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A REVIEW ON MANUFACTURING STRATEGY WITH THEIR ISSUES, PERFORMANCES & ADDITIVE MANUFACTURING

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Abstract: In several organizations, Manufacturing Strategy (MS) is an often unnoticed aspect of strategic planning. Ensuring all long-term manufacturing growths are constant with the overall business strategy is the MS's objective. Offering the company's products along with services over a particular period was the major scope of the MS and also it denotes where those products will be sold in the target markets. The methods for creating the MS are assuring linkage betwixt the business strategies and MS, performing an initial manufacturing audit, addressing the issue of product grouping, examining the degree of focus presented in every plant, developing MS, and suggesting allocation of product lines to plants. Several limitations in MS are high transportation costs, lack of control, augmented time to market, etc. Therefore, this paper discusses the approaches to create the MS, issues in the MS, and performance in the MS. The specific energy required in the additive MS process categories, the specific speed required in the additive MS process categories, together with the specific resolution required in the additive MS process categories are examined in this paper.

Keywords: *Manufacturing strategy, Approaches in manufacturing strategy, Challenges in manufacturing strategy, performance in manufacturing strategy, Production strategies, and Additive MS*

1. INTRODUCTION

In the last ten years, the surroundings of manufacturing companies have changed entirely. Due to the change as of a seller to a buyer's market, augmenting globalization, the decreasing market growth in numerous sectors, and the rising environmental awareness of customers, considerable variations could be perceived. Thus, constant augments in complexity are faced by manufacturing companies recently. A few consequences are smaller batch sizes of modified products, shorter product life cycles, along with continuously increasing international competition, which is caused by the variations [1]. Furthermore, for counteracting the intensified competition, the augmented quality, time, and cost targets must be attained [2]. It has been identified that if equipped along with handled suitably, manufacturing could well be a powerful competitive weapon. It is critical for developing and following a coherent MS. The MS comprising plant along with equipment is explained in figure 1. The total business objectives are supported by manufacturing via the suitable design and usage of manufacturing resources along with capacities. This is named MS [3]. The MS must be aligned with the marketing strategy and the overall business strategy for supporting the overall business.

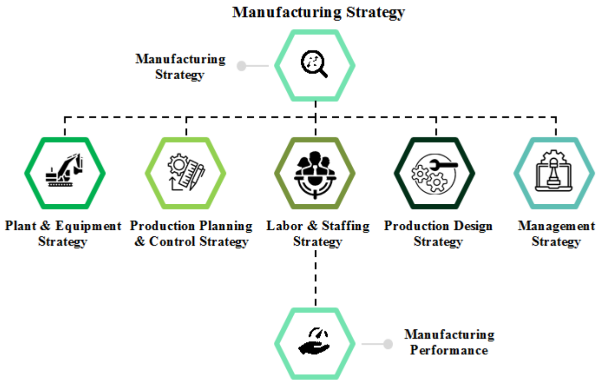

Figure 1: MS including plant and equipment

On account of product diversity, short product life cycle, together with the subsequent decrease in profit margins, the market throughout most industries is becoming more and more competitive. The customers and the competitors are encompassed by the market. For a concentrated industry, an insight into the market characteristics will be offered by individual analysis of the competitors along with their products. Currently, it is no longer enough for controlling and adapting the manufacturing by using temporary targets in effectiveness [4]. Furthermore, more relevance is gained by manufacturing for the enterprise's competitiveness along with its long-term strategic decisions. A strategic competitive factor via which companies could distinguish themselves as of their competitors is called manufacturing [5]. A process for creating an MS is vital for meeting the particular needs of strategic manufacturing management. Therefore, in the fabrication field, the resources along with capabilities required for the establishment or maintenance are specified in MS, which contribute towards enterprise competitiveness [6]. Several fundamental needs in the manufacturing strategies [7] are:

- REQUIREMENT 1: The MS should be expressed in a way that the enterprise's competitiveness is assisted by manufacturing.
- REQUIREMENT 2: The MS must be correlated with other functional strategies.
- REQUIREMENT 3: For the implementation of the MS, enterprise-specific contents along with sub-strategies must be deemed.
- REQUIREMENT 4: The MS should be expressed that for augmenting the manufacturing's efficiency and improving the enterprise's competitiveness, the content enterprise-specific resources, as well as capabilities, must be established or maintained.

