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Application of Mold Flow Analysis in Metal to Plastics Replacement in Automotive Industry by using Thermostat Cover

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ABSTRACT

Plastic engineering is synonymous in practically all modern day industries due to flexibility of plastic materials today. Right from resettles in the medical field to the soles in footwear industry, there is a plastic available to suit every possible condition. All of these have been possible only due to the relentless research and change in the polymer science / plastic engineering field.

In this work the main objective is to design automotive component which include replacing existing thermostat cover in metal with plastic, which can withstand the same existing conditions, by using mold flow analysis. At present, plastic industry face problems in designing for metal to plastic replacement they need to do trial and error methods which is costly and doesn't know that results meet with actual requirement or not. Metal to plastic replacement results provide reduction in the weight, cost of an automobile and increase in the efficiency of the vehicle.

*Keywords***— Injection molding, Metal to plastic replacement, Mold flow analysis, Thermoplastics**

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I. INTRODUCTION

The automotive industry today is a very economical industry. Every manufacturer in automotive industry wants to lower the weight of vehicle to improve performance. In short, plastics come across every Challenges of an industry whose demands are greater than ever. While car owner want high performance cars with greater luxury, safety, fuel efficiency, style and lower prices, people demands lower pollution levels and increased recovery at end of life. Repeated innovation is a key feature in the use of plastics in automobile. Plastics will continue in the next years to help designers and engineers to transformand take car performance better. The automotive industry is on the brink of a revolution, and the plastics industry controlled to play a major role.

II. METAL TO PLASTIC REPLACEMENT

Presently we can realize metal to plastic replacements in industries like automotive, aviation, medical, lighting / electrical, electronics, furniture and so on. Automotive industry has now moved majorly from metals to plastics for many of their components, now made in iron or aluminium alloys, which savings, energy savings and improving their carbon footprint. Metal to Plastic Conversion is now seen in automotive parts, power-train, brake parts, fuel pump parts. Provide them with weight reduction chances, thereby leading to cost. [2]

A. Outputs of metal to plastic replacement

- Reduction in weight because plastic materials including composites are lighter than metals like steel and aluminium.
- Reduction in costs of total system.
- Reduced post finishing operations.
- Opportunity for parts consolidation.
- Capacity to resist temperatures more than 500oF and most chemicals and corrosive environments.
- Complex shapes can be produced.
- Wide range of properties tailored to meet specific applications.
- Plastic product manufacturing methods are an energy efficient than metal product manufacturing methods because less number of operation.[2]

B. *Outputs in Automobile Industry*

Reduction in weight, Alternative fuels used in automobile industry are corrosive and plastic resist corrosive, and cut costs through parts consolidation and replacement of stamped metal body components. These profits are being extended from automobiles to heavy trucks, tractors, diesel engines, as well as to minor engines that power a wide range of equipment such as lawn mowers and electrical generators.[2]

III. LITERATURE REVIEW

A systems approach to metal to plastic replacement brings to forth a concrete road map for any industry or any product without receiving lost, in the quest for achieving improved. As mentioned before, the boundary for this system can be set depending on the application of the product, its functionality, strength and mouldability. The three factors that effort metal replacement today are: (I) Weight reduction (II) Performance Enhancement (III) Cost out. [2]

In general, metal replacement is made when plastics deal equal or better performance at a saving of at least 20 precent in finished part cost. To find the saving, the company needs to define improvements in part performance and costs. Doing so means calculating the materials, the assembly and manufacturing perform, and the application. In comparing an existing metal part with one of plastic, accounts for all real costs, plus finishing and operating costs buried in overhead;

In past years, the field of flow analysis has enlarged growing importance in injection molding. Mold flow analysis provides balanced solutions to many of the intricate effects that cause complications in the injection molding process. These effects have involved warping, molded-in stress, excessive fill pressures, part flashing, and others. The interrelationships between part design and molding process parameters were analyzed in order to determine the optimum criteria. [4]

IV. GENERAL FEASIBILITY STUDY

General feasibility consideration during replacement of metal component by plastic:

- Number of parts per year.
- Existing material(metal).
- No. of machining steps involved to make the part.
- Current component cost(price).
- Temperature environment(low temp & high temp) peak temperature.
- Cyclic loading (thermal & flexural) on component
- Chemical environment.
- Any metal inserts (sleevetorque requirement, pull out forces).
- Is the part subjected to vibration (fatigue) what are the requirements?
- Space constraints to modify design. Does it need to be a 100% plastic copy of metal part?
- Tolerance requirement of the metal part possible areas of tolerance relief.
- If the tolerance is tight, what is the sealing requirement?
- What are the validation testing the plastic part must pass to be considered acceptable?
- Workable parts/model/assembly(2D & 3D – preferably parametric).

V. DESIGN STUDY

A. *Existing Design Study*

The preliminary step in the Metal to Plastic replacement Project is to do a detailed study of the existing design and identify issues that may be detrimental to plastic conversion. Existing design study forms the basis for further design modification of the metal product.Wall thickness plot of the main cover,

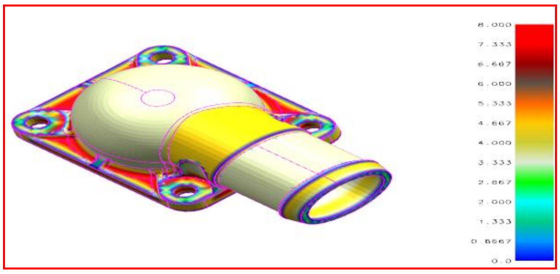

Fig. 1 Wall thickness plot (Top side)

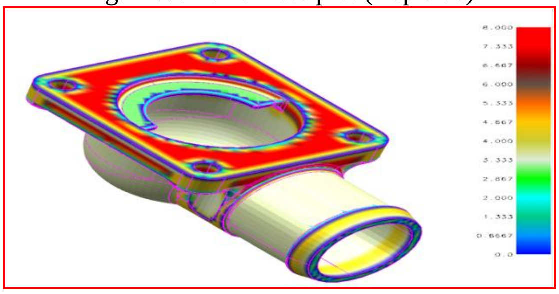

Fig. 2 Wall thickness plot (Bottom side)

The existing metal cover has maximum wall thickness at critical functional area shown by red color. As shown in the above figure, the maximum thickness observed is in the range of 5mm to 8mm which is not acceptable in plastic product design.The wall thickness may be still higher in localized area like those near bosses or an inserts, which is acceptable.

B. *Design Modification*

After detailed study of the existing design, the existing issues were worked upon. In consultation with the plastic raw material supplier, the preliminary design modifications were done on the basis of following points:

- General wall thickness of the part to be considered between 2.5-3 mm.
- Coring to be provided in the thick sections.
- Additional ribs to be provided for strength.
- Threaded metal inserts to be used at existing self-tapped threaded holes.

Coring is provided in draw direction to reduce wall thickness at thick sections. This method creates a pocket, opening, or blind hole in a part, often to reduce weight, eliminate heavy wall sections, or provide mounting points.

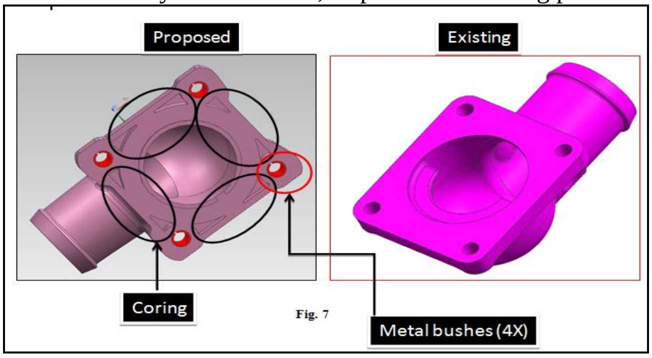

Fig. 3Modified design of thermostat cover

C. *Modified Design Study*

After completing design modification wall thickness plot of main covershows following result:

