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Optimization of printing process parameters to avoid the plastic strain during the printing of micro channel

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Abstract: The problem of designing a compact high-performance evaporator for miniature refrigeration system has been investigated. Micro cooling channel has multiple applications to transfer the heat and cool the system. To manufacture these micro channels through conventional machining is very difficult to overcome these problems we choose Additive manufacturing to manufacture the model. We choose SLM 280HL printer to simulate the model and we used Altair inspire tool to simulate printing process for different laser powers to find the optimized laser power. Due to very less cross section present in the micro channel very large stress and temperature will be developed. Due to large temperatures the warpage plate will occur, to control this warpage laser power has been optimized to control the warpage of the model. After performing this simulation, the laser optimized at 600W giver better printing results.

Key words: Optimization, strain, micro channel, warpage, SLM 280HL

I. INTRODUCTION

Liquid cooling plates have vast applications in electronic devices, computer processors, automotive engines, etc. Amid dense processing units, temperature stability is of key importance in technological advancement. Multitask processors are widely used in this techno-era. Liquid cooling processes in the perspective of system space and working fluid may lead to an appropriate thermal environment. A liquid cooling plate is used for the transmission of heat from hot surfaces of gadgets having a high load to the fluid circulating within a liquid plate system. A number of various heat sink plates have been introduced to manage high heat flux while considering the allowable temperature in electrical equipment [1]. The use of conventional air cooling systems is being outpaced to meet demands of modern high tech appliances [2, 3]. So, liquid cooling plates with micro-channel setups have been considered as a possible method to overcome high power concentrations [4] and hybrid 2 micro-channel systems [5, 6] have been considered as a possible method to overcome high power concentrations. While micro-channel liquid plates may have relatively better thermal performance than their conventional counterparts, they do require high pumping power, and this is due to the enhanced compactness of the flow channels [7]. Consequently, liquid cooling plates having micro-channel setups should be designed carefully with reliable estimates of pressure drop to fulfill cooling demands of high heat flux applications.

Micro-channel cooling is an effective method to enhance cooling for electronic devices. The problem of boundary layer development as a liquid coolant travels downstream persists in convection micro-channel heat sink.

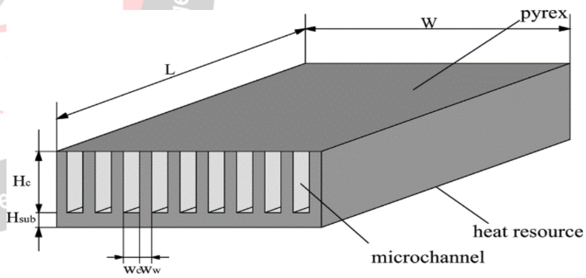

Fig 1.0: Cooling system

1.1 Invention: The use of micro-channel as a visible cooling system was proposed by TUCKER MAN & PEASE (GERMAN ENGINEERS). They designed cooled hat sink by etching micro channel heat sink with 50um wide and 300um height on a silicon substrate. Fluid flow inside channel is at the heart of many natural and man-made systems. Heat and mass transfer is accomplished across the channel walls in biological systems, such as brain, lungs, kidneys, intestines, blood vessels etc.. as well as in man-made systems, such as heat exchanges, nuclear reactions, air separation units, desalination etc…. In general, the transport process occur across the channels walls where as bulk flow takes place through the channel of cross-sectional area. The channel cross section thus serves as a conduct to transport fluid to and away from channel walls

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HEAT SINK:

In electronic systems, a **heat sink** is a passive heat exchanger component that cools a device by dissipating heat into the surrounding air. In computers, heat sinks are used to cool central processing units or graphic processors. Heat sinks are used with high-power semiconductor devices such as power transistors and optoelectronic devices such as lasers and light emitting diodes (LEDs), wherever the heat dissipation ability of the basic device package is insufficient to control its temperature.

