ADDITIVE MANUFACTURING OF NICKEL SPRING USING LASER WIRE DIRECTED ENERGY DEPOSITION PROCESS

M.Tech. Thesis

By

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DEPARTMENT OF MECHANICAL ENGINEERING

INDIAN INSTITUTE OF TECHNOLOGY INDORE

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A THESIS

Submitted in partial fulfillment of the requirements for the award of the degree

of

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by

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CANDIDATE'S DECLARATION

I hereby certify that the work which is being presented in the thesis entitled **ADDITIVE MANUFACTURING OF NICKEL SPRING USING LASER WIRE DIRECTED ENERGY DEPOSITION PROCESS** in the partial fulfillment of the requirements for the award of the degree of **MASTER OF TECHNOLOGY** and submitted in the **DEPARTMENT OF MECHANICAL ENGINEERING, Indian Institute of Technology Indore**, is an authentic record of my own work carried out during the time period from July 2023 to May 2025 under the supervision of Dr. Yuvraj Kumar Madhukar, Associate Professor, Department of Mechanical Engineering, Indian Institute of Technology Indore.

The matter presented in this thesis has not been submitted by me for the award of any other degree of this or any other institute.

09/06/2025

SHIVAM CHOUBEY

This is to certify that the above statement made by the candidate is correct to the best of my knowledge.

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SHIVAM CHOUBEY has successfully given his M.Tech. oral examination held on 26/05/2025

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Convener, DPGC

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ABSTRACT

This thesis presents the successful completion of additive manufacturing of a helical nickel spring using the laser wire directed energy deposition (LW-DED) process. A systematic analysis was performed to find the suitable range of process parameters, such as wire feed rate, laser power, and rotation speed, to achieve continuous and sound deposition.

Critical aspects like effect of each process parameters, alignment orientation, cooling strategy were studied for their effects on deposition quality. Post-deposition, mechanical separation techniques were employed to extract the spring. Post separation, mechanical tests were performed to evaluate properties of the spring. Challenges such as non-uniform pitch and wire path deviation were analysed, and appropriate corrective measures were implemented.

This research contributes to expanding the applicability of LW-DED in fabricating customised, near-net-shaped spring geometries, offering potential use cases in aerospace, robotics, and medical applications.

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ACRONYMS

AM	Additive Manufacturing
ASTM	American Society for Testing and Materials
CNC	Computer Numerical Control
DED	Directed Energy Deposition
DLD	Direct Laser Deposition
FDM	Fused Deposition Modelling
HV	Vickers Hardness
LW-DED	Laser Wire Directed Energy Deposition
RPM	Revolutions Per Minute
SLM	Selective Laser Melting
SLS	Selective Laser Sintering

Chapter 1: Introduction

1.1 Additive Manufacturing and Its Classification

Additive Manufacturing (AM) is a transformative approach to industrial production that enables the creation of lighter, stronger parts layer by layer. Unlike traditional subtractive manufacturing techniques, AM builds objects layer by layer directly from digital models, thereby minimizing material waste and enabling the fabrication of complex geometries.

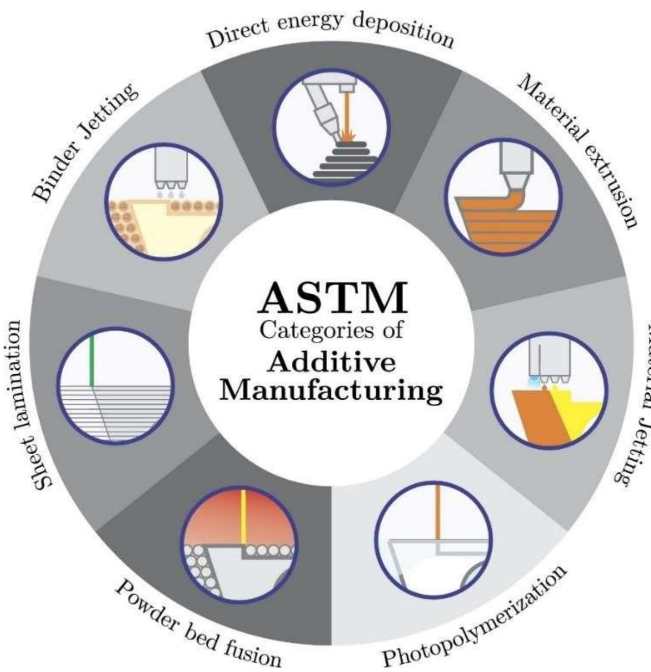


Fig. 1 : ASTM Types of Additive Manufacturing [1]

AM processes are generally categorized into the following seven groups as defined by ASTM F2792:

1. Material Extrusion – Material is selectively dispensed through a nozzle (e.g. Fused Deposition Modelling - FDM).
2. Vat Photopolymerization – A light source cures liquid resin in a vat (e.g. Stereolithography).
3. Binder Jetting – A liquid binding agent selectively joins powder particles.

4. Material Jetting – Droplets of build material are deposited (like an inkjet printer).

5. Powder Bed Fusion – Thermal energy selectively fuses regions of a powder bed (e.g., SLS, SLM).

6. Sheet Lamination – Sheets of material are bonded to form an object.

7. Directed Energy Deposition (DED) – Focused thermal energy fuses materials by melting them as they are being deposited.

