



# ME – MTech (Res) Thesis Colloquium



## Linear delta system for metal additive manufacturing.

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### ABSTRACT

Directed Energy Deposition (DED) using powder feedstock is a well-established metal additive manufacturing process for fabrication, repair, and feature addition. Conventional implementations typically rely on serial gantry systems or multi-axis robotic manipulators to position the deposition head. While effective, these architectures exhibit inherent limitations: both gantry systems and serial robots require a large machine footprint to achieve extended workspace, while also accumulating structural deflections and positioning errors along long axes. Parallel kinematic machines (PKMs) offer an alternative by distributing loads across multiple kinematic chains, resulting in improved stiffness, reduced error accumulation, and compact footprint. Among these, the linear delta mechanism is particularly suited for DED due to its purely translational motion, compact architecture, and scalability, enabling consistent performance across the workspace.

In this work, we present a linear delta mechanism-based DED platform, with primary emphasis on parametric design. The selection of geometric parameters—such as link lengths and base radius—directly governs workspace feasibility, kinematic conditioning, and structural performance. Achieving well-conditioned behaviour across the operational workspace is critical, making design a primary determinant of system capability.

Subsequently, trajectory planning is addressed to account for the nonlinear inverse kinematics of the mechanism, wherein Cartesian paths map to coupled joint motions. Naive interpolation of toolpaths can introduce Cartesian tracking error and joint velocity discontinuities, particularly at sharp corners, leading to mechanical jerk and non-uniform material deposition. To address this, a path planning framework is developed that incorporates geometric conditioning of toolpaths, corner smoothing through spline and fillet strategies, and segmentation into constant-velocity motion primitives while enforcing kinematic consistency.

Together, this work emphasizes the importance of design-driven kinematic optimization followed by structured trajectory planning to enable stable, accurate, and consistent DED operation on a linear delta platform.

### ABOUT THE SPEAKER

G. Sai Santhosh Sivan is a MTech (Res) student in Mechanical engineering department of Indian Institute of Science. He works under the guidance of Prof Koushik Viswanathan in Laboratory of Advanced Manufacturing and Finishing Processes (LAMFiP). His work primarily focuses on robotics, embedded systems, parallel kinematics, and trajectory planning for manufacturing applications.

