Additive Manufacturing and its Implications for Nuclear Nonproliferation

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Goals & Objectives

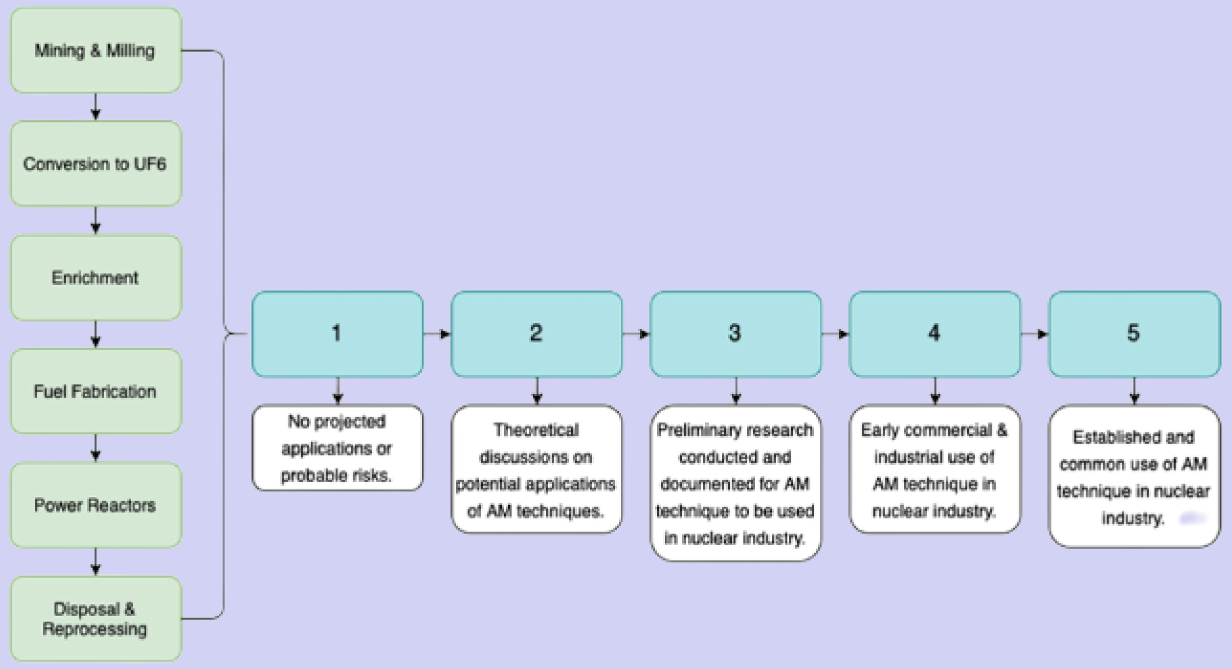
The rapidly evolving field of Additive Manufacturing (AM) holds growing concerns regarding its potential application in the realm of nuclear weapons and enrichment technology. To address this issue, this study aims to categorize and rank 33 different AM techniques based on their impact on the nuclear fuel cycle and the development of nuclear weapons, thereby providing a framework for introducing effective export controls and legislation to monitor and manage proliferation pathways.

Introduction

Since the 1940s, the nuclear industry has experienced the emergence of new technologies, with conventional manufacturing techniques such as subtractive manufacturing being initially utilized. In recent years, however, a transition towards the utilization of additive manufacturing (AM) has been observed in the production of complex components. AM offers increased design freedom and the ability to create intricate geometries, resulting in benefits such as reduced waste, improved efficiency, and enhanced customization when compared to traditional methods. Despite these advantages, the absence of standard regulations and consistent enforcement of AM export controls presents a substantial challenge in ensuring the safe and responsible deployment of this technology, particularly regarding the issue of nuclear proliferation.