Each classification serves specific purposes based on application requirements such as accuracy, material compatibility, speed, and geometry complexity. Among these, Directed Energy Deposition (DED) has gained prominence in fabricating and repairing high-value components in aerospace, defense, and tooling sectors.

1.2 Directed Energy Deposition (DED) in Additive Manufacturing

DED is a highly flexible additive manufacturing method where focused thermal energy (usually from a laser, electron beam, or plasma arc) is used to fuse materials by melting them as they are deposited. DED can be used to build new parts or repair existing ones by adding material in a controlled manner.

In DED, material in the form of powder or wire is continuously fed into the melt pool created by the energy source. The key advantages of DED include:

- Ability to process a wide range of metals including titanium, Inconel, steel, and nickel.

- High deposition rates and flexibility in deposition on curved or damaged surfaces.

- Suitability for functionally graded materials and multi-material components.

1.3 Laser Wire Directed Energy Deposition (LW-DED): Approach and Applications

Laser Wire Directed Energy Deposition (LW-DED) is a specialized form of DED where metal wire is used as the feedstock instead of powder. The wire is melted by a high-power laser beam and deposited precisely onto the substrate to build the desired part layer by layer.

Fig. 2: Laser Wire DED [2]

Approach:

- A laser head and wire feeding system are synchronized with motion controls (typically CNC-based).
- The substrate may rotate or move linearly to guide deposition.
- Process parameters such as laser power, wire feed rate, substrate movement are tightly controlled to ensure consistent deposition.

Key Benefits:

- High material efficiency
- Easier post-processing and material handling.

Applications of LW-DED include:

Aerospace – Repair and manufacture of turbine blades and structural parts.

Automotive – Custom parts and engine component restoration.

Energy – Refurbishment of turbine and oil & gas equipment.

Medical – Production of custom implants and surgical tools.

Tooling – Repair and modification of dies, moulds, and cutting tools.

1.4 Utilization of LW-DED in the Present Work

In this thesis project, LW-DED has been employed for the additive manufacturing of a helical nickel spring. The wire-based deposition approach was selected for its high material utilization, better deposition control, and compatibility with reactive metals like nickel.

Implementation Plan:

- A high-power CW fibre laser system was used for melting 0.8 mm nickel wire.
- Deposition was conducted on hollow cylindrical substrates (copper and mild steel) mounted on a rotary chuck.
- The spring geometry was defined by controlling substrate rotation, linear feed, and Z-axis increment, creating a helical path.

- Initial trials identified challenges in deposition continuity and bonding due to thermal mismatch, leading to a transition from copper to mild steel substrates.
- A water-cooling setup was incorporated to manage thermal gradients at the start and end points of the deposition.
- After deposition, mechanical separation was performed to isolate the spring.

The use of LW-DED allowed fabrication of a near-net shape spring directly from wire without extensive tooling or forming processes. This approach demonstrated potential for customized spring production with design flexibility in pitch, diameter, and coil count.

The methodology employed highlights the practical adaptability of LW-DED in small-scale component manufacturing and sets a pathway for future exploration in functional, load-bearing, and smart structures using additive techniques.

Chapter 2: Review of Past Work and Problem Formulation

2.1 Review of Past Work

Svetlizky et al. (2021) [3] and co-authors provided an in-depth review of the Directed Energy Deposition (DED) process, focusing on key processing variables and their impact on the properties of deposited materials. Their study also explored the mechanisms behind common defect formations, such as porosity and cracking, and provided insight into modern characterization techniques. The authors discussed high-end industrial applications and emphasized the need for critical process optimization to ensure defect-free builds.

In a follow-up study, Svetlizky et al. (2022) [4] examined material selection strategies in laser-based DED of advanced alloys. The paper highlighted design challenges and potential opportunities in processing difficult-to-weld materials such as titanium, aluminum, nickel alloys, intermetallics, and shape memory alloys. Their research emphasized the material-dependent behaviour during laser deposition and guided selection strategies for better deposition.

Javidrad et al. (2024**)** [5] and co-authors optimized the process parameters for laser powder DED of Inconel 738LC. Though their study used powder feedstock, the methodology for tuning laser power and scan speed aligns closely with the parameter optimization strategies employed here. Their experimental design influenced the setup used to determine suitable wire feed rates and rotation speeds.

Yadav et al. (2019) [6] and co-authors investigated the deposition of copper-nickel graded layers using LDED on a copper substrate. They successfully fabricated Cu-Ni graded structures with over 99% relative density and minimal porosity. This study provided valuable insights into depositing dissimilar metals with high interfacial integrity, which is directly relevant to nickel-on-copper deposition challenges.

Jacquier et al. (2024) [7] and colleagues explored DED of tungsten on copper using a graded multi-material interface. Their work focused on enhancing compatibility at the Cu-W interface and achieving good wettability and bonding. Notably, nickel was used as an intermediate layer on sandblasted copper, which yielded strong adhesion and minimal defects, offering a strategy to improve dissimilar metal bonding.

