Cardiovascular Stent Manufacturing By Laser Micro-Cutting

Mini-Project Review
ME6320

Prof. G. L. Samuel
Department of Mechanical Engineering, IIT Madras

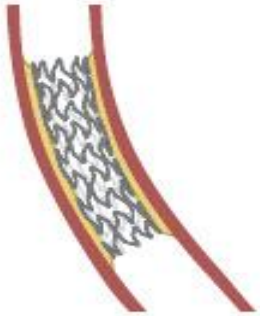
Shankeshi Rahul | ME17B067
Yerra Jai Ganesh | ME17B075
Sushant Uttam Wadavkar | ME16B172

Introduction

- What is a **Cardiac Stent** ?
  - a stent is a thin walled tube made of metal alloys such as stainless steel, memory effect alloys like nitinol or polymers which is inserted into Coronary arteries.

Plaque Before Treatment

Stent Procedure

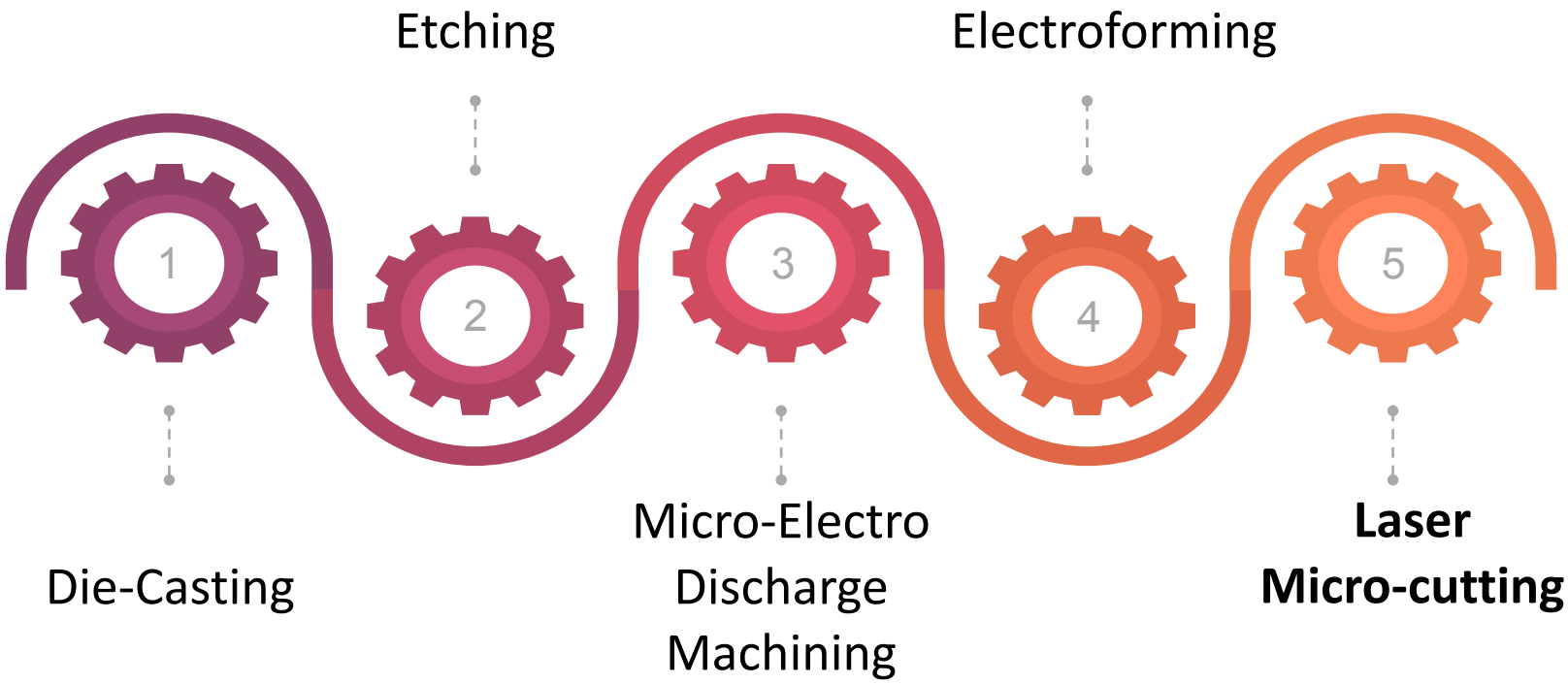


Result After Stent Procedure

- What are its **uses**?
  - It is used to treat narrow or blocked coronary arteries by increasing the blood flow through them, which avoids heart attack.