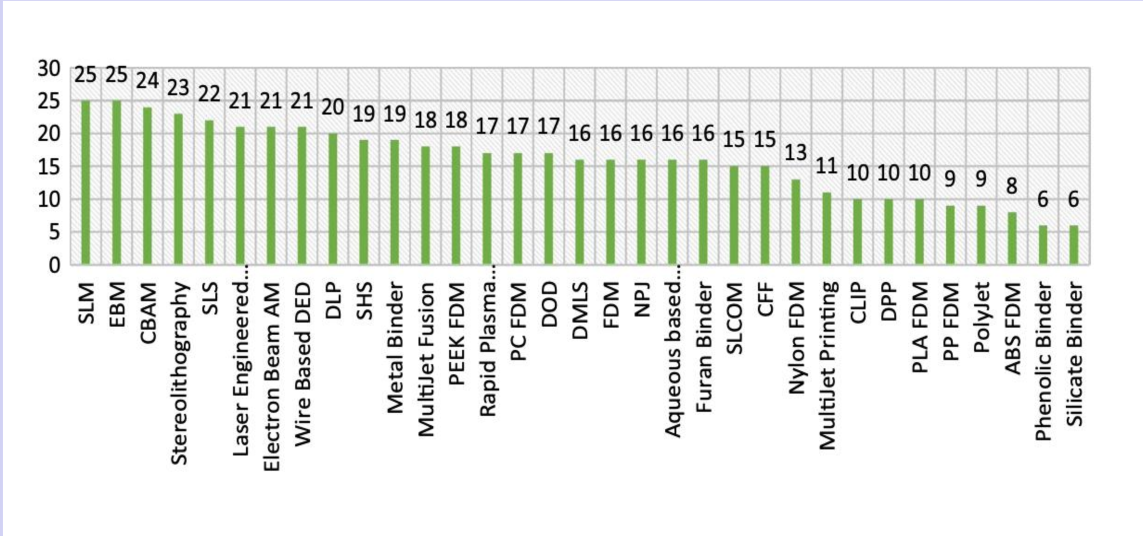
Methodology

- This study presents an evaluation of 33 diverse additive manufacturing techniques in terms of their potential proliferation risks within the nuclear industry.
- In order to standardize this evaluation, a numerical rating system was devised, with a score of 1 indicating no perceived risk and a score of 5 indicating active applications within the nuclear fuel cycle.
- The manufacturing process, design, finished product quality and complexity, and current/experimental applications of each technique were analyzed and compared to the relevant processes and products within the nuclear fuel cycle.
- Upon the completion of the numerical scoring of each technique using the established rubric, a comparison of the results was conducted both within each category and in terms of their overall risk ranking, from highest to lowest.
- Based on these findings, recommendations for potential additive manufacturing export legislation aimed at mitigating the proliferation risks will be proffered.

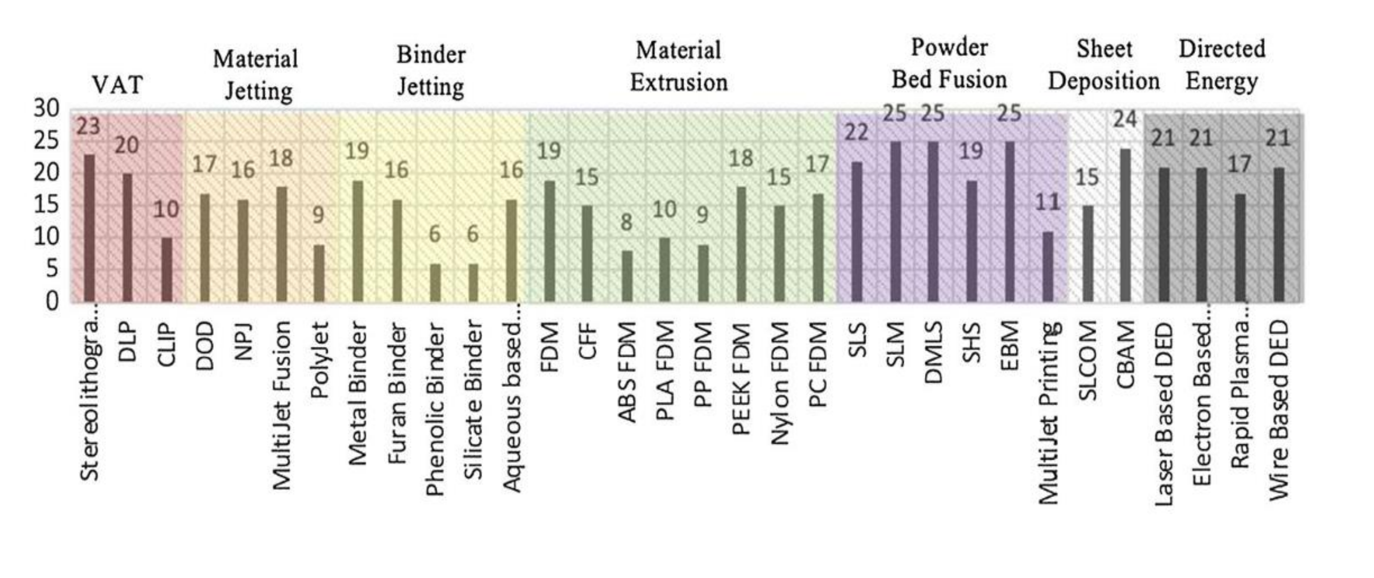


Results

- The evaluation of the 33 additive manufacturing techniques reveals that 9 of them can be classified as "high risk" techniques.
- Of the 7 categories of additive manufacturing techniques explored in this study, two categories, Powder Bed Fusion (PDF) and Directed Energy Deposition (DED), exhibit a particularly high number of techniques with current or potential applications within the nuclear sector.



- The average number of "high risk" techniques among these categories is significantly higher than the other categories.
- Most of the experiments utilizing additive manufacturing in the context of the nuclear fuel cycle utilize either Powder Bed Fusion or Directed Energy Deposition techniques.



Next Steps

To address the proliferation risks associated with the utilization of additive manufacturing in the nuclear industry, it is recommended that collaboration be established between relevant stakeholders, including suppliers, developers, and regulatory bodies. This collaboration should focus on the implementation of proliferation safety measures within the additive manufacturing process. An evaluation of the cost and feasibility of additively manufacturing parts for nuclear applications is necessary. Legislative efforts should be directed towards the creation of export controls specific to the unique attributes of additive manufacturing and the nonproliferation of nuclear materials.

Conclusions

The categorization of individual additive manufacturing (AM) techniques does not provide sufficient information for the development of effective export controls that mitigate the risk of proliferation. The numerical ratings obtained from this study are indicative of the methodology employed and should not be considered as the sole basis for export control decisions. Further in-depth examination and evaluation of AM methods is necessary to fully comprehend their proliferation potential and inform the formulation of effective export controls.

References

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