Ghadimi et al. (2015) [8] and co-authors studied nanocrystalline Ti-Ni-Cu shape memory alloys and reported that copper addition enhanced thermal hysteresis control and shape memory behaviour. The resulting NiTiCu phase showed nanostructured homogeneity, which can be leveraged for precise thermomechanical. Performance actuator and spring applications.

Velmurugan and Senthilkumar (2018) [9] analysed the effects of copper addition on the mechanical behaviour of NiTi alloys. They found that Cu enhanced nanostructure formation and increased hardness and phase stability. This work supports the use of Cu-modified NiTi alloys for improved mechanical performance in functional components like springs.

Ferreira et al. (2021) [10] deposited Inconel 625 claddings onto low-alloy steel (42CrMo4) using Direct Laser Deposition (DLD). They varied laser power, scan speed, and feed rate to analyse interfacial bonding and dilution effects. Their work validated the suitability of nickel-based alloys for structural reinforcement on steel, which parallels the current use of nickel on mild steel substrates.

Wu et al. (2024a) [11] and colleagues studied crack propagation behaviour in steel-nickel interfaces fabricated via wire arc DED. They reported strong corrosion and creep resistance in the bimetallic regions, suggesting the reliability of nickel-steel interfaces for load-bearing and high-temperature applications.

Wu et al. (2024b) [12], In a separate study, investigated interweaving deposition strategies for steel-nickel components using wire arc AM. They achieved enhanced tensile strength (634 MPa) exceeding that of both steel and nickel feedstock. This work demonstrates the mechanical potential of hybrid steel-nickel parts and supports structural integrity of similar deposits.

2.2 Problem Formulation and Research Gaps

Despite the increasing adoption of Laser Wire Directed Energy Deposition (LW-DED) in manufacturing applications, there is currently no literature specifically focused on the fabrication of spring geometries using this process. This represents a notable research gap, particularly in the context of understanding how LW-DED parameters affect the structural integrity and dimensional accuracy of free-standing spring structures.

Moreover, limited research exists on the optimization of LW-DED process parameters—such as wire feed rate, laser power, and substrate motion—for spring fabrication. Challenges such as oxidation, defect formation, and control over mechanical properties remain underexplored in this context.

Another critical gap lies in the absence of systematic studies on thermal management during the deposition of complex, curved geometries like springs. Uneven heat distribution during deposition can result in residual stresses, geometric distortion, and inconsistent layer bonding.

Chapter 3: Experimental Setup and Methodology

3.1 Materials Used

Copper and mild steel were selected as substrate materials for the deposition of nickel spring structures. The copper substrate was a hollow cylindrical tube with an outer diameter of 30 mm and a wall thickness of 2.5 mm, whereas the mild steel tube had a 35 mm outer diameter and 2.5 mm wall thickness. Initially, deposition was attempted on copper, but due to bonding issues, mild steel was adopted for subsequent experiments.

The feedstock material used for the deposition process was high-purity nickel wire with a diameter of 0.8 mm. This solid wire form was selected over powder due to better handling, reduced oxidation risk, and higher material utilization efficiency in wire-fed DED processes.

3.2 Equipment and Experimental Conditions

The deposition was carried out using a MEHTA 4-axis fiber laser system equipped with a maximum 2 kW continuous wave (CW) laser operating at a wavelength of 1080 nm. The system comprised three linear axes and a rotary axis to facilitate cylindrical part rotation, essential for helical spring fabrication. The nickel wire was side-fed through a nozzle directed precisely at the melt zone, where the laser beam and substrate interaction occurred.

To manage the high thermal gradients generated during deposition and to reduce the chances of residual stress and warping, a dual-point water cooling system was implemented. Flexible pipes were directed toward the start and end points of the deposition region to ensure localized and uniform cooling throughout the process.

