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RPT Method Selection using MCDM Techniques

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Abstract: *Rapid Prototyping is the one of the emerging technology in the field of manufacturing which substantially reduces the product development time. Many times when multiple manufacturing processes are available for product manufacturing it may be troublesome for selecting the right one. The rapid prototyping methods can be implemented for rapid production of products or prototype but due to various process capabilities it is difficult to select the correct method. The process can be selected according to the products requirement or availability with concern of various criteria of the product such as surface finishing, build time. Geometrical accuracy, material elongation etc. with the proper decision support system for process selection the higher accuracy and reliable output can be obtained. This paper includes remarks about current rapid prototyping methods along with their strengths and weaknesses.*

Keywords: RP Methods, Decision criteria, process capabilities

I. INTRODUCTION

Rapid Prototyping (RP) refers to a group of emerging technologies for fabricating physical objects directly from computer-based geometry descriptions of part designs. In RP a CAD file of an object is converted into a physical model using an additive or layered manufacturing technique. These physical models help to see, understand and analyze characteristics of the final product. It Allows fabrication of physical prototypes of any complexity using a layer-by-layer deposition technique directly from a computer-aided design model without any conventional requirements of process planning, tooling or numerical control programming. The rapid prototyping process greatly reduces the time and cost necessary to bring a new product to market. The prototypes made by these systems are used in a range of industrial applications including design evaluation, verification, testing, and as patterns for casting processes. Rapid prototyping technologies first emerged in 1987 with the advent of Stereo lithography, the first commercial RP system, marketed by 3D Systems. The choice of a rapid prototyping system depends on a number of factors or selection criteria such as price, accuracy, build envelope, build material, build speed, surface finish and end applications. The various available rapid prototyping processes are basically material additive type where as material removal and hybrid layered technologies are also evolved. Rapid technologies may be divided broadly into those involving the addition of material and those involving its removal. The material addition technologies may be divided by the state of the prototype material before part formation. The liquid based technologies may entail the solidification of resin on contact with a laser, the solidification of electro setting fluid, or the melting and subsequent solidification of the prototype material. The processes using powder compound then either with a laser or by the selective application of binding agents. Those processes which use solid sheets may be classified according to whether sheets are bonded with a laser or with an adhesive There are currently several different RP technologies available, each with its own unique set of competencies and limitations. Advance manufacturing technique such as Rapid prototyping is widely used in the automotive, aerospace, medical, and consumer products industries. Rapid prototyping and manufacturing prototypes are increasingly used in the development of new products, spanning conceptual design, functional prototypes and tooling

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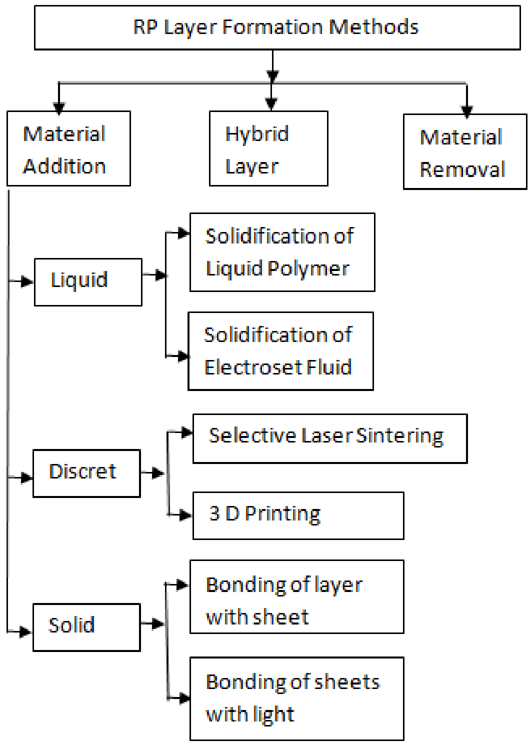


Fig 1:- Classification of RP Methods

RP has become essential during the design process of a product. Along with computer visualization tools, a tangible design representation allows fully explore the strong and weak points of product. By seeing and touching a physical model, it will be much easier to identify the areas of product that require improvement. It might even inspire to come up with new solutions. This type of prototype will allow designers to explore the basic size, look and feel of a product without simulating the actual function. They can help assess ergonomic factors and provide insight into visual aspects of the product's final form. The basic principle of RP methods belongs to generative (or additive) production processes unlike subtractive or forming processes in