A heat sink is designed to increase the surface area in contact with the cooling medium surrounding it, such as the air. Approach air velocity, choice of material, fin (or other protrusion) design and surface treatment are some of the factors which affect the thermal performance of a heat sink. Heat sink attachment methods and thermal interface materials also affect the eventual die temperature of the integrated circuit. Thermal adhesive or thermal grease fills the air gap between the heat sink and device to improve its thermal performance. Theoretical, experimental and numerical methods can be used to determine a heat sink's thermal performance.

Fig 1.2: A finned heat sink and fan clipped onto a microprocessor, with a smaller heat sink without fan in the background.

1.2 Objectives:

A channel serves to accomplish two objectives

i) Bring a fluid into intimate contact with channel wall, and
ii) Bring fluid to the wall and remove fluid away from the walls as the transport process is accomplished.

The rate of transport process depends on surface area, which varies with the diameter D for a circular tube, whereas flow rate depend on cross sectional area. In human body, the head and mass transfer occurs inside lungs and kidneys with flow channels approaching capillary dimensions of around 4um.

Mini channel	3mm >= D > 200um
Micro channel	200um >= D > 10um
Transitional micro channel	10um >= D > 1um

Heat transfer and fluid flow in mini channel and micro channel

a) Single-phase gas flow in micro channels
b) Single-phase liquid flow in micro channels
c) Single-phase electro-kinetic flow in micro channels
d) Flow boiling in micro-channels
e) Condensation in micro-channels
f) Biomedical applications of micro-channel flows.

Types of Micro-channel Cooling System's:

a) Single Phase Liquid Flow in Micro-channel:
b) Single Phase Electro-Kinetic Flow in Micro-channels:
c) Single Phase Gas Flow:
d) Flow Boiling in Micro-Channels:

1.2.2 Considerations:

i) High heat transfer coefficient during flow boiling.
ii) Higher heat removal capability for given mass flow rate of coolant.

Advantages: Ability of fluid to carry large amount of thermal energy through latent heat of vaporization.

1.2.3 Bio-Medical Applications:

i) Transport and manipulation of living cells and biological macromolecules place increasingly critical demand on maintaining system conditions with acceptable ranges.

ii) Micro-channel geometry used in changing the temperature of small liquid volumes in DNA chains.

iii) Concentration of solutes, nutrients, gases metabolic products are maintained within specified tolerances to ensure cell proliferation with bio-reactors of micro-channel cooling system.

Consequently, convective heat transfer performance of a heat sink deteriorates in the direction resulting in elevated maximum temperature and significant temperature gradient across heat sink.

Heat Sink: A passive heat exchange component that cools a device by dissipating heat into surrounding air.

Heat sink is used with high power semiconductor devices (power transistors, optoelectronic devices, lasers, light emitting devices (zed)).

1.2.4 Types of Flows in Micro-channel Cooling System:

1) Laminar Flow through Micro-channels:

The fluid flows in the channel in parallel layers of channels with no disruptions between layers and channels. The liquid tends to flow without mixing in the channels.
Use: Micro-scale cooling system

a) For circular micro-pipes and convection ducts.

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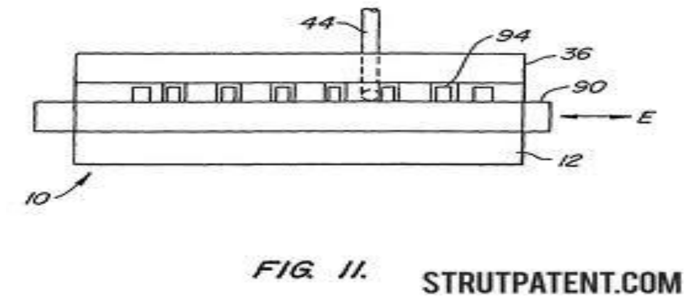

Fig 1.2.4(a): Laminar flow through micro-channels

2) **Integrated Micro-channel Cooling for 3D Electronic Circuit Architecture:**

In this type of micro-channels the fluid flows in all layers of the chip. These devices are in two or more than two layers. The di-electric liquid flows in all direction covering all channels of the sink.