3.3 Methods and Approaches

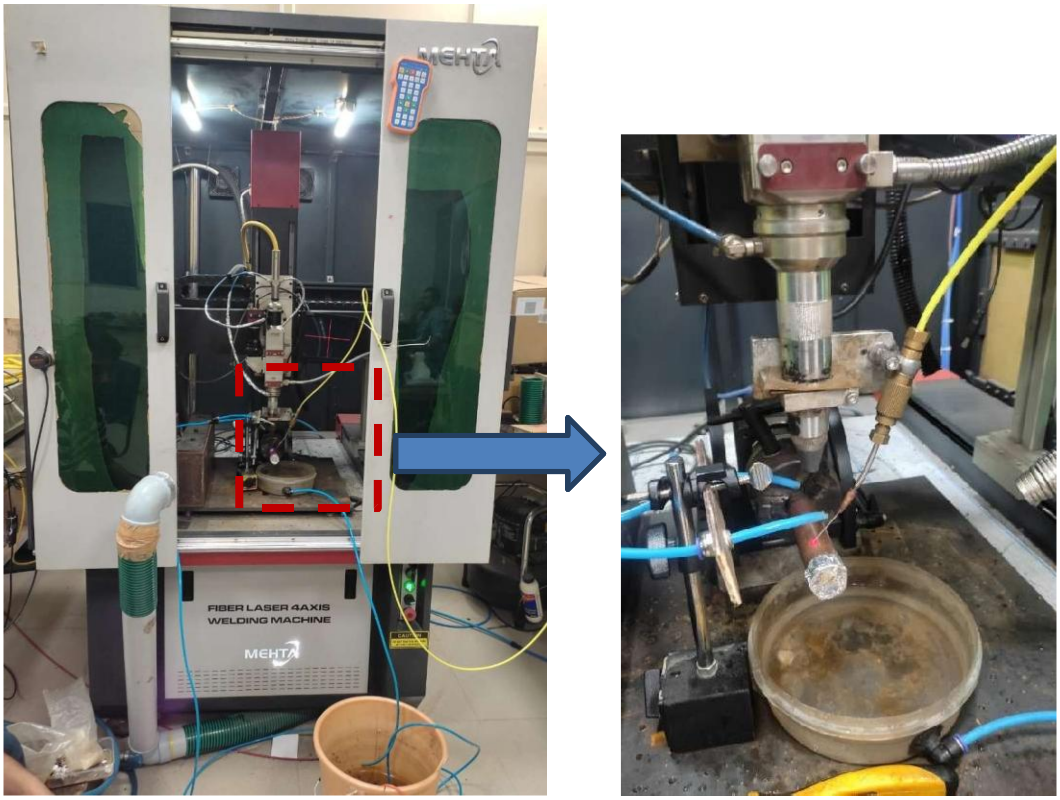


Fig. 3: Experimental Setup

Fig. 3 shows the experimental setup for deposition. The substrates were first cleaned and fixed on the rotary chuck of the laser system. CNC controller was programmed to follow a helical toolpath around the cylindrical surface to simulate a spring structure.

The wire feed rate was maintained around 2 meters per minute, and the laser power was varied from 1200 to 1700 watts based on trial results. The substrate rotation speed was optimized within the range of 1 to 1.5 revolutions per minute to ensure consistent layer formation without distortion.

It was observed that deposition on copper substrates resulted in poor adhesion and inconsistent melt pools due to copper's high thermal conductivity, which quickly dissipated heat. Conversely, mild steel substrates supported stable deposition with better metallurgical bonding and uniform melt pool behaviour. Hence, all further final deposition trials were performed on mild steel.

After deposition, the spring was extracted by internal turning using a lathe machine at speeds ranging between 200-300 rpm and depth of cut ranging from 0.05–0.2 mm was used for clean separation. To remove any remaining thin substrate layer, manual filing was performed at the interface region to reveal a clean and free-standing spring structure.

This systematic experimental approach ensured a stable, continuous, and repeatable nickel spring deposition using the LW-DED process, laying the groundwork for further optimization and structural testing.

Cooling Strategy: To maintain the thermal stability during laser deposition, a water-cooling arrangement was implemented where water jets were directed at points located slightly beyond both the starting and ending locations of the deposition. These positions were chosen to be as close as possible to the deposition region without allowing water to enter the melt pool zone, thereby ensuring uninterrupted process stability. This setup promoted effective and uniform heat dissipation along the substrate, which in turn helped minimize thermal stresses. By preventing localized overheating, the controlled cooling also contributed to consistent layer bonding and improved surface finish throughout the deposition process. Fig. 4 below shows the schematic representation of cooling arrangement:

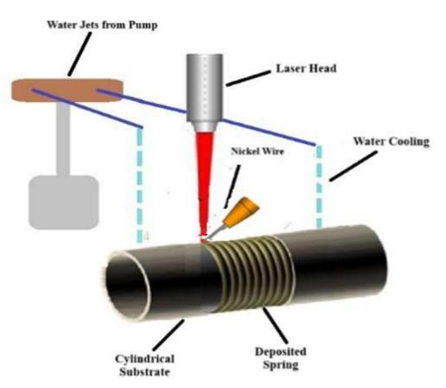


Fig. 4 : Cooling Arrangement

Chapter 4: Results and Discussion

4.1 Deposition on Copper Substrate

The initial experimental trials for spring deposition using the LW-DED process were conducted on a hollow cylindrical copper pipe having an outer diameter of 30 mm and a wall thickness of 2.5 mm. The copper substrate was selected for its excellent thermal and electrical conductivity, aiming to facilitate rapid heat dissipation during the deposition process. However, the deposition process encountered several challenges due to relatively low melting point of copper. The difference in melting point of copper (1085°C) compared to nickel (1455°C) [13] resulted in a thermal mismatch, causing incomplete fusion and weak adhesion.

The laser power during these trials ranged between 1200–1700 W, while the wire feed rate was maintained around 2 m/min, and the substrate rotation speed was adjusted between 1.0–1.5 rev/min. Despite multiple attempts, consistent bonding between the nickel wire and copper substrate could not be achieved. which contributed to inconsistent pitch formation and alignment deviation. Due to these limitations, it was concluded that copper was not an ideal substrate for this application, and the focus was subsequently shifted to mild steel, which offered better thermal compatibility.

Laser Power (Watts)	Wire feed rate (m/min)	Rotational speed of Copper Tube (rev/min)	Deposition Nature
Deposition – 1700 W Preheating - 900 W	2 m/min	1.4 rev/min	Continuous Non- Uniform deposition.