The strategies in technology, depth of manufacturing, location, along with capacity are the most generally named contents. For generating competitive advantages, the future growth activities for the product along with manufacturing process technology are decided via the technology strategy [8]. The number, the size, along with the position of every individual site together with their technological focus is determined by the location strategy [9]. The position within the overall value chain is specified by the strategy for the depth of manufacturing. The manufacturing's capacitive performance is determined by the capacity strategy [10].

In the research and also the mechanical engineering field, MS has turned into a more challenging and promising field. Only fewer researchers deeply examined MS even though MS was examined by several researchers. Therefore, this paper reviews the approaches on developing MS, challenges, and concerns in the MS, along with performance in the MS.

2. LITERATURE REVIEW

The progression and utilization of production-total production abilities with business unit objectives along with strategies is the MS. For attaining the full competitive capability of a business unit, the MS could be deemed as a pattern of choices. These strategies are either checked or entirely realized as manifested in a stream of real-time decisions made at disparate points in time. But, there are several challenges and issues in MS. Therefore, the MS is elucidated in section 2.1. The challenges in the MS are explicated in section 2.2. Section 2.3 proffers the issues in the MS. Section 2.4 presents the performance in the MS. Section 3 offers the results along with a discussion.

2.1. MANUFACTURING STRATEGY

The collective patterns of coordinated decisions that execute the formulation, reformulation, along with utilization of manufacturing resources are called an MS. A competitive advantage is offered by MS for every strategic initiative of the firm. The right capability must be possessed by the manufacturing process so that the concerned business could continue winning the battle at the correct time. The MS's evolution is depicted in figure 2.

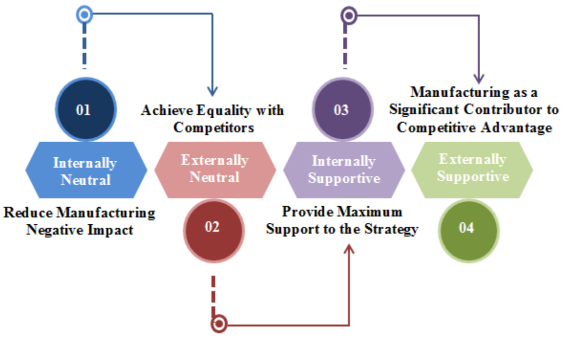

Figure 2: Evolution of the MS

J.-W. Jeong, et al.[11] presented the MS for mechanically transformed electronics. Widespread probable applications beyond these existent electronics technology were possessed by the Mechanically Transformative Electronics Systems (TES) because of their capability of attaining rigid and soft features. The results illustrated that the boundary betwixt conventional rigid electronics and rising soft devices could be possibly broken by the

TES (centered on stimuli-responsive materials). For securing body parts in a permanent position with soft wearable devices, TES was complex.

Ibrahim H. Garbie, et al.[12] introduced the Non-Conventional Competitive MS (NCCMS) for renewable industrial enterprises. The major objectives were reducing complexity, increasing leanness along with agility. The results illustrated that the NCCMS's most efficient dimensions were the complexity, leanness, and agility indexes which were sustainable. The NCCMS index's assessment was done and it ranged as of 38.98% to 41.40%. The average value was almost equal to 40.00%. When contrasted to other non-conventional manufacturing strategies, it would be more appropriate.

Gunnar Palmerud, et al.[13] examined the mechanical exposure implications of rationalization with the contrast of MS in the Swedish plant. Identifying the differences betwixt the '2' production strategies was a major aim. The results exhibited that slower movements were possessed by the machine-paced NEW system with lesser time consumed in movements of high velocity when analogized with the self-paced OLD system. However, no considerable differences were found betwixt the time median posture levels.

A. Lamikiz, et al.[14] described the high deposition arc of mild steels utilizing MS with the heat input effect of microstructure along with mechanical properties. For depositing mild steel material, the Gas Metal Arc Welding (GMAW)-centered WAAM system was created. The results denoted that productivity was augmented by the oscillated strategy. In manufactured walls, like, in the vertical along with horizontal directions, isotropic mechanical properties were attained. The process appeared to be slow because of the low deposition rate in GMAW.