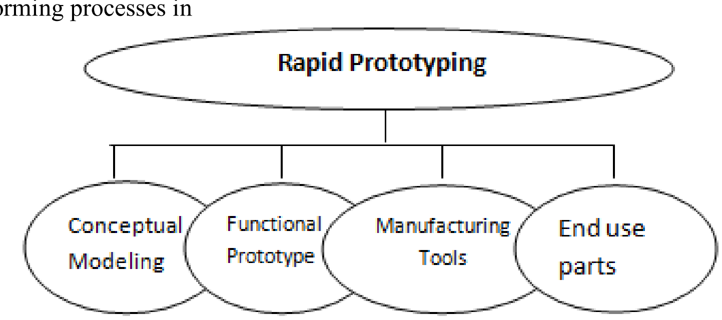


Fig 2:- Applications of RP Methods

In all commercial RP processes, the part is fabricated by deposition of layers contoured in a (x-y) plane two dimensionally. The third dimension (z) results from single layers being stacked up on top of each other, but not as a continuous z-coordinate. Therefore, the prototypes are very exact on the x-y plane but have stair-stepping effect in z-direction Stereleothography is the most popular RP method relies on a photosensitive monomer resin which forms a polymer and solidifies when exposed to UV light and this reaction takes place near the surface. In Selective laser sintering process fine polymeric powder like polystyrene, polycarbonate or polyamide etc. is spread on the substrate using a roller. The laser is modulated in such away that only those grains, which are in direct contact with the beam, are affected. In this process support structures are not required. In Fuse deposition modeling a movable nozzle on to a substrate deposits thread of molten polymeric material.

Table 1:- Development of RP Methods

Name	**Acronym**	**Development years**
Stereolithography	SLA	1986-1988
Solid Ground Curing	SGC	1986-1999
Laminated Object Manufacturing	LOM	1985-1991
Fused Deposition Modeling	FDM	1988-1991
Selective Laser Sintering	SLS	1987-1992
3 D Printing	3DP	1985-1997

Analytical Model

Analytical calculations are carried out to find out best available rapid prototyping method. The parameters considered are surface roughness, geometrical accuracy, tensile strength, build time, and cost

Table 1: Measurement Matrix

$$x_{ij} = \frac{y_{ij} - Min\{y_{ij}, i=1,2,...,n\}}{Max\{y_{ij}, i=1,2,...,n\} - Min\{y_{ij}, i=1,2,...,n\}} \quad ......1$$

	SF	**GA**	**TS**	**BT**	**C**
SLA	10	21	30	31	10
SLS	0.16	0.21	0.41	0.32	0.16
3 DP	41	42	37	33	41
FDM	185	175	170	190	185

$$x_{ij} = \frac{Max\{y_{ij}, i=1,2,....,n\} - y_{ij}}{Max\{y_{ij}, i=1,2,...,n\} - Min\{y_{ij}, i=1,2,...,n\}} \quad ....2$$

Grey relational numbers are generated using these formulae

Table 2: Normalization Matrix

	SF	**GA**	**TS**	**BT**	**C**
SLA	1	1	0.88	0.25	0
SLS	0.47	0.78	1	0.75	1
3 DP	0.04	0	0.44	1	0.85
FDM	0	0.34	0	0	0.75

For higher the better equation number 1 is used and for lower the better equation 2 is used.

$$\gamma(x_{0j}, x_{ij}) = \frac{\Delta_{\min} + \zeta \Delta_{\max}}{\Delta_{ij} + \zeta \Delta_{\max}} \quad ....3$$

Grey relation coefficient is calculated for determining closeness of x_{ij} and y_{ij}

Table 3 : Grey Relational Coefficient

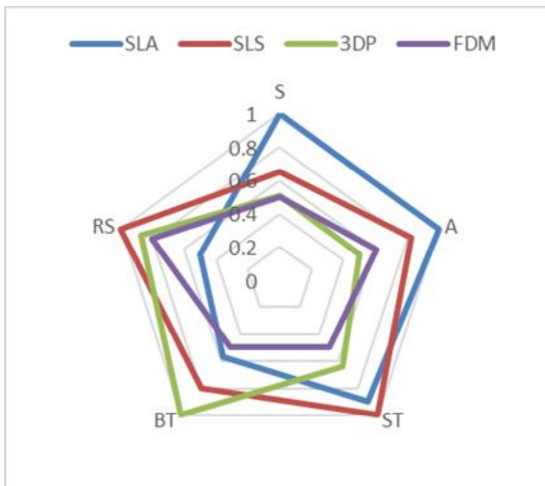
	SF	**GA**	**TS**	**BT**	**C**
SLA	1	1	0.9	0.57	0.5
SLS	0.65	0.82	1	0.8	1
3 DP	0.51	0.5	0.64	1	0.86
FDM	0.5	0.60	0.5	0.5	0.8

Grey relational grade is calculated using this formula

$$\Gamma(X_O, X_i) = \sum_{j=1}^{m} w_j \gamma(x_{oj,} x_{ij}) \quad for i = 1,2,\ldots,n$$

Table 4 : Grey Relation Grade

	Grey Relational Grades
SLA	0.8752
SLS	0.8127
3 DP	0.6333
FDM	0.5541



Graph 1: Radar chart Indicating Most desirable method

Ranking for the methods used are obtained by using Grey relational Analysis in which highest overall Grey relational grade indicates best available alternatives and descending order of the overall Grey relational grade indicates the next suitable alternatives

II. CONCLUDING REMARKS

The graph shows that values far from zero and close to one are meeting requirements, while values close to zero or in the center are either weak or require improvement. Using fast prototyping, this study attempts to suggest the optimal way to build the item. The grey relationship grades can then be used to determine the best choice. Based on the specifications of each component, it is quite straightforward to make an overall measurement. The order in which the appropriate RP method is chosen can be determined by the overall performance.

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