Table 1 : Deposition parameters for copper substrate

Fig. 5 : Deposition on Copper Substrate

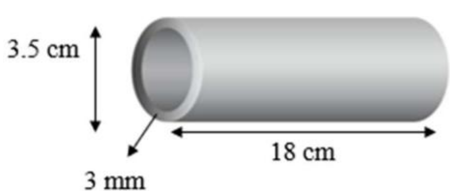
- Higher thermal conductivity (385W/m/K) [13] of Copper causes it to quickly dissipate heat. This prevents the temperature in the deposition zone from staying high enough to facilitate strong bonding between copper and nickel.
- The difference in melting point of copper (1085°C) [13] compared to nickel (1455°C) results in a thermal mismatch, causing incomplete fusion and weak adhesion

Material	Melting Point (°C)	Coefficient of Thermal Expansion ($\times 10^{-6}$ /°C)	Thermal Conductivity (W/m·K)
Nickel	1455	13.4	90
Mild Steel	1370	11.7	46
Copper	1085	16.5	385

Table 2 : Thermal Properties values of chosen materials [13]

4.2 Single layer deposition on Mild steel substrate

After facing bonding and thermal mismatch issues with copper, mild steel AISI 1018 was selected as the substrate for the deposition of the nickel spring due to its better thermal compatibility, relatively closer melting point, and improved machinability. The selected substrate was a hollow cylindrical mild steel pipe with an outer diameter of 35 mm, a wall thickness of 3 mm, and sufficient length to accommodate the spring geometry. The substrate was securely mounted on the rotary chuck of the Laser Wire Directed Energy Deposition (LW-DED) system and carefully aligned to ensure concentric rotation. The deposition process was carried out using a nickel wire of 0.8 mm diameter with a wire feed rate of approximately 2 m/min, which was found to be suitable for achieving uniform deposition. The laser power was set between 1200–1700 W, and the substrate rotation speed was maintained between 1.0 and 1.5 RPM, depending on layer consistency and bonding behaviour. To mitigate heat accumulation, water-cooling pipes were directed toward both ends of the deposition zone, enabling thermal stability during the build. Continuous layer fusion, consistent pitch, and metallurgical bonding were achieved under the above conditions. The resulting spring adhered well to the substrate, demonstrating clean geometry and uniform buildup throughout the deposition length.



Mild Steel Substrate Dimensions:

Outer Diameter: 35 mm

Thickness: 3 mm

Laser Power (Watts)	Wire feed rate (m/min)	Rotational speed of Substrate (rev/min)	Deposition Nature
Deposition -1300 W Preheating - 500 W	2 m/min	1.4 rev/min	Continuous Uniform

Table 3 : Deposition Parameters for Mild Steel -Single Layer

Fig. 6 below shows the single layer depositions of different pitches with average layer heights as 3 mm:

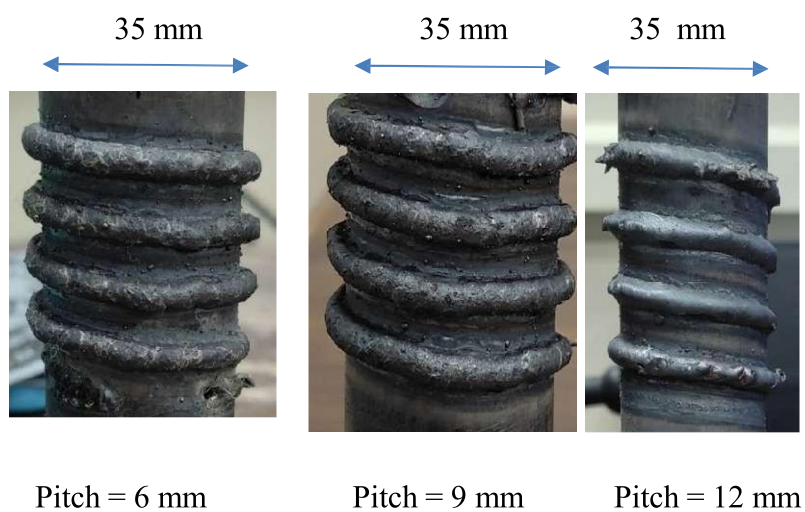


Fig. 6: Single Layer Depositions on Mild Steel

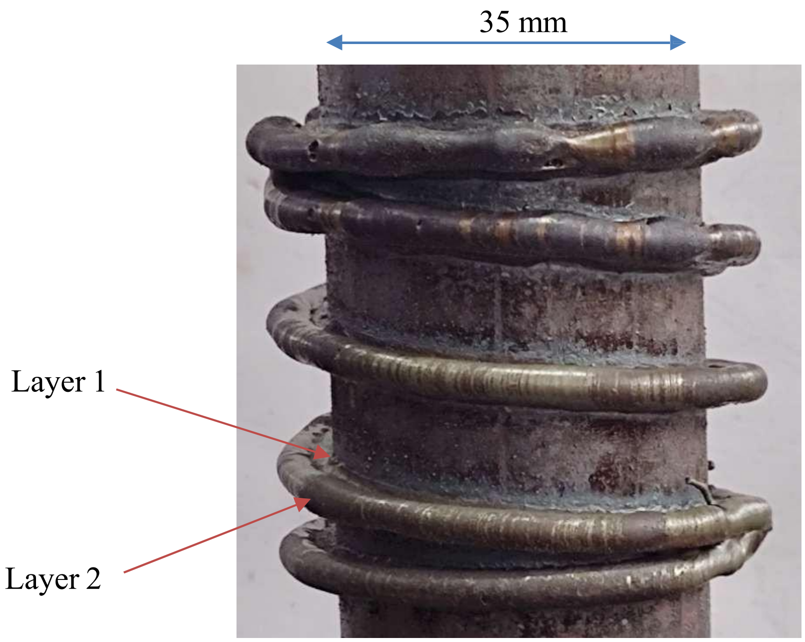
4.3 Multilayer deposition on mild steel substrate

Following the successful deposition of a single-layer helical spring on mild steel, efforts were made to achieve multi-layer deposition to increase the deposition height. The same mild steel substrate (35 mm outer diameter, 3 mm thickness) was used, with deposition parameters initially maintained similar to the single-layer process: laser power between 1200–1700 W, wire feed rate around 2 m/min, and substrate rotation speed of 1.0–1.5 RPM.

Laser Power (Watts)	Wire feed rate (m/min)	Rotational speed of Substrate (rev/min)
Layer 1 Deposition - 1300 W	2 m/min	1.4 rev/min
Layer 2 Deposition - 1200 W	2 m/min	1.4 rev/min

Table 4 : Deposition Parameters for Mild Steel -Multi Layer

Fig.7 and Fig. 8 on next page shows the deposited multilayer springs using above parameters.

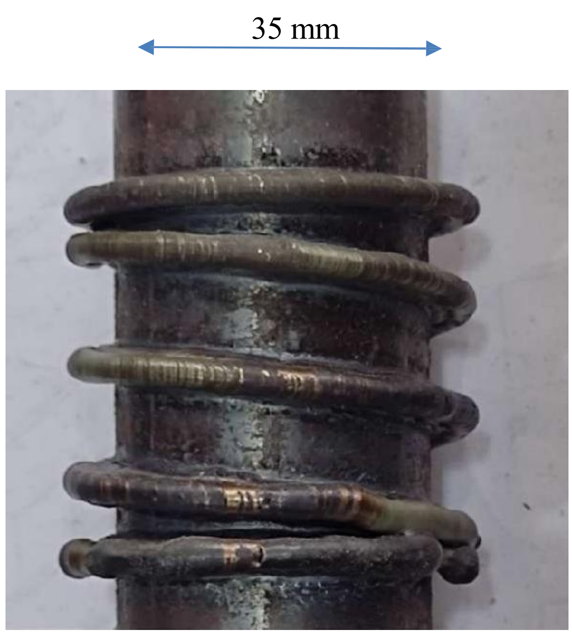


Layer 1 Height = 2.6 mm

Layer 2 Height = 2.4 mm

Pitch = 12 mm

Fig. 7 : Multilayer Deposited Spring 1



Layer 1 Height = 2.1 mm

Layer 2 Height = 1.9 mm

Pitch = 9 mm

Fig. 8 : Multilayer Deposited Spring 2

4.4 Separation of the Spring

4.4.1 Separation Steps

Following successful deposition of the nickel spring on the mild steel cylindrical substrate, the next critical step was to extract the spring without compromising its structural integrity. For this, internal turning was selected as a primary method due to its precision and ability to selectively remove material from the inner side of the substrate. The process was carried out on a conventional lathe machine under controlled speed and feed settings, specifically 240 RPM with depth of cut 0.2 mm initially and finally for last few layers 0.05 mm. These values were carefully chosen to minimize both thermal and mechanical stresses imparted to the spring during the cutting operation. A carbide-tipped boring tool was used to gradually machine the internal surface of the mild steel pipe, reducing its thickness until the spring was visibly loosened. Throughout the operation, the setup was regularly inspected to ensure that the spring did not experience bending. Once the internal wall was sufficiently thinned, the spring was gently separated using manual assistance and light filing to break any remaining mechanical bonds at the interface. This method proved effective in extracting a structurally intact nickel spring, ready for mechanical testing. Fig. 9 below shows the steps that were involved in turning internally.

Fig. 9: Separation Steps

4.4.2 : Separated Springs

The springs were successfully extracted without deformation, maintaining their overall geometry and surface finish suitable for further testing. The separated springs are shown in Fig. 10 and Fig. 11.

Fig. 10 : Separated Multilayer Spring 1

Separated Spring Dimensions:

Pitch = 9 mm

Inner Diameter = 3.4 cm

Outer Diameter = 4.3 cm

Fig. 11: Separated Multilayer Spring 2

Separated Spring Dimensions:

Pitch = 12 mm

Inner Diameter = 3.4 cm

Outer Diameter= 4.5 cm

4.5 Mechanical testing and analysis

4.5.1 Hardness Test:

Sample	Reading 1	Reading 2	Reading 3	Reading 4	Reading 5	Average Hardness (HV)
Deposited Nickel	**110.2**	**112.4**	**111.6**	**113.5**	**109.1**	**111.3**

Table 5 : Hardness Readings

- Hardness values of pure nickel is around 123 HV [14]
- The measured hardness of 111.3 HV is within the expected range and slightly lower than the Pure Nickel.
- Possible reason is minor porosity.

