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ECONOMIC COMPARISON OF ADDITIVE AND CASTING METHOD OF MANUFACTURING

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Abstract— *This paper compares the cost of additive manufacturing with casting manufacturing method follows a detail breakdown of cost per piece. Extrapolating the data and plotting a chart to proof the statement of various economic theories suggested in the direction of AM.*

Keywords- *Designing; casting; extrapolation; Breakeven; 3-D printing; Manufacturing; Minimum efficient scale.*

INTRODUCTION

Additive manufacturing further refer as AM is an emerging technology that is advancing its scope in various dimensions in manufacturing. This paper discusses the economic viability of AM over casting method followed by its future scope.

WHAT IS ADDITIVE MANUFACTURING?

Additive manufacturing uses data computer-aided-design (CAD) software or 3D object scanners to direct hardware to deposit material, layer upon layer, in precise geometric shapes. As its name implies, additive manufacturing adds material to create an object. By contrast, when you create an object by traditional means, it is often necessary to remove material through milling, machining, carving, shaping or other means.

Although the terms "3D printing" and "rapid prototyping" are casually used to discuss additive manufacturing, each process is a subset of additive manufacturing. [1]

WHAT IS CASTING METHOD?

Casting is a process in which a liquid metal is somehow delivered into a mold (it is usually delivered by a crucible) that contains a hollow shape (i.e., a 3-dimensional negative image) of the intended shape. The metal is poured into the mold through a hollow channel called a sprue. The metal and mold are then cooled, and the metal part (the *casting*) is extracted. [2] Further in this paper, casting will be refer as Conventional method Or CM.

CREATING THE DESIGN

Sophisticated 3D scanning and imaging Tools are emerging as alternatives for traditional CAD programs. In addition, stylus based and other design technologies that allow consumers to modify digital models themselves— without the need for extensive CAD experience—are expected to drive growth in the personal AM systems space. New formats, such as additive manufacturing file format (AMF), are also being developed to address. STL's limitations and allow for more flexible file structures. [3]

The elements are designed in AutoCAD -2013 and converted into .STL file using cura-15.04.

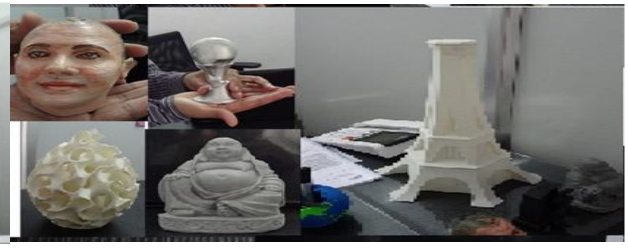


Figure 1.1 Color parts by AM *Figure 1.2 Complex geometries*

Figure 1.3 3-D Model of a house scaled to 1:1000

PROCEDURE

The File is taken to AHA 3-D printer corporation [4]. With the help of their 3-D Printer using ABS plastic as material.

The parts Manufactured by 3-D printer is Later used as pattern for Casting.

- The patterns are made up in Plaster of Paris casting.
- Aluminium is heated up to melting point in a muffle furnace.
- Then the hot metal is poured into the mould.
- Give it 15 minutes to set and cool
- Use various machining methods for finishing.

ANALYSIS

The cost comparison between Additive manufacturing and casting can be done by breaking down the cost of various components. This includes the following-

1) Major cost: It includes the setup cost (majorly apparatus required) , operating cost of the apparatus majorly comprises of electricity cost , which varies in different geographic locations , countries based on availability. Labor cost for conventional manufacturing depends on the wage rate of a country and for additive manufacturing, the involvement of labor is minimal as most of the process is inherently automated. Cost of finishing depends on the precision and polishing required on the final product, however AM requires less finish because the final product is already very polished and finished.

2) Time required: Setting up and calibrating the apparatus is time taking process in conventional manufacturing, while calibrating AM machines require very less time.

AM is a time-consuming process as the product is formed layer by layer while on the other hand casting requires only cooling off period.

