INTRODUCTION:
The injection molding has seen steady growth since its beginnings in the late 1800’s. The technique has evolved from the production of the simple things like combs and buttons to major consumer, industrial, medical, and aerospace products. The main concept of plastic molding is placing a polymer in a molten state into the mold cavity so that the polymer can take the required shape with the help of varying temperature and pressure. There are different ways of molding a plastic, some of them are blow molding, injection molding, rotational molding, and compression molding. Each technique has its own advantages in the manufacturing of specific items. Injection molding is perhaps the most common and important of all plastic processing processes. The process is extremely versatile, and can produce very complex shaped parts, with the use of multi-sided molds. Even parts with metal inserts can be produced. While injection molding dies are expensive to produce, each die can be used to make tens of thousands of components at very rapid rates, so that per-part cost is very low.

The cycle of operations during the production of a molded part is as shown in fig 1. The moving platen puts the mold together; the mold halves are held with large force, and the molten charge is forced into the cavity; the plastic solidifies, and finally, the moving platen is retracted, and ejector pins in the mold push the part out.

Fig No 1: Cycle of operation for injection molding [9]

Cycle of operation for injection molding consist of four steps: 1) Filling stage 2) Pack and hold stage 3) Cooling stage 4) Part ejection stage

RELEVANCE:
Design for the ‘plastic’ component part is followed by the Design for its mold. The intricateness for the geometry over is features offers a challenge to the mold Design Engineer. The characteristics of the material and the associated process of manufacturing further underlines the need to undertake the assessment of ‘Design’ for the mold in a critical manner and outlook. This dissertation work shall focus on the Design aspects of the mold. Title evaluating the ‘peculiarities’ of the pated as evident through ‘flow’ simulation using SAE software. Practices followed in corporate in the “Design phase” of these work.

8. LITERATURE REVIEW:
Lu et al [11] investigated an adaptive decoupling temperature control for an extrusion barrel in a plastic injection molding process. The decoupling control design was derived based on the minimization of a generalized predictive performance criterion. The set-point tracking, disturbance rejection, and robustness capabilities of the proposed method can be improved by appropriate adjustments to the tuning parameters in the criterion function. Through the experimental results, the proposed method has been shown to be powerful under set-point changes, load disturbances, and significant plant uncertainties.

Erzurumlu et al [12] investigated the minimization of the warpage and sink index in terms of process parameters of the plastic parts with different rib cross-section types, and rib layout angle using Taguchi optimization method. Considering the process parameters such as mold temperature, melt temperature, packing pressure, in addition to rib cross-section types, and rib layout angle, a series of mold analyses are performed to exploit the warpage and sink index data. Confirmation analysis test with the optimal levels of process parameters are carried out in order to demonstrate the goodness of Taguchi method. From this, it can be concluded that Taguchi method is very suitable to solve the quality problem occurring the injection-molded thermoplastic parts.

Jiang et al [13] investigated an implicit control volume finite element method for simulation of injection molding, the time steps were controlled for both flow and thermal simulation by local flow information, and then the computing complexity analysis was conducted. The implicit scheme was based on updating the melt-air interface.

Hassan et al [14] investigated gate location is among the most critical factors in achieving dimensionally accurate parts and high productivity of the molding process. To investigate the effect of the gate location on the cooling of polymer by injection molding, have
carried out a full three dimensional time-dependent analysis for a mold with cuboids-shape cavity having two different thicknesses. The cooling of the polymer material is carried out by cooling water flowing inside six horizontal circular channels. 

Chen et al[6] optimal process parameter is important parameter influences productivity, quality, and cost of production in the plastic injection molding (PIM) industry. Previously, production engineers used either trial-and-error method or Taguchi’s parameter design method to determine optimal process parameter settings for PIM. However, these methods are unsuitable in present PIM because the increasing complexity of product design and the requirement of multi-response quality characteristics. Have proposed an approach in a soft computing paradigm for the process parameter optimization of multiple-input multiple-output (MIMO) plastic injection molding process

Baltussen et al[6] studied the viscoelastic flow front instability in the full non-linear regime by numerical simulation. A two-component viscoelastic numerical model is developed which can predict fountain flow behavior in a two-dimensional cavity. The extended Pom-Pom (XPP) viscoelastic model is used. The level set method is used for modeling the two-component flow of polymer and gas. The difficulties arising from the three phase contact point modeling are addressed, and solved by treating the wall as an interface and the gas as a compressible fluid with a low viscosity. The resulting set of equations is solved in a decoupled way using a finite element formulation.

Rajalingam et al[7] investigated the process parameters which will affect the shrinkage defect on a plastic cell phone shell component. The process parameters selected in this study are the mould temperature, injection pressure and screw rotation speed. The Design of Experimental (DOE) approach was used to investigate and identify the optimal moulding process parameters setting. Statistical results and analysis are used to provide better interpretation of the experiment.

Ahamed et al[8] have worked on Designing and Optimizing the Parameters which affect the Molding Process using Design of Experiment In injection molding the processing condition have critical effect on the finished molded products the effect of various factors like Melt temperature, Injection pressure, and Cooling time are selected for the experiment. A Plastic product polycarbonate plastic material was taken for the experiment with optimal injection molding conditions and its tensile stress test was conducted in order to minimize defects and increase its strength.

