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Applications of Rapid Prototyping – 3D Printing Technology to Ease Manufacturing and Verification

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***Abstract*—The Rapid Prototyping (RP) system shall claim fast processing at low operating costs with stringent tolerance. The utility of this RP system shall find its importance by reducing time and cost to 1/5th in comparison to the conventional, heuristic proto development methodology. The RP proto can be used to verify form, fit and function. Rapid Prototyping (RP) Technique in the recent times has found its application in the industrial sector. RP allows variety of options of build methods and materials and its usage has been widened proportionally. The usage of RP technique crosses over many different industries but every case comes under any one of the following applications: 1) Visualization, 2) Form and Fit, 3) Functional Prototypes, 4) Patterns, 5) Rapid Tooling, 6) Component Manufacture, 7) Reverse Engineering, 8) Concurrent Engineering. The future might bring the sophistication of preferring to a rapid prototype model instead of drawings. With advance in materials and processes, the list of application will continue to grow.**

I. INTRODUCTION

The RP system shall claim fast processing at low operating costs with stringent tolerance. The utility of this RP system shall find its importance by reducing time and cost to 1/5th in comparison to the conventional, heuristic proto development methodology. The RP proto can be used to verify form, fit and function. There are wide options to choose between the processes for a specified task. Choosing the right process is a complicated decision and requires clarity in understanding the need very carefully. Before choosing a process one must understand the process's strengths and weakness and for this experience in usage plays a key role. The consideration bulletins for choosing the right process is a long list yet are grouped under three classifications: 1. Physical considerations, 2. Operational considerations and 3. Application consideration. Quick, accurate and cost effective are the main theme to select the RP technique. Choosing the right material for the process is the next complicated task after choosing the right technology. When material selection is not given a thought, the results shall have deviations.

The paper shall explain the effects and effectiveness and wide range of the usage of Rapid Prototyping Technique (RP) for industrial purpose. The following nomenclature shall provide a categorized description of the applications of rapid prototyping technique.

II. VISUALIZATION

This application is considered to be the earliest of all other RP Techniques. It allowed designers to visualize the parts they had designed in 3-dimension. It helped to be a revolutionary application because the designers would never have a clear view of the parts they design until the final part is produced, by which time, investment of time and money made on the part is already critical for a setback. This 3-D model held physically gave them a great advantage while dealing with non-technical people such as customers or sales and marketing departments. In such cases, holding a 3-D model helped them understand the design well and also helped to check the ergonomics of the product at a time so early, to avoid setbacks.

Fig. IVisualization Technique.

III. FORM AND FIT

Form and fit of a part or a component are among the main and basic clause of engineering. Even complex structures, components or assemblies could be checked for form and fit to ensure there are no design errors. This application of 3-D modeling in form and fit check is to detect any errors in the first iteration and can be corrected easily before any significant amount of time or money is wasted on a wrong design. Fully functional complex models could be modeled using this technique, eg: a screw gauge can be modeled and can be used for measurement once when calibrated.

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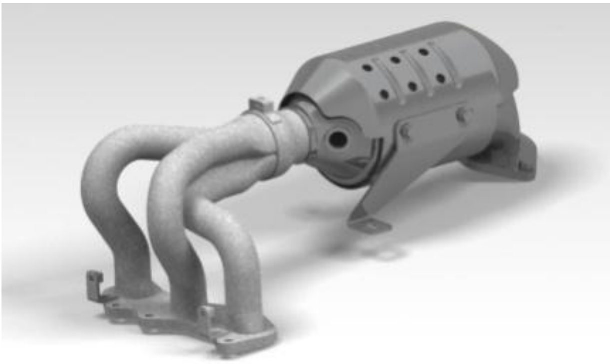

Fig. II Form and Fit checking of Exhaust Hot End Assy.

IV. FUNCTIONAL PROTOTYPES

Components where liquid flow or wind flow is involved, RP application plays a vital role, eg: Engine manifold, wind tunnels, AC Units, hydraulic and pneumatic systems etc. Some of the SLA methods provide a sufficient transparent finish that permits a direct view or videotape facility of flow of colored smoke through pipes or cavities.

Fig. III Functional Check-Manifold of Exhaust System.

V. PATTERNS

RP Techniques has not only helped in modeling parts but also has been used to make moulds. Patters for manufacturing both castings and mouldings can be made using RP Technique. Laser sintering or fused deposition modeling method permits development of sacrificial castings using wax. SLA Quick cast system, which uses epoxy resins permits manufacturing of honeycomb structures which collapse very easily compared to solid models during casting. SLA and sand ground curing techniques helps produce re-usable sand patterns.

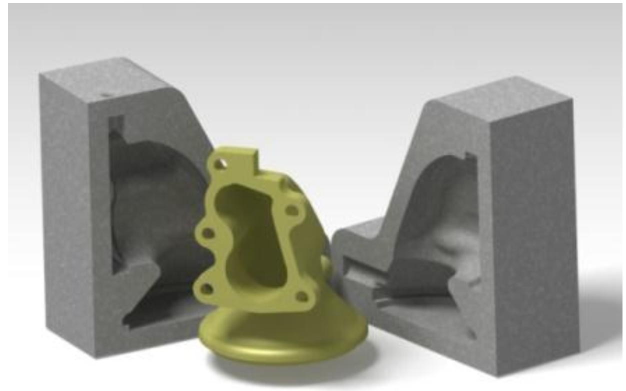

Fig. IV Patterns can be made using RP Technique.