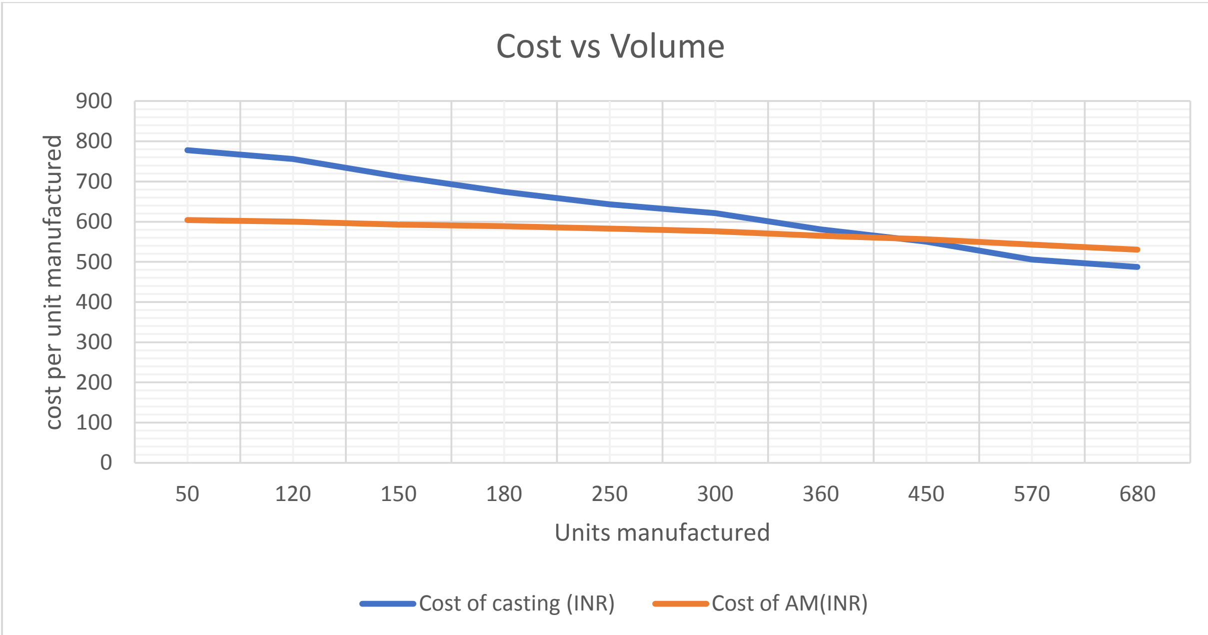
*All the cost is in Indian rupee (INR) in the following table.

Major Cost	Additive manufacturing	Casting
Setup cost	8,000 INR (Nozzles, Motor setup, microprocessor)	6,000 INR (furnace , pattern ,mold etc.)
Operating cost (electricity)	5 INR = 1 KWH (for motors, heated nozzle)	100 INR = 20 KWH (for electric furnace)
Finishing cost	Sand paper (10 INR)	Abrasive machining (60 INR per piece)
Labor cost (skilled labor not included)	Nil	500 INR per hour
Material cost	Can't be compared	Can't be compared
Total	8000 INR approx.	7000 INR approx.
Time taken		
Setup time	10 minutes	45 minutes
Process time	80 -90 minutes	30 minutes
Total time taken	100 minutes	75 minutes
Per piece cost analysis		
Labor cost (Skilled labor cost not included)	Nil	625 INR
Operating cost (electricity)	8 INR	50 INR
Material cost (differ in every situation)	600 INR	110 INR
Total cost per piece	608 INR	785 INR

EXTRAPOLATING THE COST

A The total cost per piece for both the manufacturing methods came out to be 608 INR and 785 INR, by extrapolating the cost for larger volume of manufactured cost, the reduction in cost per unit can be observed.

Cost of AM(INR)	Cost of casting (INR)	Units manufactured
608	785	50
604	778	120
600	756	150
593	712	180
589	674	250
583	643	300
576	621	360
565	581	450
556	550	570
543	506	680
530	487	800



<u>Observations:</u>

- The Graph illustrates the trend between cost per unit manufactured and number of units manufactured.
- The two key function that is plotted on this graph are AM and CM.
- Overall it can be observed that CM observes a downward trend in cost as the volume manufactured increase, while on the other hand AM observes almost a constant trend with no significant change in cost per unit.
- The breakeven point decides that the cost for both the method s are same at (570 units)
- However, upon continuously increasing the volume does reduce the cost per unit CM but the difference is not very significant.

MINIMUM EFFCIENT SCALE

<u>Capital vs. Scale</u> [5]: Minimum efficient scale shapes supply chains: AM has the capability to reduce the minimum efficient scale over a period, that may be promising for upcoming production facilities and ease of Adopting AM increases.

AM impacts the economics of production by reducing minimum efficient scale. In some cases, AM provides flexibility for consumers to satisfy their individual demands without the large labor or capital investments that might have the case with CM. The data of extrapolation supports this conclusion. Multiple economic studies exemplify that minimum efficient scale for AM can be achieved at low unit volumes. This cost trend contrasts with that of CM that face higher initial costs for tooling and setup.

The cost curves illustrate the change in average cost for each incremental unit of production. Breakeven between two alternative production approaches occurs where these curves cross.

The average cost curve is for AM is almost flat, suggesting that marginal cost does not change significantly with volume. More traditional production methods may yet yield cost advantages at higher volumes, as suggested by the declining cost curve. It concludes that AM production, using a variety of materials, can provide an efficient alternative for low-to-medium-sized production runs. Furthermore, expected reductions in material costs leave open the potential for breakeven points to substantially increase in the future. Improvements in throughput and reductions in the cost of AM equipment can only serve to further amplify these effects, increasing the production quantities at which AM might compete with more traditional.

CONCLUSION

In conclusion, AM has the potential to reduce and time and cost, if implemented widely it will optimize the product Lifecyle as well supply chain. The agility and customization offered to the user/ customer is very high in AM compare to CM, these traits of AM will be grown over the period of time with extensive research and AM will be adopted by Industries, thus replacing traditional methods.

ABOUT THE AUTHORS

Rohit Mehta, a graduate in mechanical engineering , currently serving as Product Data Management consultant with tata technologies working on project for McLaren automotive(UK). His area of interest includes Product Life-cycle Management, manufacturing, industrial engineering & finance.

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