter of a revolving work piece. The main purpose of turning is to reduce the work component's diameter to the desired size. Step turning, drilling, and facing are the turning operations employed in the manufacture of the emitter and surface, as depicted in Fig 5.2.

Fig. 5.3. Tapping

Tapping is the process of using a tap-like cutting tool to cut internal threads in a hole. On a tap, cutting edges in the shape of threads can be found. Because a tap removes metal and cuts internal threads when screwed into a hole, the hole you drill will be smaller than the tap size. As indicated in Fig. 5.3, the tapping operation is used on the upper fixture.

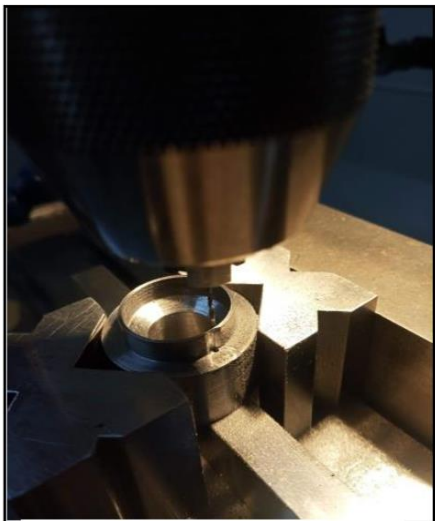

Fig. 5.4. Drilling

Drilling is a cutting technique that involves using a drill bit to create a circular cross-section hole in solid materials. A multi-point rotary cutting device is typically used as a drill bit. The bit is pressed on the work piece and spun at hundreds to thousands of revolutions per minute. As shown in Fig. 5.4, the drilling operation is utilised to make a hole in the top fixture.

Fig. 5.5. Assembly 1

Fig. 5.6. Assembly 2

The Fig 5.5 & 5.6 shows the assembly of manufactured prototype. The prototype assembly is tested for electrical insulation between emitter and collector by continuity test using Multimeter. This test is performed to indicate that whether the manufacturing tolerances are achieved or not.

A continuity test determines if two electrodes or points are connected electrically. An electric current can freely flow from one end to the other if something is continuous. There is a break somewhere in the circuit if there is no continuity. From the continuity test it is found that the emitter and collector are electrically insulated and manufacturing of prototype have successfully passed the criteria of providing electrical insulation. This developed prototype is further utilized in the experimental setup as a test device. The experimentation process is elaborated in the next chapter.