CONCLUDING REMARKS:
Following outcomes can be drawn from the above literature review of plastic injection mold

- In making the mold it was necessary to have the best possible product design so that it does not complicate the mold designing process.
- The quality of the injection molded part is a function of plastic material, part geometry, mold structure and process conditions.
- Gate location is among the most critical factors in achieving dimensionally accurate parts and high productivity of the molding process. Gate location should be such that it required minimum time to completely solidify the product and minimum solidification of the product during the filling stage.
- When designing a mold, the designer needs to take many factors into account in addition to the actual shape of the mold, warpage, shrinking, venting, runner size, porosity, air traps and blow holes are factors that must be considered while in the design stage.

PROBLEM STATEMENT:
The sponsoring company being an ESP (Engineering Service Provider) support assignments in the domain of Design & ‘Finite Element Analysis’. Further with the competency in Die / Mold Design it is now working on Automotive projects for design of Plastic injection mold. One such assignment offered by the client specters the use of thermoplastic as the raw material that would need at least two cavity molds for meeting the demand. The component design received from the previous stage need to be studied further for evolving the ‘mold’ design. The potential problem areas in the form of defects in the molded component should be minimized through on the part of the mold Design Engineer.

9. PROPOSED WORK:

a) Objectives:
- Use the geometry for product as input to mold design
- Define parting line along with a core and cavity
- Calculate the tonnage for the given mold
- Determine mold layout by specifying the gate location, sprue diameter, gate thickness, gate location or other design parameters for flow analysis
- Using Mold Flow to simulate the flow and finding fill time, weld line, warpages, sink mark etc.
- Using the above evaluation for determining mold design
- Validation through trials and testing

b) Scope of work
Flow simulation for Plastic Injection Molded part geometry
Design of Plastic Injection Mold
Trials and Testing (Experimentation)
Validation through comparison with the Analytical methodology

c) Methodologies:
Analytical: The analytical formulation for a problem involves reference to the empirical and pure Engineering practices for arriving at a solution. Typically, empirical formulae that are historically developed for the application can offer a solution for the given problem. For e.g. - The tonnage (clamping force for both halves) for Plastic Injection Molding needed to produce the component is derived from the projected surface area of the component.

3D model and mold design created using CAD software such as CATIA. Meshing is carried out using Hypermesh as pre-processor software. Analysis/Simulation can be performed using suitable software in the CAE domain. The popular software used in the industry can be identified as Moldex/Mold Flow/Any customized software used by Industry etc. For the dissertation work, the sponsoring Company would employ one of the above software for finding the solution. From the simulation
and analysis, the software for flow simulation provides sufficient information regarding one or more of the below:

- filling time,
- injection pressure
- Cooling time
- Defects like air traps, weld lines etc.

With these results, users can avoid the defect of the plastic in actual injection such as sink mark, hesitation, air traps, and over-packing. The analysis will also help the mold designer to design a perfect mold with minimum modifications and which will also reduce the time and cost. Thus analysis/simulation provides an insight into the nature of processing and consequently offers valuable inputs towards the design of the mold. Flow chart for general process related for simulation is shown in fig.2 General Process Related for Simulation:

![Flow chart showing General Process Related for Simulation](image)

**Fig No 2: Flow chart showing General Process Related for Simulation**

d) Experimentation:

Experimentation carried out using physical tests to find out the defects such as porosity, air traps and blow holes.

Typical points to be assessed for experimentation:

- Pics captured during trials and testing
- Workmanship and fitment for mold to be satisfactory
- Good quality component achieved upon setting suitable processing parameters like Melt temp & Injection pressure.
- Flash found to be minimal

- No prominent sink marks to be found
- No unacceptable warpage to be found
- Visual checking coupled with measuring instruments (for dimensions) to be deployed for the acceptance of overall quality
- Fitment with mating part check for any issues. No problems to be found in fitment.

Typical plastic injection molding machine is shown in fig.3 and specifications related to molding machine parameters is shown in Table No.1

![Typical plastic injection molding machine](image)

**Fig No 3: Typical plastic injection molding machine[10]**
Table No 1: specifications related to molding machine parameters.

<table>
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<tr>
<th>Component</th>
<th>Making Freq</th>
<th>Making Force</th>
<th>Mold Gravity Stroke</th>
<th>Mold Height (Min/Max)</th>
<th>Melt-During Inter Plate Space</th>
<th>Shot Oil Pressure</th>
<th>Distance between Nozzles</th>
<th>Insert Molding Capacity</th>
<th>Melt Weight in Moving Plate</th>
<th>Hydraulic System Capacity</th>
<th>Injection Force Reduction Force</th>
<th>Oil Tank Capacity</th>
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REFERENCES:

8. Dr. A. RiazAhamed, Dr.A.K. ShaikhDawood, R.Karthikeyan “Designing and optimizing the parameters which affect the molding process using Design of Experiment” International Journal of Research in Mechanical Engineering Volume 1, Issue 2, October-December, 2013 pp.116-122