Hongsheng Guo, et al.[15] addressed the High-Speed Machining (HSM) for the hardened die along with mold steels centered upon mechanical along with thermal MS. For cutting hardened die steel, experiments were executed utilizing AlTiN-coated micro-grain carbide end mill cutters. The cutting force and temperature had augmented with engaged angles as signified by the results.

2.1.1. Approaches for developing manufacturing strategy

Since key decisions are made by MS around manufacturing with greater certainty, there exists a need for creating an MS. For developing the MS, several approaches are proffered by the authors. Process approach, content approach, resource-based approach, Multi-Criteria Decision Making (MCDM) approach, quantitative approach, fuzzy analytic hierarchy process (AHP) approach, along with quality function deployment approach are encompassed by the approaches. The approaches utilized for creating MS with the uses and limitations are explained in table 1.

M. Bai, et al.[22] presented the fuzzy QFD approach for the MS growth. Centered on QFD, a method associated with MS development was created. The applied method had the ability to capture the imprecision of decision-pertinent inputs and facilitate the examination of decision-pertinent QFD information, which was proved by the results. The exact information along with linguistic variables was handled in a mathematically distinct way. However, it did not instantly analyze and control the issues of product assembly quality.

Table 1: Approaches used for developing MS with the uses and limitations

AUTHOR NAME	APPROACHES USED	USES	LIMITATIONS
Jaime Evaldo Fensterseifer, et al.[16]	Resource-centered view approach	The companies could create their MS as of disparate input and internal arrangements utilizing these approaches.	It was unfeasible to compile a homogeneous sample in the approach because of the company's heterogeneity.
Lanndon Ocampo, et al.[17]	MCDM Approach	It was easy to manage the decision-making complexity in this approach. It was utilized for addressing the individual decision maker's unclear judgment.	The uncertainty analysis was often very qualitative, along with consistent scores were hard.
Tabrizi Moghadam, et al.[18]	Fuzzy AHP approach	Manufacturing decisions with quantitative along with qualitative factors was illustrated by the approach.	The issues with such inaccurate information could not be effectively handled by conventional multiple attribute decision-making methods.
Emmanuel Francalanzaa, et al.[19]	Fuzzy logic approach	The way in which the machine requirements would evolve, was predetermined by the approach, After that, the machine module's morphology was determined with upgradeability and adaptability.	The results were mainly not precise, and it could not be accepted.
K.W. Platts, et al.[20]	Process approach	An organization was allowed to concentrate on enhancing its effectiveness along with efficiency by concentrating on end-products and customers.	Time along with cost would be high.
Nelson Hein, et al.[21]	Quantitative approach	For measuring the characteristics, the descriptive plans were usually structured along with specifically modeled.	It was hard to elucidate centered on precise geographical realities.

Maemunsyah, et al.[23] proffered the MS in the process, content, along with implementation utilizing the top-down approach. Producing a product or service was a vital role in the company's production function. However, now, generating the added value was the focus of the production function. The results illustrated that the '2' elements of the MS, like competing priorities along with the pattern of manufacturing decision making, were addressed by the content of the MS. Specialized knowledge was not utilized by the approach, which might be in the lower echelons of the organization.

Jan Frick, et al.[24] presented the formalization of the MS along with its influence on the relationship with their objective, improvement, and action plans utilizing the top-down approach. Utilizing the top-down approach, the relations were detected suitably betwixt the formalization of the MS as indicated by the results. Nevertheless, owing to the top-down approach, the responses to the difficulties in the MS could be slowed down along with creativity could be restricted.

2.2. ISSUES IN THE MANUFACTURING STRATEGY

Mostly, the key competitive priorities, namely quality, flexibility, delivery, along with cost are the issues of MS [25]. Process technology, capacity, et cetera are the key structural issues and quality management, management, human resource, along with organization culture, etc are the infrastructural problems.