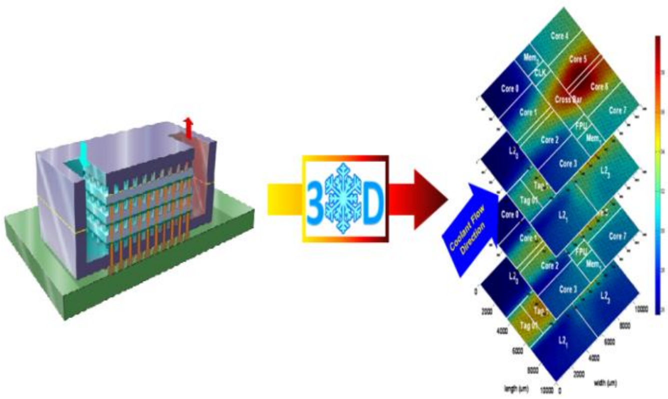

Fig 1.2.4(b): Integrated micro-channel cooling

3) **Micro-channel Cooling for High Power Semiconductor Devices:**

In this type of channel cooling system used in semiconductor devices like transistors, bi-polar chips. This system is used in linear operations of electronic equipment's.

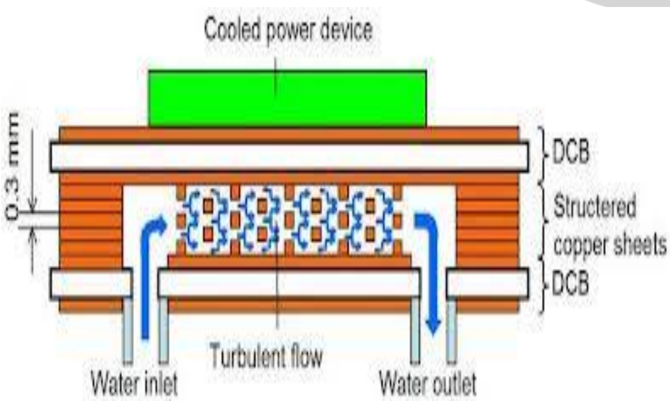

Fig 1.2.4(c): Micro-channel cooling for high power semiconductor devices

Micro-scale pumping technologies for micro-channel cooling systems

100= h (50) (T1-T2)

Type of metals used: silicon, aluminium.

Geometry Optimization of Micro-channel Cooling System:

1) Heat dissipation rate
2) Flow rate
3) Pressure drop
4) Fluid temperature rise
5) Fluid inlet to surface temperature difference.

Advantages of Micro-channel Cooling System:

1) Cools integrated circuits.
2) Heat is absorbed by walls and heat is moved to the radiator.
3) Cools integrated chips 50 times faster than convection cooling.
4) Easy to manufacture
5) Very effective for small areas (<7centimeter square)

A liquid cooling plate is used for the transmission of heat from hot surfaces of gadgets having a high load to the fluid circulating within a liquid plate system. A number of various heat sink plates have been introduced to manage high heat flux while considering the allowable temperature in electrical equipment [1]. The use of conventional air cooling systems is being outpaced to meet demands of modern high tech appliances [2, 3]. So, liquid cooling plates with micro-channel setups have been considered as a possible method to overcome high power concentrations [4] and hybrid 2 micro-channel systems [5, 6] have been considered as a possible method to overcome high power concentrations. While micro-channel liquid plates may have relatively better thermal performance than their conventional counterparts, they do require high pumping power, and this is due to the enhanced compactness of the flow channels [7]. Consequently, liquid cooling plates having micro-channel setups should be designed carefully with reliable estimates of pressure drop to fulfill cooling demands of high heat flux applications. High-power electric equipment, fuel cell power bases and concentrated solar plates all require operational thermal stability to attain a harmless and better effective process. Heat bases containing comparative outsized smooth plate measurements stand commonly required for heat dissipation in fuel cell tools [8, 9]. In the latest practices of solar energy technology, concentrated solar panels also required flat plate dimensions [10, 11]. Presently, air convection heat bases used as a feasible way to thermally stabilize electric appliances, mainly addressing the little cost with great consistency [12].