Fig. 12: Hardness Testing

4.5.2 Compression Test

Dimensions:

Pitch = 9 mm

Inner Diameter = 3.4 cm

Outer Diameter = 4.3 cm

Mean Diameter = 3.85 cm

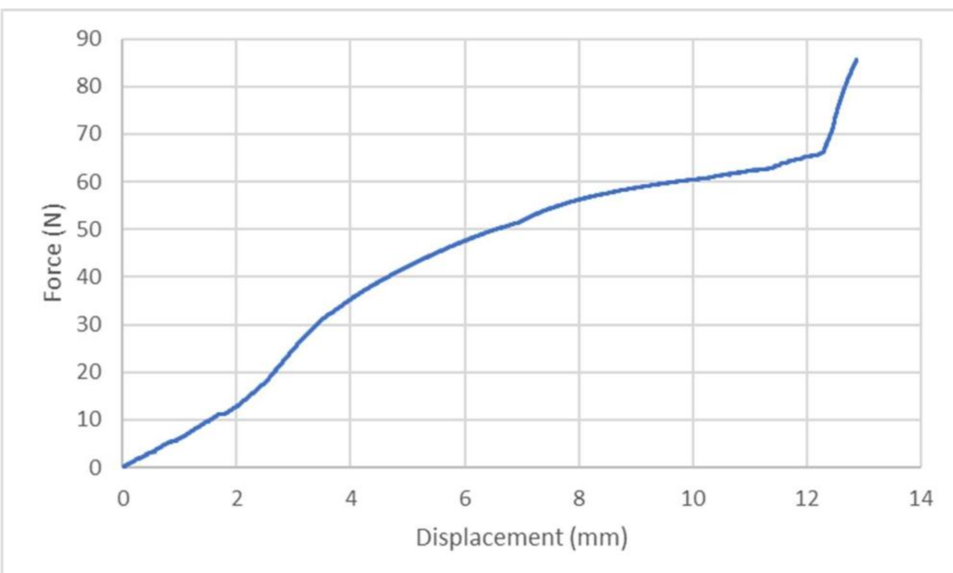


Fig. 13: Force vs Displacement curve for Multilayer Spring 1

Spring Stiffness = 8.3 N/mm

Calculated using the slope of the initial linear portion of curve, consistent with Hooke's Law.

Dimensions:

Pitch = 12 mm

Inner Diameter = 3.4 cm

Outer Diameter = 4.5 cm

Mean Diameter = 3.95 cm

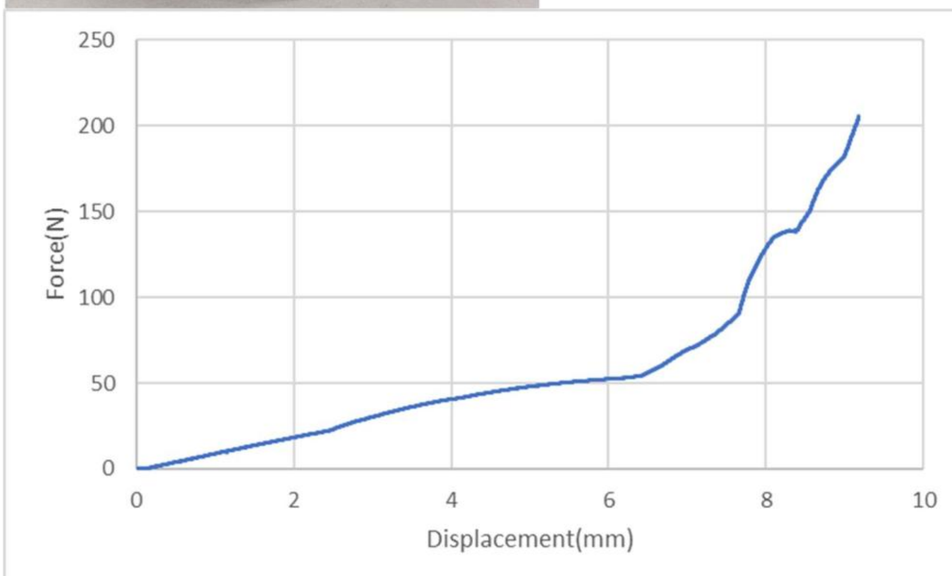


Fig. 14: Force vs Displacement curve for Multilayer Spring 2

Spring Stiffness = 9.2 N/m

Calculated using the slope of the initial linear portion of curve, consistent with Hooke’s Law.