Mahender Singh, et al.[26] elucidated the MS issues in the manufacturing sector. It offered the sector-wise contrast of competitive priorities, enhancement activities that was Advanced Manufacturing Technology, Integrated Information Systems, Advanced Management Systems, along with performance measures. The results denoted that quality was still emphasized by several Indian companies. Nevertheless, for competing globally with a higher innovation rate, quicker new product growth, along with continuous improvement, the automobile sector had been prepared. However, the linkages of manufacturing priorities along with action programs with MS were not mentioned.

O. P. Sharma, et al.[27] proffered the issues in the key priorities (flexibility) of MS. It addressed the different connotations of flexibility, measures of flexibility, manufacturing flexibility, opinions, and trends in flexibility along with agile manufacturing, suitability, and justification of Flexible Manufacturing Systems (FMSs). The results exhibited that a scarcity of tools was brought by the MS of flexibility for measuring flexibility. There was a deficit of understanding what to expect as well as not expect as of the manufacturing flexibility's physical organs. Several factors that determined flexibility were ignored by the measures centered on the manufacturing method's physical feature.

Laure Ambroise, et al.[28] described the configuration problems of MS in the manufacturing firms. There was a problem betwixt servitization and customer-oriented organizational design. An augmented performance could be caused by all the servitization strategies as confirmed by the results as of structural equation models along with qualitative comparative analysis. However, for maintaining the constant competition against the other firms, servitization was hard.

Barnabas Ekpere Nwankwo, et al.[29] presented the problems in the MS's key priorities (quality control). The results revealed that for a successful business, Quality Control (QC) methods were crucial tools. For assuring the production of first-class equipment or products to consumer satisfaction, the QC method's application could be helpful, which led to a successful business. When implementing QC practices, a few difficulties were non–awareness of QC methods and incapability of understanding the customers' needs.

Walter Terka, et al.[30] offered the problems in the MS's key priorities (flexibility). Filling the modeling gap betwixt a production issue and the manufacturing system which was suitable to face that issue was the basic problem. The link betwixt the requirement for flexibility and the manufacturing system's design was still weak as indicated by the results. It was general to find deviations for the compound forms of flexibility that were rather difficult to contrast without utilizing the dimensions and the levels.

Hairulliza Mohamad Judi, et al.[31] proffered the issues in the MS's key priorities (Quality control) within the manufacturing companies. It addressed the problems in QC implementation. The results revealed that ease of use of the method, capability of measuring product specification achievement, and capacity to enhance critical quality along with productivity problems were the '3' factors that influenced the selection of QC techniques in the companies. It would be hard to manage charting manually when the QC machine broke down.

Harmen Denekamp, et al.[32] explicated the issues in the MS. Concerning analysis, discussion, and deliberate decision making, the weaknesses of comprehensiveness and criticality originated from a lack of attention as depicted by the results. By proffering a comprehensive analysis of the vertical integration, these weaknesses had been discussed. Since more detailed attention was needed by DFMA, design for production efficiency and shifting strategy, the applicability was hard to examine.

Petr Novák, et al.[33] presented the problems in the key priorities (Cost) of the MS. Identifying the issue in the cost of MS was a major aim. Recently, there had been an increase in the share of indirect costs up to 40% (till 2009), whilst steady growth in the portion of these costs was exhibited by about half of the companies as revealed by the results. It still needed more requirements, so problems along with difficulties were caused concerning the performance of products in the manufacturing companies.

Reinaldo Pacheco da Costa, et al.[34] explained the issue in the key priorities (Cost) of the MS. Operational, decision support, along with strategic control was the '3' dependence levels that were proffered. The alignment's significance among the cost management model along with the competitive approach for business success was illustrated by the results. For decision-taking in a global strategy, the activity-centered costing model's sufficiency was used as a supporting tool. For determining profitability, costs information alone was not adequate. Quality criteria, productive flexibility, along with innovation were handled via the management methods.

2.3. PERFORMANCE IN THE MANUFACTURING STRATEGY

Assessing the performance fairly in the MS is complicated. ROI, profitability, et cetera are the financial measures that are generally plant-level measures. Those measures are subjected to numerous factors out of the manufacturing operation's scope. For isolating the operation function's performance, measures are utilized in which a primary part is played by the management of operations, i.e. operational performance measures. Delivery, quality, flexibility, and cost performance are the general set of competitive priorities that coincided with the dimensions utilized [35]. The examples of the internal along with external measures in the MS performance are offered in Table 2.