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Significant research on air-cooling heat exchangers is carried out in the last few years, and substantial perfections in heat exchanger models mainly accomplished centred with CFD studies [13, 14], corresponding with tentative evaluations [15, 16].

Additive Manufacturing

EOS M 290 machines

EOS Used Materials:

Aluminium AlSi10Mg:

Copper CuSn10:

Introduction to CAD Modelling:

Fusion 360 is a cloud-based CAD/CAM tool for collaborative product development. The tools in Fusion enable exploration and iteration on product ideas and collaboration within a product development team.

Fusion 360 enables fast and easy exploration of design ideas with an integrated concept to production toolset. Fusion lets you focus on the form, function, and fabrication of your products. Use the sculpting tools to explore form and modeling tools to create finishing features. These tools let you quickly iterate on design ideas. Once you have settled on a design, you can create assemblies to validate fit and motion in your design or create photo-realistic renderings to verify the appearance. Finally, you need to fabricate your design. Use the 3D print workflows to create a rapid prototype or the CAM workspace to create tool-paths to machine your components.

Fusion 360 also helps bring design teams together for collaborative product development. All your designs are stored in the cloud, which means you and your team always access the latest data. Fusion also tracks versions of your design as you work.

You can use Autodesk A360 to view each version in your web browser and promote an old version to the current version. Finally, use Fusion and A360 to share your designs and track design activity. You can even provide controlled access to your designs without requiring an Autodesk ID.

Fusion 360 uses a hybrid environment that harnesses the power of the cloud when necessary and uses local resources when it makes sense. For example, your design data is stored on the cloud and renders amazing images every time you save a new version of your design. This happens in parallel while you are creating and editing designs locally on your machine. This allows you to harness the power of your computer and the power of the cloud at the same time.

Throughout this course, you explore these areas of Fusion 360. This course gets you started designing with Fusion and helps you understand how it can improve your design processes.

4.1.1 Preferences:

Preferences control default settings in Fusion. The Preferences dialog contains many pages of settings. Any changes you make to the preferences are saved with your Autodesk ID and are loaded when you log into another machine.

Some important preferences to review:

- General: general settings such as versioning (saving), pan, zoom, and orbit.
- General > Design: settings for the design workspaces: model, sculpt, patch.
- General > Drawing: settings for the creation of drawings.
- Material: controls the default physical material and appearance.
- Unit and Value Display: sets the precision and display of units.
- Default Units > Design and CAM: sets the default unit type.

Lesson 1: Setting Your Preferences

Learning Objectives

1. Access preferences
2. Modify preferences settings

Datasets Required

No dataset are required. You start with a new empty design.

Step 1: Access the preferences dialog box.

1. Click on your name in the upper right corner then select Preferences.

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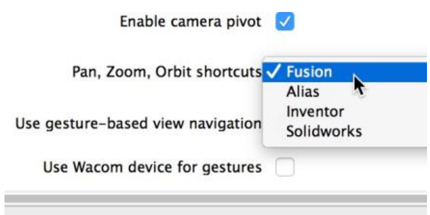
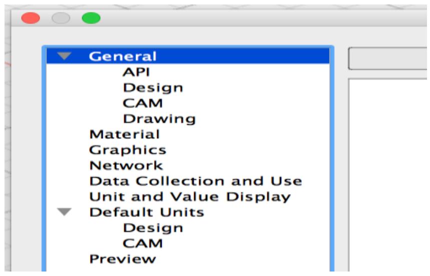
Step 2: Change the General settings.

1. Click General in the preferences list.
2. Scroll to Pan, Zoom, Orbit shortcuts.
3. Select the CAD application you are most comfortable with. This changes the mouse behavior for pan, zoom, and orbit.
4. Scroll through the other options in the General page.