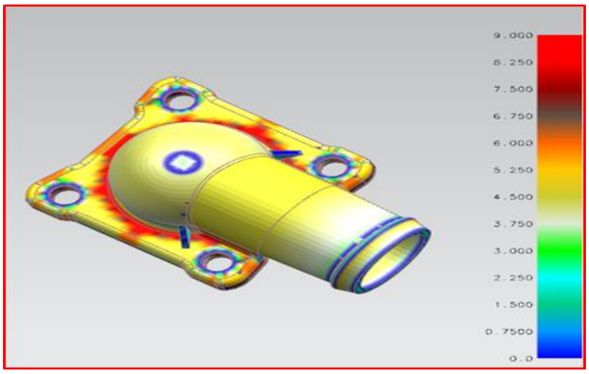

Fig. 4 Modified Wall thickness plot (Top side)

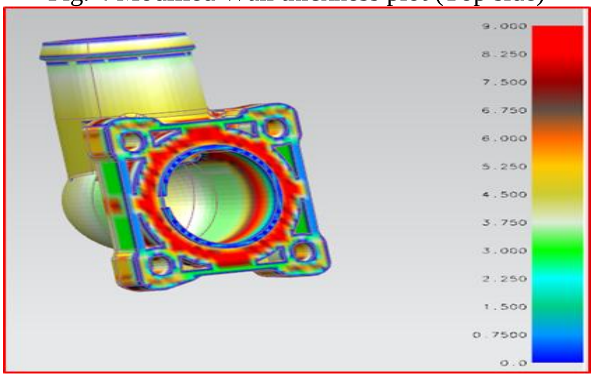

Fig. 5 Modified Wall thickness plot (Bottom side)

VI. MOLD FLOW ANALYSIS

Benefits of mold flow design principles:

- It is a set of rules that impact the design of a part & tools to optimize the filling of a part.
- Positioning Meld and Weld Lines.
- Uniform cooling.
- To identified part shrinkage area.
- Higher quality parts.
- Faster cycle time.
- Part deflection.

A. *Fill Time Plot*

Fill time is the time taken to fill up the part inside the cavity. All flow paths finish at the same time and reach the edges of the model simultaneously. Previous diagram shows each flow path should end with red contours. [5]

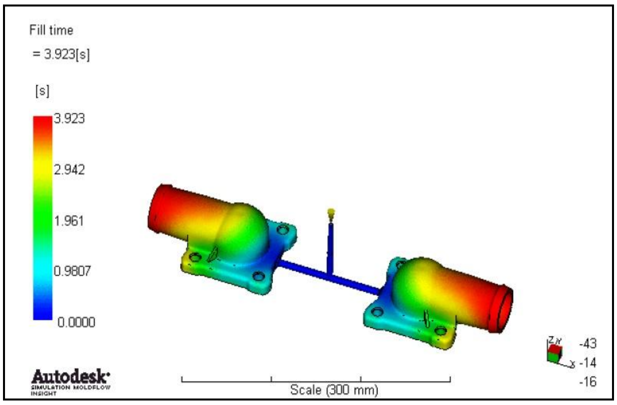

Fig. 6 Fill time plot

B. *Temperature at Flow Front Plot*

Using this result minimize the flow front temperature variation in the filling phase to under 2-5°C. Smaller temperature variations cause fewer problems. If the Confidence of fill result is reduced, use the Temperature at flow front result to see whether the problems are caused by low melt temperatures. [7]

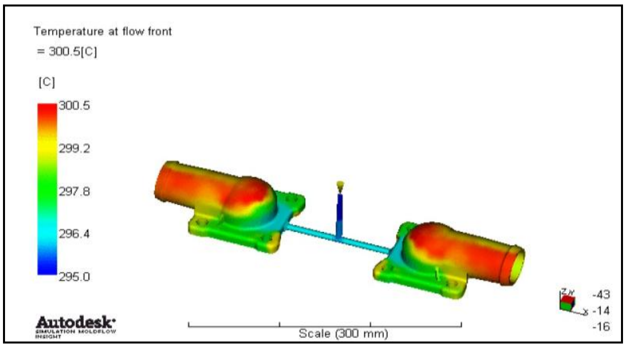

Fig. 7 Temperature at front flow

C. *Pressure Plot*

The injection location pressure result shows the pressure at various times during the filling and packing phases of the analysis.