Table 2: Internal and External measures in the MS performance

OPERATIONAL PERFORMANCE DIMENSIONS	INTERNAL PERFORMANCE MEASURES	EXTERNAL PERFORMANCE MEASURES
QUALITY	Rework cost, percentage of passed quality inspection, along with the QC's cost	Accordance to agreed-upon specification, along with product's performance
DELIVERY	Production lead time (LT), the inventory status accuracy along with the reliability of internal LT	Delivery LT, prompt deliveries along with stock availability
COST	The unit cost of manufacturing, inventory turnover, capacity utilization and yield	Product selling as well as the market price
Flexibility	Set up time or cost, the fixed production schedule's length along with the quantity of operating capacity	Product range, total products presented, capacity to manage volume along with product mix changes

Rosman Iteng, et al.[36] presented the impact of Quality Management (QM) on MS performance. Disparate elements of QM practices were possessed by various sectors of industries. The results exhibited that QM practices were deemed as the best solution to the outcome of all these factors owing to market competition, customer expectations, and augmenting customer demand. But, in the automotive sector, there were insufficient constructs.

Gyusun Hwang, et al.[37] examined the integrated key performance measurement for MS management. For deriving the final performance values, extra formulas were employed. The importance of indicators had differed as exhibited by the outcomes. By changing interest in the work's priority to be completed at every level, this was primarily caused. It was found that at the site, stock management did not perform well. As per the stock, numerous expenses were paid.

Wonhee Lee, et al.[38] presented the relationships among MS process, manufacturing-marketing integration, along with plant performance. On '221' manufacturers, a survey was performed as of the machinery, automotive, along with electronics in South Korea. There was a positive relationship among the MS process, manufacturing marketing integration, along with plant performance as indicated by the result analysis. Operationalizing the content's quality was difficult.

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Kai Meng, et al.[39] elucidated the smart recovery decision-making of utilized industrial tools for sustainable manufacturing. For the execution of smart EOL management, a system framework centered on product condition monitoring was implemented. The results exhibited that when the service age was above 6000 h, it must be recycled. Besides, for the bearings along with the seriously degraded motors, material recycling was suggested. Nevertheless, in the profit-maximization model, the environmental performances were not completely analyzed.

Matteo Lucchese, et al.[40] examined the Business services and also the export performances of MS in industries. The dynamic efficiency gains produced by the interaction of manufacturing along with BS industries were the major empirical focus. Although these effects differ as per the sort of intermediate intangible input attained along with the type of user sector, a positive impact was exerted by BS upon the global competitiveness of manufacturing industries as shown by the results. Sometimes, concerning the probable complementary relationships, it was hard to create clear-cut research hypotheses.

Raghed Ibrahim esmaeel, et al.[41] explained the MS's business performance. For manufacturing companies, globalization along with technological advances was now generating challenges. For enhancing the total performance, the creation of efficient along with effective paradigms in response to the international economies was needed by the global competition as illustrated by the results. When deemed with the MS, it was hard to divide the profitability in business growth.

S. Maryam Masoumik, et al.[42] examined the significance of the MS performance in the Malaysian manufacturing sector. For analyzing the total impacts of green strategy adoption on competitive benefits, a model was implemented. There was a considerable relationship among the green strategies, ecological performance, along with competitive benefits as depicted by the outcomes. There was no considerable impact upon companies' competitiveness.

Niklas Burger, et al.[43] explained the flexibility as a performance dimension of a Manufacturing Value Modeling Methodology (MVMM). These challenges along with solutions were tried to be solved using technological roadmaps along with interventions in manufacturing systems. The results signified that the detection of pressure and challenges was allowed by MVMM concerning flexibility demand that affected the company's surroundings. Specific flexibility kinds and capabilities were defined that were vital for driving companies to reconfigure their methods. However, there was a lack in detecting the factors, which could result in a flexibility demand.