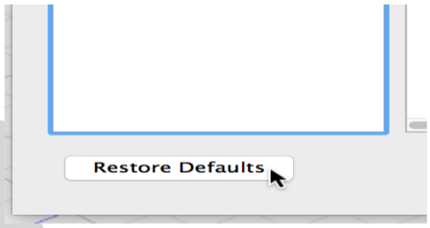
Step 3: – Review the other pages.

1. The Preferences dialog contains multiple pages. Click through the other pages to review the available settings.



Step 4: – Reset the preferences.

1. If desired, click Restore Defaults in the lower left of the Preferences dialog. This resets all settings to the installed settings.



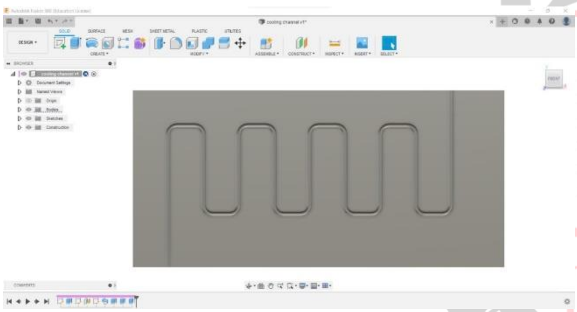


Fig 4.1(a) liquid cooling channel

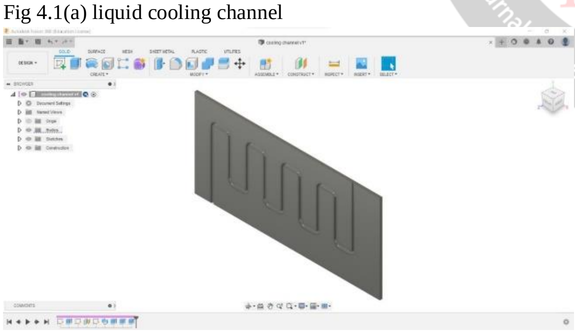


Fig 4.1(b) isometric view of liquid cooling channel

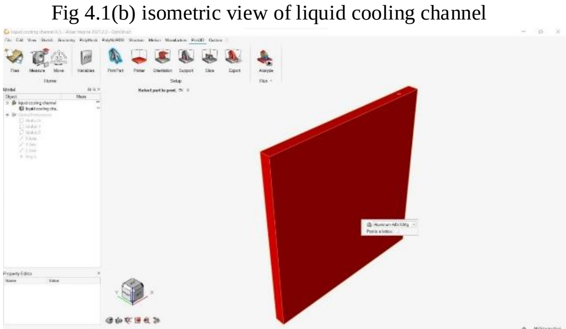


Fig 4.2(a) assigning material to the micro channel

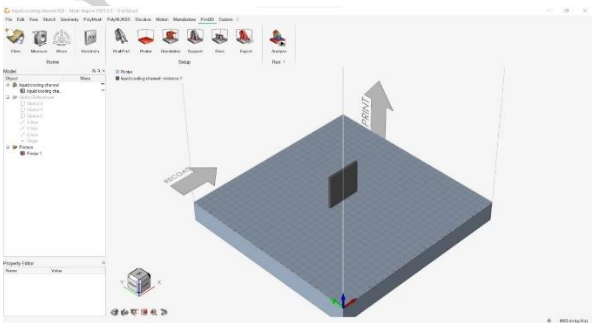


Fig 4.2(b) SLM printer

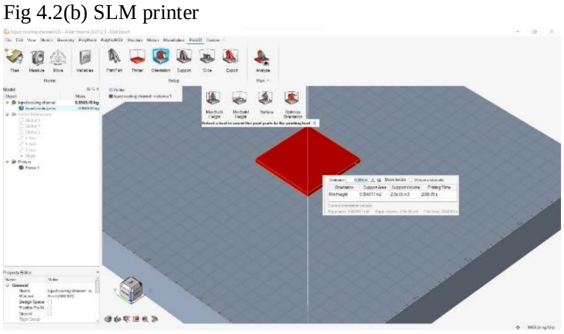


Fig 4.2(c) orientation optimization and support material calculation

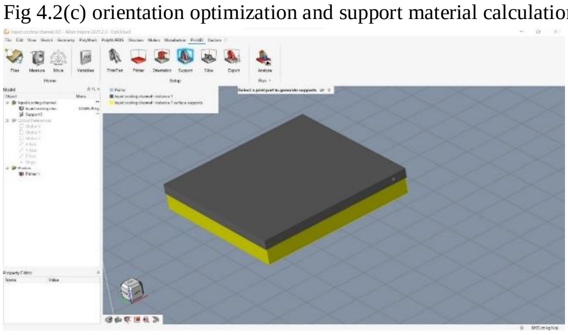


Fig 4.2(d) support structure generation

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Results

5.1 3D Printing Simulation for SLM 500 W:

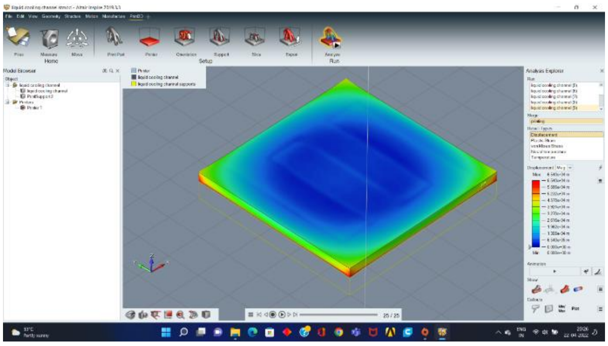

Fig 5.1(a) displacement of micro channel in SLM printer

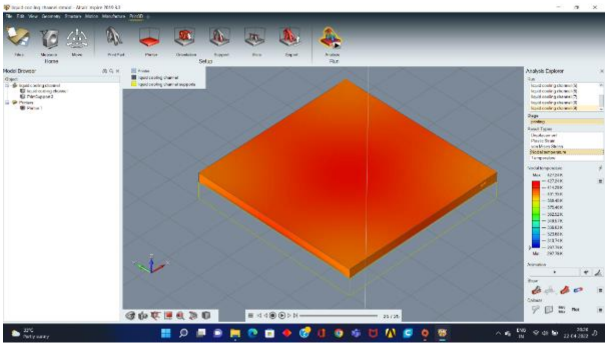

Fig 5.1(b) nodal temperature of micro-channel in SLM

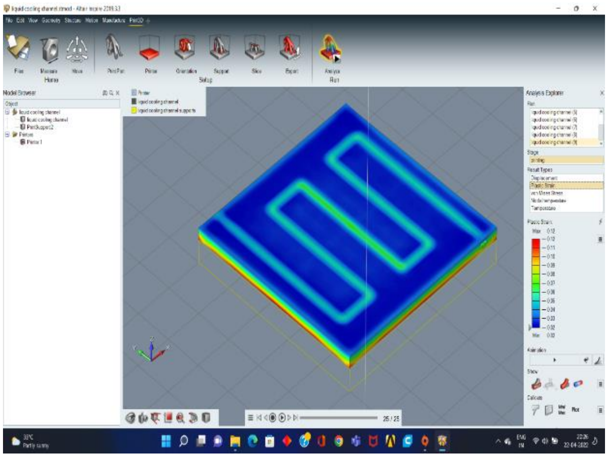

Fig 5.1(c) displacement of micro-channel in SLM

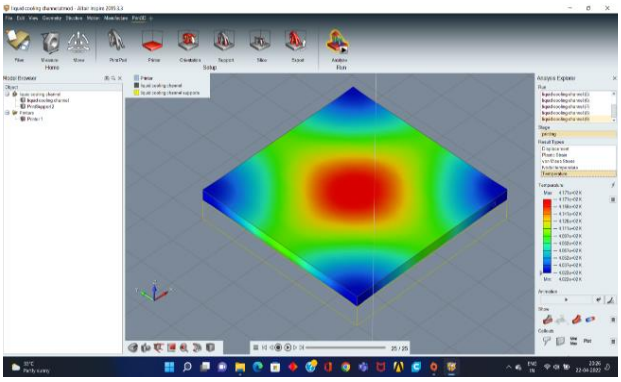

Fig 5.1(d) temperature distribution of micro-channel in SLM

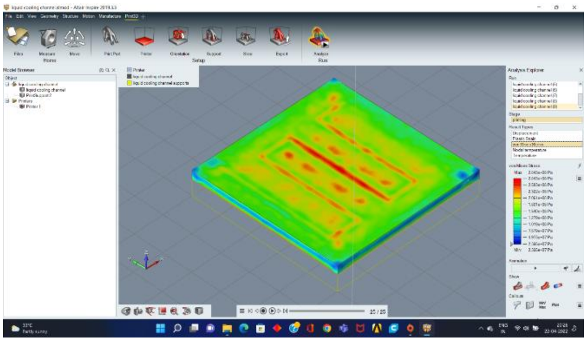

Fig 5.1(e) von mises stresses developed in micro-channel in SLM printer

5.2 3D Printing Simulation for SLM 550 W:

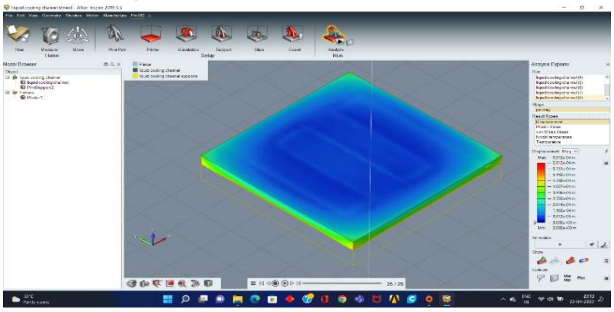

Fig 5.2(a) displacement of micro-channel in SLM

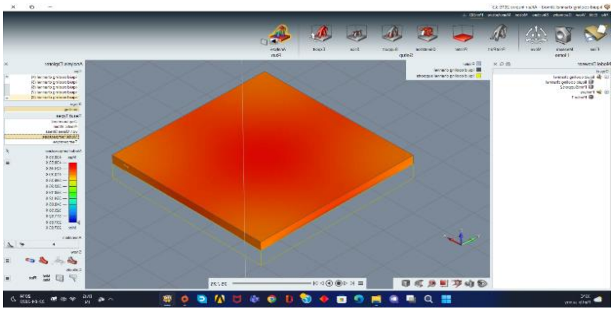

Fig 5.2(b) nodal temperature of micro-channel in SLM

II. CONCLUSION

We have performed the analysis for different laser powers and different machines to find the best suitable machine for 3d printing the micro channel. From the above results we conclude that

1. The displacement of the micro channel for different laser powers has been studied and the optimal displacement came at 600W. Micro channel is very less in thickness due to that reason more temperature is concentrated and causes displacement of the printed part.

2. Plastic strain of the component is optimized at 600W laser power with value of 0.11.

3. The nodal temperature is developed minimum at 600W with 415.73 K is developed on the surface of the micro channel. Similar to nodal temperature, temperature distribution developed more at the minimum cross section thickness.

4. Von mises stresses are developed minimum at the internal cutting cross sections because minimum thickness present at the internal cutting cross section due to this reason rapid cooling occur at the minimum thickness and produces stresses.

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5. To reduce the stresses in the micro channel position and optimization need to be done. But the 3D printing support material and support printing time will be increases.

From the above conclusions at 600 W laser power gives better printing properties. At that laser power we are getting minimum values of displacement and plastic strain.

III. REFERENCES

[1] Zhang, H., et al. Thermal management of high power dissipation electronic packages: From air cooling to liquid cooling. in Proceedings of the 5th Electronics Packaging Technology Conference (EPTC 2003). 2003. IEEE.