Patterns produced by RP Technique are sprayed with metal and then backed up by a thin layer of metal with sand filled epoxy resin or a plaster, creating a parting line for extracting the pattern. These moulds can be used for a short production of injection mould parts.

RTV-Room Temperature Vulcanizing is a technique in which silicone rubber is vulcanized and casted around pattern which creates the needed parting line to remove the pattern. These moulds can be used for the production of cast plastic parts such as nylon, acrylic or polyurethane.

VI. RAPID TOOLING

This is an effective technique in which direct production of parts or tools, done on an experimental basis by using SLS-Selective Laser Sintering of plastic coated metal powders and by 3-dimensional printing by using a binder from a print head which helps the bonding of the metal powder. One when these forms are produced, they are heated and sintered to remove the binder material from the part which leaves the form with 50% porosity. These porous parts can be infiltrated with molten copper which makes the RP part as an effective usable tool (Until date, tools produced by this process are used for demonstration purpose only).

VII. COMPONENT MANUFACTURE

Current available RP Techniques do lack in its capabilities of manufacturing components in the desired materials economically. For most of the applications, it is currently economical to produce tooling using RP and then manufacture parts by casting or molding. 3-D printing and SLS-selective laser sintering process has the prospect of producing porous parts, which had to be down streamed with metal infiltration or hot isostatic pressing to obtain the much needed structural integrity.

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However, 3-D printing allows customer designed material composition on different parts of the component to meet varied applications using computer controlled methods. E.g.: Tough core materials and hard ware resistant surface materials. With recent development of tough, strong, accurate photosensitive resins, the further applications and future developments are far from exhausted.

VIII. Reverse Engineering

Reverse engineering is one of the important and effective applications of RP Techniques. The shape and dimensions of a component or a part whose drawings have been lost or if any small modifications are needed can be brought digitally by just using the touch or probes or snaps using scanners (Laser Scanning Technique). The feed collected from the scan or the probe can be easily converted to a CAD solid model. This model can be used for altering any changes in the shape and dimension and can then be 3-D printed again.

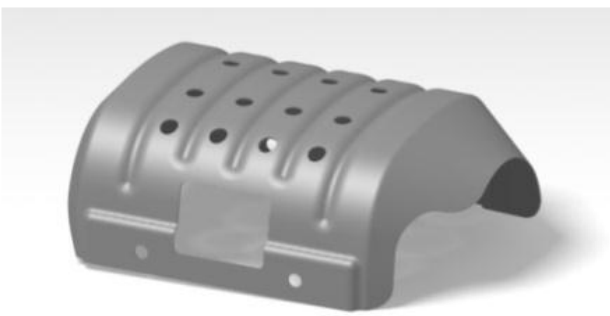

Fig. V Reverse Engineering of Exhaust Heat Shield.

IX. Concurrent Engineering

The new RP Techniques are considered to be a very valuable tool for concurrent engineering. The 3-D models developed are demanded by many companies to accompany the drawings or the CAD files of any new component or part that's been developed.

Fig. VI Concurrent Engineering for Flange.

The 3-D model can be used for any inspections to be carried out in the initial phase. Inspections and engineering correction requests for complex parts were said to be decreased to a scale of 5:2 after 3-D models were accompanied with the drawings or CAD files.

X. Latest Development

New giant 3-D printers are now capable of building a 2500 square-foot house in just 24 hours. This giant 3-D printer, developed by professor Behrokh Khoshnevis from the University of California, acts as a giant robot, replaces construction workers with giant nozzles on a gantry, squirts out concrete and builds a house layer by layer based on computer patters fed to it. This technique is called CONTOUR CRAFTING. The potential application of this technology is believed to be far reaching including in emergency, low-income and commercial housing. This also reduces potential usage of energy and emissions to fabricate large components.

The professor also says his applications of contour crafting are also towards building habitats in other planets such as moon and mars which are being targeted for human colonization. These contour crafting techniques provide a superior surface finish when compared to the conventional heuristic methods.

XI. Conclusions

With time the companies shall start preferring to 3-D prints without drawings and the customers to will come to that sophistication.

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As of now, 3-D prints however are used to operate internally in many companies. With advanced discovery in materials and processes, the list of applications will continue to grow.

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AUTHOR'S PROFILE

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As a corporate executive in the United States and India for over three decades, Dr. Rajadurai managed strategy on power train development and emission control for low, ultra low, super ultra low and partial zero-emission systems. From 1990-1996, he was the Director of Research at Cummins Engine Company. He was the Director of Advanced Development at Tenneco Automotive between 1996 and 2002 and subsequently Emission Strategist and Director of Emissions at ArvinMeritor until 2004. From 2004-2009, he was Vice-President of ACS Industries and since 2009 as Head of R&D Sharda Motor Industries Ltd.

Dr. Rajadurai has held leadership positions on the Board of Directors for the U.S. Fuel Cell Council, Manufacturers of Emission Control Association (MECA), Chairman of MECA Committee on Advanced Technologies and Alternate Fuels and Walker Exhaust India. He is an active participant in Clean and Green Earth Day demonstrations since 1997 and US Clean Diesel School Bus Summit (2003). He was a panelist of the Scientists and Technologists of Indian Origin, New Delhi 2004. He is a Fellow of the Society of Automotive Engineers. He was the UNESCO representative of India on low-cost analytical studies (1983-85). He is a Life Member of the North American Catalysis Society, North American Photo Chemical Society, Catalysis Society of India, Instrumental Society of India, Bangladesh Chemical Society and Indian Chemical Society.

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