2.4. ADDITIVE MANUFACTURING STRATEGIES

Recently, constant growth has been observed by Additive Manufacturing (AM) in adoption by varying production processes, maintenance, supply chain, product development, along with the global economy. Via the process of adding material, three-dimensional objects as of digital models are manufactured by AM which is a group of technologies. The materials could be ceramics, metals, and polymers. The AM strategies with their results and limitations are explained in table 3.

Table 3: Additive manufacturing strategies with its results and limitations

AUTHOR NAME	AMS CATEGORIES USED	RESULTS	LIMITATIONS
Ming C. Leu, et al.[44]	Material Extrusion (ME)	Centered on these outcomes, ceramic components with complex geometries were obtained by post-printing of the shapeable green bodies.	Constructing huge solid (non-sparse) parts was hard for robocasting because of the stresses that took place in the non-uniform drying, which produces warpage along with cracks in the parts.
Abdollah Saboori, et al.[45]	Directed energy deposition (DED)	It was exhibited that a 62% augment in average was possessed by the elongation of repairing by DED, because of its smaller HAZ size, which had a high hardness zone.	Prior to the component's final approval, the qualification phase was quite long. Defining a standard procedure for repairing to decrease the period of the qualification phase was the next step.
Alessandro Carrozza, et al.[46]	DED	It was confirmed that a direct effect upon the component's final properties, namely microstructure along with grain size was possessed by the process atmosphere.	The possibility to efficiently construct components could be affected if there was a modification in the mechanical properties.
Ian Gibson, et al.[47]	Sheet Lamination (SL) process	It was exhibited that when random foil arrangements were utilized, superior tensile properties were caused by a 50% overlap.	Utilizing UC, SEM became quite difficult for bonding parts when the height-to-width ratio was 1:1 as signified by the modeling results.
Hadi Miyanaji, et al.[48]	BINDER JETTING (BJ)	For powder types I, II, along with III, the spherical particles with the unimodal size distribution of 14 µm, 31 µm along with 78 µm mean particle diameters were encompassed by all '3' powder types.	The lack of theoretical models for anticipating the 3D-printed part's quality and significant uncertainties was caused by a process fundamental's deep understanding regarding the accuracy along with the strength of fabricated parts which were the process's drawback.

Reginaldo T. Coelho, et al.[49]	DED	For micro-hardness (209 HV), a workpiece with the minimum average value was produced by the contour strategy, which was also the nearest to the annealed SS 316.	In a layer, a raster path could well be employed as a DED strategy. However, it might not be the best, relying upon the thermal distribution.
Yee Ling Yap, et al.[50]	Material jetting (MJ)	For cubes with and without a base plate in the X- as well as Y-axes, the lowest clearances were constant at 0.15mm as exhibited by the results for benchmark printed in matte mode.	After post-processing, the support materials were eliminated. During printing, the parts comprising the shafts, cylinders, along with cubes, which did not combine were separated for showing the limits along with fits of these features.
Vladimir V. Popov, et al.[51]	Powder Bed Fusion (PBF)	It was depicted that fatigue life was augmented by over 14 times contrasted to AM samples and 57 times over the traditionally generated material by utilizing 3D LSP.	Obtaining high-density products with powders that possess uneven grains strongly deviating as of spherical shape was quite complex.

Marek Pagac, et al.[52] explicated the Vat Photopolymerization technology materials, applications, challenges, along with trends. The prototyping method was considerably changed by AM (3D printing) concerning the construction, technology, materials, and also their multiphysical properties. When contrasted to DLP, the parts could well be fabricated by CDLP/CLIP with superior accuracy along with mechanical properties owing to the platform's constant movement and the dead zone's presence as exhibited by the results. The chain-forming chemical-thermal method was not reversible and the prototypes couldn't be changed back to liquid form.

Riya Singh, et al.[53] proffered the PBF process in AM. One among the basic methods linked to AM was the PBF process. It was a quick manufacturing technique and extensively utilized in aerospace and medical or orthopedic implant industries as exhibited by the results. When utilizing EBM with titanium along with a layer thickness of 0.1%, superior results were offered in a quicker time and could decrease the cost by up to 35%. Removing the part as of the build platform with no distortion was not possible.