4.5.3: Scratch Test

Scratch velocity = 0.1 mm/ sec

Normal Load = 15 N

Stroke Length = 3 mm

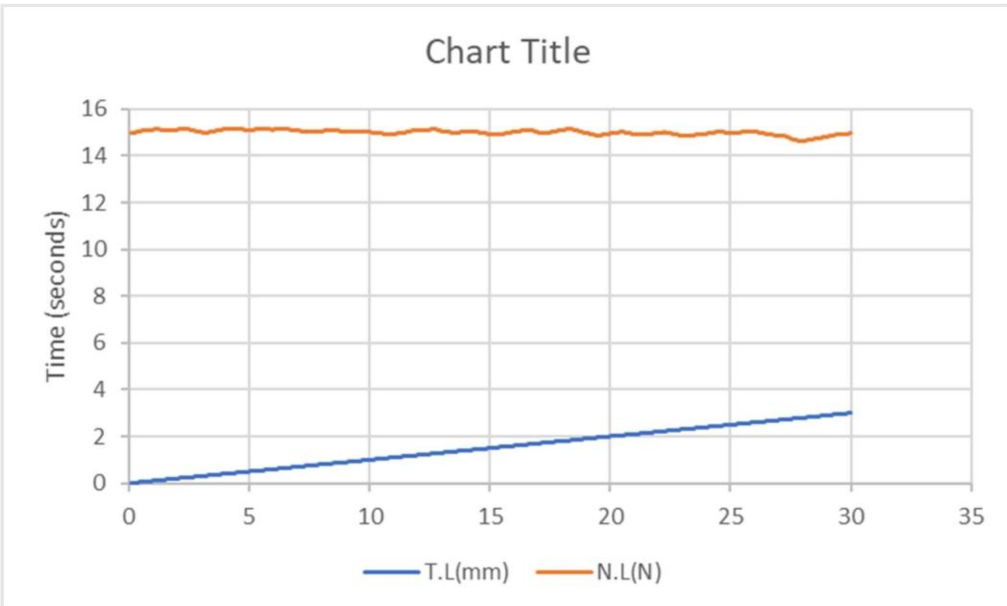


Fig. 15 : Traction Load and Normal Load vs Time

FN = Normal Load= 15 N

D = Scratch Width = 175 microns

N.L. = Normal Load

T.L = Traction Length

$$\text{Scratch hardness (Hs)} = \frac{8F_N}{\pi D^2}$$

$$Hs = \frac{8 \times 15}{\pi \times (0.175)^2} = \frac{120}{\pi \times 0.030625} = \frac{120}{0.096226} = 1247.3\,\text{N/mm}^2$$

The resulting scratch width was measured at 175 µm, which indicates moderate surface resistance to plastic deformation and wear. These values suggest that the deposited nickel layer has decent resistance against surface abrasion, which is critical in practical use-cases involving cyclic contact or friction.

Chapter 5: Significant Findings

5.1 Suitable range of parameters and effect of each process parameter on deposition:

1. Laser Power: 1600-1700 Watts for Nickel on Copper and 1200-1300 Watts for Nickel on Mild Steel

- *Low Laser Power*: Results in insufficient melting of the wire, leading to weak bonding with the substrate and incomplete fusion, leading to incomplete shapes.
- *High Laser Power*: Excessive heat cause material vaporization, over-melting, and increase oxidation chances. This can also damage the substrate.

✓ *Ideal Laser Power*: Ensures uniform melting of the wire with minimal defects. It provides smooth deposition with good fusion, structural consistency, and accurate geometry.

2. Rotational Speed of Cylindrical substrate: 1-1.5 rev/min

- *Low Rotational Speed*: Excessive heat gets applied to a single area, leading to localized overheating and uneven material buildup.
- *High Rotational Speed*: Result in incomplete or inconsistent deposition, with insufficient time for the material to bond properly to the surface. This creates gap in the deposit.

✓ *Ideal Rotational Speed*: Ensures uniform deposition with consistent thickness and smooth surface quality.

Fig. 16: Rotating Substrate

3. Wire Feed Rate: Around 2m/min

- *Low Wire Feed Rate*: Insufficient material may be deposited, leading to thinner layers, gaps and incomplete coverage.
- *High Wire Feed Rate:* Too much material is deposited, causing an uneven surface, making it harder to achieve the desired shape.
- *Ideal Wire Feed Rate*: Proper wire feed ensures smooth, even deposition with strong bonding to the substrate, ensuring good mechanical properties and structural integrity.

Fig. 17: Wire Feeder

Chapter 6: Conclusions and Scope for Future Work

This work successfully demonstrated the feasibility of fabricating a helical nickel spring structure using the Laser Wire Directed Energy Deposition (LW-DED) process on a cylindrical mild steel substrate. Key process parameters such as wire feed rate, laser power, substrate rotation speed, and water-based cooling strategy were suitably found to achieve consistent deposition with uniform pitch and geometry. Internal turning followed by manual assistance using hand grinder and filing was used as an effective post-processing method for spring separation. Mechanical testing, including hardness and scratch, showed values in acceptable range for pure nickel, confirming the structural integrity of the deposited spring. Multi-layer deposition posed challenges such as wire deviation and path instability, the project offered valuable insights into alignment sensitivity, thermal management, and process control in wire-based additive manufacturing. The outcomes of this study lay the groundwork for future development of near-net-shaped, customised springs and similar components using DED techniques.

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