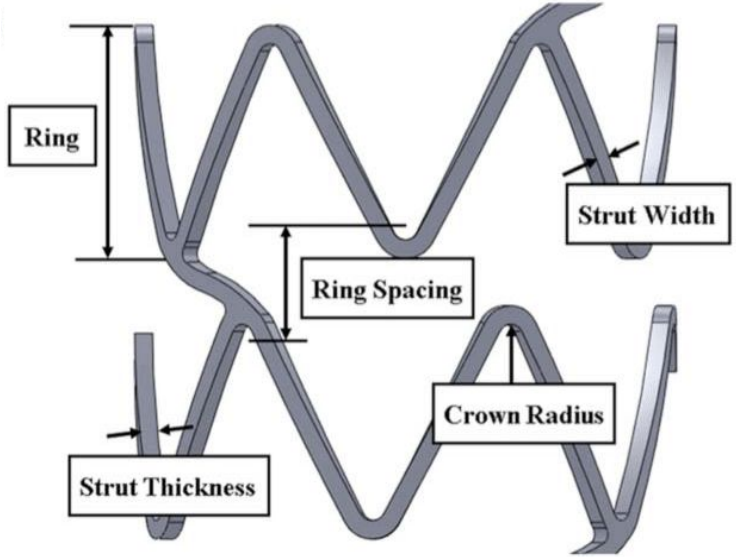
Types of Machining Processes

For manufacturing a stent



Why LASER Micro-Cutting

- Due to the complex shapes in 1 to 20 mm outer diameter of tubes.
- Walls with as thin as 200 µm.
- With strut width going from 110 µm all the way down to 60 µm.



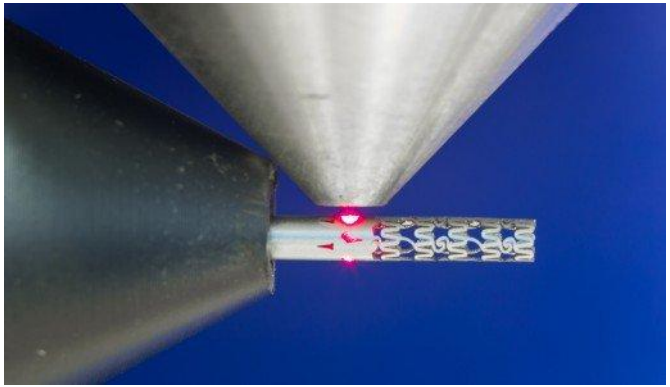
Parts of a stent

Long Pulse Vs Short Pulse

- Long pulse laser creates large heat-affected zones which effects the walls of the stent.
- Short pulse laser will be the best possibility as it creates minimally heat-affected zones, which does not disturb the integrity of the stent.

Objectives

- Explore the possibilities of laser cutting in stent manufacturing.
- 3D model of stent using fusion.
- Force simulation of stent using ansys.
- Finding the challenges and limitations of stent manufacturing using laser cutting.



Methodology

Five technique has been used to manufacture stents: Nowadays, **laser micro-cutting** is used for better accuracies

A high energy density laser beam is focused on workpiece surface; the thermal energy is absorbed which heats and transforms the workpiece volume into a molten, vaporized, or chemically changed state that can easily be removed by flow of high pressure assist gas jet

Tools

A micro tube laser cutting machine

Software

For 2-D Modeling of the Stent

Stress - Strain Simulation subjected to given Machining Process

Creating Mathematical Model of given structure

For 3-D Modeling of the Stent & Material Characteristics Analysis

Expected Outcomes

01.

High precision and accuracy can be accomplished.

02.

Extremely low tolerances (upto few micrometers to few hundred nanometers) could be achieved

03.

Effects of machining process on surface features are evaluated

04.

To obtain machining parameters for a given process

05.

Stress-strain analysis would be beneficial for future usage of the stent

References

1. Laser Processing Systems for Micro-Machining Applications in Bio-technology and Engineering Design https://www.newequipment.com/learning-center/article/21154754/laser-processing-systems-for-medical-stent-manufacturing#:~:text=Laser%20Cutting%20of%20Metal%20Stents&text=Stents%20are%20produced%20from%20thin,memory%20effect%20alloys%20like%20nitinol.&text=It%20is%20possible%20to%20laser,as%20thin%20as%200.2%20mm
2. Micro-cutting of the Stent https://www.spilasers.com/case-study-medical/micro-cutting-of-stents/
3. Laser Micro-processing of Cardiovascular Stent with Fiber Laser Cutting System https://www.researchgate.net/publication/238935493_Laser_micro-processing_of_cardiovascular_stent_with_fiber_laser_cutting_system
4. W. W. Duley, UV Lasers: Effects and Applications in Material Science, Cambridge University Press, 1996.
5. U. C. Paek and F. P. Gagliano, “Thermal analysis of laser drilling processes”, IEEE Journal of Quantum Electronics
6. F. W. Dabby and U. C. Paek, “High-intensity laser-induced vaporization and explosion of solid material”, IEEE Journal of Quantum Electronics
7. J. R. Ho, C. P. Grigoropoulos and J. A. C. Humphrey, “Computational model for the heat transfer and gas dynamics in the pulsed laser evaporation of metals”, Journal of Applied Physics
8. A. Kar and M. Mazumder, “Mathematical model for laser ablation to generate nanoscale and sub micrometer-size particles”, Journal of Physical Review
9. M. F. Modest, “Three-dimensional, transient model for laser machining of ablating decomposing materials”, International Journal of Heat Mass Transfer
10. M. Aden, E. Beyer, G. Herziger and H. Hunze, “Laser-induced vaporization of a metal surface”, Journal of Physics
11. R. K. Singh and J. Narayan, “Pulsed-laser evaporation technique for deposition of thin films: physics and theoretical model”

THANK YOU