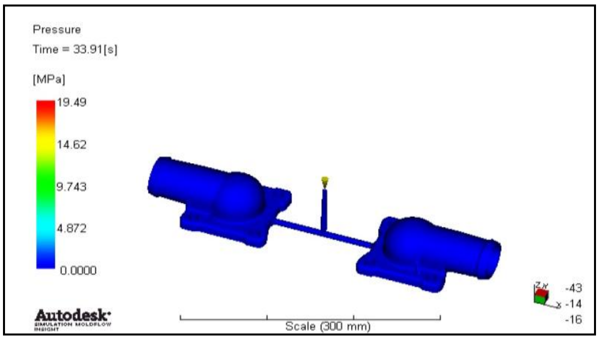

Fig. 8 Pressure plot.

All of the injection locations on the model will have the equal pressure. This is an assumption used in the analysis. The Pressure at injection location result is very useful for checking whether there is any pressure spike, which is normally a sign of imbalance. [6]

D. Average Volumetric Shrinkage Plot

The Volumetric shrinkage result shows the volumetric shrinkage for each node, as aproportion of the original volume. Volumetric shrinkage is the percentage increase in local density from the end of the packing phase to when the part has cooled to the ambient reference temperature (the default value is 25°C/77°F).

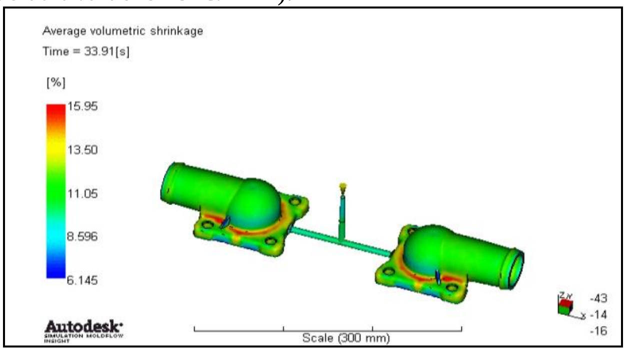

Fig. 9 Average volumetric shrinkage plot.

This result can be used to detect sink marks on model. High shrinkage values could indicate sink marks or voids inside the part. Volumetric shrinkage should be uniform across the whole part to reduce warpage. Volumetric shrinkage can be controlled by the use of packing profiles. [6]

E. Weld Line Plot

The Weld lines result displays the angle of merging as two flow fronts come across. The presence of weld lines may indicate a structural weakness and/or a surface blemish. The term "weld line" is often used to mean both weld and meld lines. The only difference among them is the angle at which they are formed; weld lines form at lower angles than meld lines.

Weld lines can cause structural problems and make the part visually objectionable, but they are unavoidable when the flow front splits and comes together around a hole, or if the part has multiple gates.Weld and meld lines should be avoided, particularly in areas that require strength or a smooth appearance. [6]

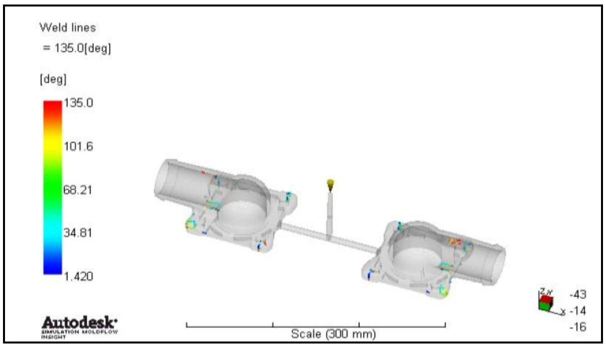

Fig. 10 Weld line plot.

VII. CONCLUSIONS

This work has successfully accomplished the following:

- Plastic product design of automotive component which replaced existing thermostat Cover metal part (Aluminum Die Cast) with a plastic part (Nylon6,6 50% GF).
- Weight reduction of approximately 410 gm.
- Cost reduction, Energy savings and Reduced Carbon Footprint.
- Reduction of wastages in terms of time and money.

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