[2] Sauciuc, L., et al. Air-cooling extension-performance limits for processor cooling applications. in Ninteenth Annual IEEE Semiconductor Thermal Measurement and Management Symposium, 2003. 2003. IEEE.

[3] Suo, N., et al., Research on thermal design control and optimization of relay protection and automation equipment, Thermal Science, 24(2020), 5, pp. 3119-3128

[4] Garimella, S.V., et al., Thermal challenges in next generation electronic systems-summary of panel presentations and discussions, IEEE Transactions on Components Packaging Technologies, 25(2002), 4, pp. 569-575

[5] Yang, M., et al., Numerical study on flow and heat transfer of a hybrid microchannel cooling scheme using manifold arrangement and secondary channels, Applied Thermal Engineering, 159(2019), pp. 113896

[6] Yang, M., et al., Multi-objective optimization of a hybrid microchannel heat sink combining manifold concept with secondary channels, Applied Thermal Engineering, 181(2020), pp. 115592

[7] Harms, T.M., et al., Developing convective heat transfer in deep rectangular microchannels, International Journal of Heat Fluid Flow, 20(1999), 2, pp. 149-157

[8] Scholta, J., et al., Externally cooled high temperature polymer electrolyte membrane fuel cell stack, Journal of Power Sources, 190(2009), 1, pp. 83-85

[9] Kandlikar, S.G., et al., Thermal management issues in a PEMFC stack–A brief review of current status, Applied Thermal Engineering, 29(2009), 7, pp. 1276-1280

[10] Gao, Y., et al., A parametric study of characteristics of concentrating PV modules, International Journal of Low-Carbon Technologies, 5(2010), 2, pp. 57-62

[11] Rosell, J., et al., Design and simulation of a low concentrating photovoltaic/thermal system, Energy Conversion Management, 46(2005), 18-19, pp. 3034-3046

[12] Dogruoz, M.B., et al., Experiments and modeling of the hydraulic resistance and heat transfer of in-line square pin fin heat sinks with top by-pass flow, International Journal of Heat Mass Transfer, 48(2005), 23-24, pp. 5058-5071 15

[13] Yang, Y.-T., et al., Numerical study of pin-fin heat sink with un-uniform fin height design, International Journal of Heat Mass Transfer, 51(2008), 19-20, pp. 4788-4796

[14] Naphon, P., et al., Numerical investigation on the heat transfer and flow in the mini-fin heat sink for CPU, International Communications in Heat Mass Transfer, 36(2009), 8, pp. 834- 840

[15] Walsh, E., et al., Low profile fan and heat sink thermal management solution for portable applications, International Journal of Thermal Sciences, 46(2007), 11, pp. 1182-1190

[16] Wadsworth, D., et al., Cooling of a multichip electronic module by means of confined twodimensional jets of dielectric liquid, (1990),

[17] Xie, G., et al., Thermal analysis of the influent of chip arrangement of a water-cooled minichannel heat sink, Thermal Science, 20(2016), 2, pp. 381-389

[18] Tzeng, S.-C.J.I.j.o.h., et al., Spatial thermal regulation of aluminum foam heat sink using a sintered porous conductive pipe, International journal of heat mass transfer, 50(2007), 1-2, pp. 117-126

[19] Sung, M.K., et al., Single-phase and two-phase hybrid cooling schemes for high-heat-flux thermal management of defense electronics, Journal of Electronic Packaging, 131(2009), 2,

[20] Nayak, K., et al., A numerical model for heat sinks with phase change materials and thermal conductivity enhancers, International Journal of Heat Mass Transfer, 49(2006), 11-12, pp. 1833-1844

[21] Klein, D., et al., Heat transfer characteristics of water and APG surfactant solution in a microchannel heat sink, International Journal of Multiphase Flow, 31(2005), 4, pp. 393-415

 DOI : 10.35291/2454-9150.2022.0264