Jiang Jingchao, et al.[54] presented the sustainable material extrusion in AM. For over 30 years, AM technology had been created. It had emerged as a mainstream manufacturing method. By deeming the post-processing, the material extrusion AM could well be more sustainable as revealed by the results. Using conventional subtractive manufacturing along with mass customization of components, the product's realization would be hard or even unfeasible to manufacture.

2.4.1. Additive Manufacturing Tests

AM is addressed by '2' standards of groups. The mechanical testing of AM materials and parts is currently addressed by both of the groups via reference to established standards. For mechanical testing of polymer AM materials along with parts, the existent standard's applicability is explained by tension, flexure, compression, shear, creep, Fracture Toughness (FT), and fatigue [55].

Ignacio López-Gómez, et al.[56] presented the assessment of compressive along with flexural characteristics of constant fiber fabrication AM technology. The increased compressive response was attained with a 0.2444 carbon fiber volume ratio, along with equidistant reinforcement configuration as exhibited by the results. It also caused a 2.102 GPa compressive modulus along with stress at the 53.3 MPa proportional limit. For rejecting the null hypothesis, there was not enough statistical evidence. Thus, it was deduced that an effect upon the specimen's strength in the proportional limit might not be possessed by the factors.

S. Romano, et al.[57] elucidated the fatigue properties of AlSi10Mg using an AM. The key to express the relationship among the fatigue strength along with material quality was an amalgamation of defect-tolerant design with entrenched and newly applied fracture mechanics methods as illustrated by the analysis. The good prediction along with a good illustration was confirmed. When the defect size was bigger contrasted to the grain size, the microstructure did not sensibly affect the fatigue limit, particularly in the case of ductile materials.

V. Damodaran, et al.[58] examined the mode-II Interlaminar FT of Polymeric matrix composites via AM. The results denoted that for attaining gradual progressive failure along with enhancing FT, the lesser reinforcement spacing at the interlaminar region was beneficial. After the PPR's deposition, no signs of curing were exhibited by utilizing the prepreg resin utilized here on account of the moving nozzle's very small heating duration.

Horacio Ahuett-Garza, et al.[59] presented the tensile properties along with failure behavior of chopped together with constant carbon fiber composites by AM. In industries, the usage of AM was quickly utilized owing to the flexibility for manufacturing complex geometries. The results exemplified that a reduction of 16.9% in the elastic modulus along with 16.5% in the tensile strength was exhibited by the middle samples of 1R 12L when analogized to the outside test. It was not always feasible to maintain the initial point of reinforcement outer the load area for several applications.

O. Quénard, et al.[60] explained the estimation of FT of metallic materials generated by AM. In the average FT of batches #1 and #2, the most significant point was the 57% average augment (+48% to +63% in proportion to the orientations) as depicted by the results. No notable decrease in the porosity rate was revealed by the observations. However, this might be centered on a very low initial rate, 0.2%. But, it did not identify the probable residual porosity on the fracture surface.

3. RESULTS AND DISCUSSION

The specific energy needed in the additive MS process categories, the specific speed required in the additive MS process categories, and the specific resolution required in the additive MS process categories are explained in this section. The creation of lighter, stronger parts along with systems is enabled by AM which is a transformative approach to industrial production [61]. The AMS process categories vs energy is described in table 3.

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Table 4: AMS process categories vs energy

AMS PROCESS CATEGORIES	ENERGY (J/CM^3)
BJ	0.023
DED	1000
ME	0.024
MJ	0.085
PBF	100
SL	110
VP	0.123

BJ, DED, ME, MJ, PBF, SL, along with Vat Photopolymerization (VP) is the AMS process categories [62]. The specific energy needed in the additive MS process categories is elucidated in figure 4.

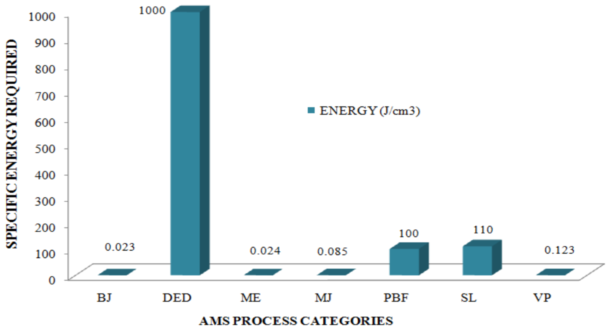

Figure 3: Specific energy required in the additive MS process categories

Higher specific energy (1000 J/cm^3) is illustrated by DED out of every AMS process category. When contrasted with the other AMS process categories (DED, ME, MJ, PBF, SL, along with VP), lower specific energy (0.023 J/cm^3) is exhibited by BJ. There exists a specific speed needed in the AMS process categories (BJ, DED, ME, MJ, PBF, SL, and VP) similar to energy. The specific speed required in the additive MS process categories is depicted in figure 5.

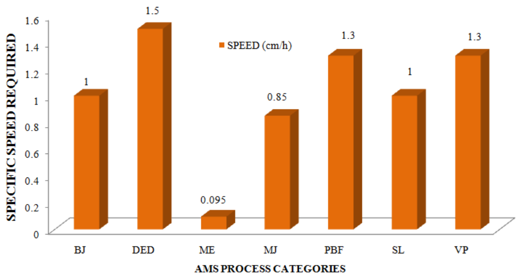

Figure 4: Specific speed required in the additive manufacturing strategy process categories

A higher specific speed (1.5 cm/h) is demonstrated by DED. In the AMS process categories, when analogized to the other AMS process categories (DED, BJ, MJ, PBF, SL, and VP), a lesser specific speed (0.095 cm/h) is shown by the ME.

There exists a specific resolution required in the AMS process categories (BJ, DED, ME, MJ, PBF, SL, and VP) similar to energy and speed. The specific resolution needed in the additive MS process categories is explicated in figure 5.

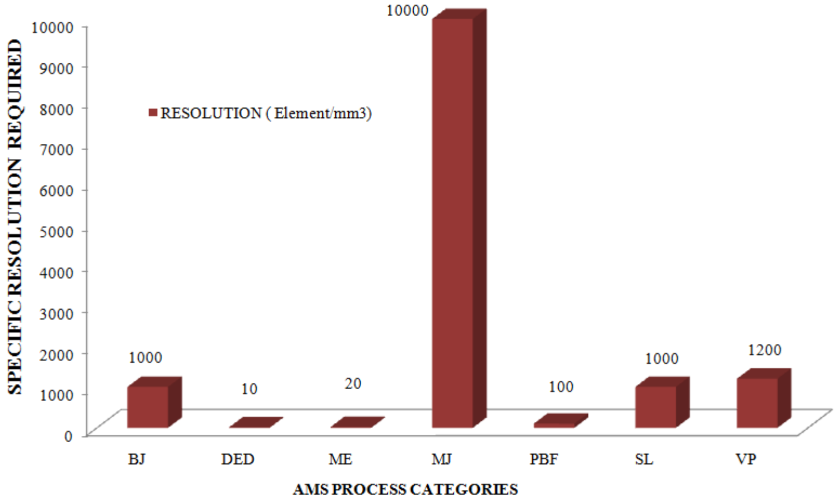

Figure 5: Specific resolution required in the additive manufacturing strategy process categories

A higher specific speed (10000 Element/mm^3) is exhibited by MJ. In the AMS process categories, a lesser specific speed (10 Element/mm^3) is depicted by DED when contrasted to the other AMS process categories (ME, BJ, MJ, PBF, SL, and VP).

4. CONCLUSION

The manufacturing's strategic contribution to the competitive strength of every company is denoted by the role of manufacturing. It is hard to recognize a strategic role that manufacturing plays alone owing to the close interaction betwixt the different functions of an industrial company. For instance, a considerable contribution is made by manufacturing via supporting sales in the quick increase of customized equipment, along with equipment growth by a capacity to prototyping. On the other end, a broad range of functional competencies along with managerial responsibilities are distributed by a lead factory. Also, new processes, equipment, along with technologies are created for the whole company representing access to skills as well as knowledge. This paper addresses the approaches for developing the MS, challenges, and problems in the MS, and performance in the MS. This paper examines the specific energy required in the additive MS process categories, the specific speed required in the additive MS process categories, and the specific resolution required in the additive MS process categories. In the outcomes, higher speed and energy are exhibited by the DED process categories, while the MJ process category is higher in resolution.

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