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Design and Manufacturing of a Two-Cavity Injection Mould with Flow Analysis for Seat Recliner Lever Production

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Abstract
Injection molding is one of the most widely used manufacturing processes for producing high-volume plastic automotive components with consistent quality and dimensional accuracy. The seat recliner lever is a critical automotive interior component that requires adequate strength, surface finish, and production efficiency. This paper presents the design, development, and manufacturing of a two-cavity injection mould for seat recliner lever production. Mold flow analysis was performed to optimize gate location, filling pattern, pressure distribution, cooling efficiency, and potential defect prediction. The mould design was developed considering cycle time reduction, balanced filling, ease of maintenance, and manufacturing feasibility. The simulation results indicate uniform cavity filling, acceptable pressure requirements, and minimized war page, leading to improved productivity and reduced manufacturing costs.
Keywords: Injection moulding, Seat recliner lever, Two-cavity mould, Mold flow analysis, Plastic product design, Automotive component.

1. Introduction
The automotive industry increasingly utilizes plastic components due to their lightweight characteristics, corrosion resistance, design flexibility, and cost effectiveness. Seat recliner levers are commonly used in vehicle seating systems for adjustment and locking mechanisms. These components require high dimensional accuracy and reliable mechanical performance.
Injection moulding remains the preferred manufacturing method for producing such components in large quantities. However, improper mould design may lead to defects such as short shots, sink marks, weld lines, warpage, and excessive cycle times.
Therefore, a systematic approach involving mould design and flow simulation is essential.
This study focuses on the design and manufacture of a two-cavity injection mould for seat recliner lever production and evaluates its performance through flow analysis.

2. Literature Review
Several researchers have investigated optimization techniques for injection mould design and flow analysis.
- Mold flow simulation is widely used to predict filling behavior and minimize manufacturing defects.
- Multi-cavity moulds improve productivity and reduce part manufacturing cost.
- Balanced runner systems help achieve uniform filling and pressure distribution.
- Cooling channel optimization significantly reduces cycle time and improves part quality.

Previous studies indicate that integrating Computer-Aided Engineering (CAE) tools with mould design improves first-time-right manufacturing.

3. Product Description
The seat recliner lever is an automotive interior component used for seat adjustment mechanisms.
Material Selection
Material: Glass Filled Polypropylene (PP-GF20) or equivalent automotive-grade thermoplastic.

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Properties:

- High impact strength
- Good dimensional stability
- Excellent fatigue resistance
- Lightweight construction
- Cost-effective processing

Product Requirements

- Dimensional accuracy
- High production rate
- Good surface finish
- Minimal warpage
- Structural durability

4. Mould Design Methodology

4.1 Mould Configuration

A two-cavity mould was selected to increase production efficiency while maintaining balanced flow characteristics.

Design Specifications

Parameter	**Value**
Number of Cavities	2
Mould Type	Two-Plate Mould
Material	P20 Tool Steel
Gate Type	Edge Gate
Ejection System	Ejector Pins
Cooling System	Water Cooling Channels

4.2 Runner System Design

A balanced runner layout was designed to ensure simultaneous filling of both cavities. Advantages:

- Uniform filling
- Reduced pressure variation
- Improved part consistency
- Lower rejection rate

4.3 Cooling System Design

Cooling channels were positioned close to the cavity surfaces to maximize heat transfer.

Benefits:

- Reduced cycle time
- Uniform cooling
- Reduced warpage
- Improved dimensional stability

5. Flow Analysis

Flow analysis was conducted using Moldflow software to validate the mould design before

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manufacturing.
Objectives
- Determine filling pattern
- Evaluate pressure distribution
- Predict weld lines
- Assess air traps
- Estimate cooling performance
- Predict warpage

5.1 Fill Time Analysis
Results showed balanced filling in both cavities with complete filling achieved within the specified injection time.
Observations:
- Uniform melt front progression
- No short shot condition
- Balanced cavity filling

5.2 Pressure Analysis
Maximum injection pressure remained within machine capability limits. Benefits:
- Reduced machine load
- Stable process conditions
- Improved product quality

5.3 Temperature Distribution
The temperature profile remained uniform throughout the filling stage. Results:
- Reduced thermal gradients
- Lower shrinkage variation
- Improved dimensional accuracy

5.4 Weld Line Analysis
Minor weld lines were observed in non-critical regions and were within acceptable quality standards.

5.5 Warpage Analysis
Simulation results indicated minimal warpage due to optimized cooling channel placement and balanced filling.

6. Manufacturing of the Mould
The mould components were manufactured using conventional and CNC machining processes.
Manufacturing Steps
1. Core and cavity machining
2. CNC milling operations
3. EDM machining for intricate profiles
4. Cooling channel drilling
5. Surface grinding
6. Heat treatment
7. Assembly and fitting
8. Trial moulding and validation

Mould Material
P20 pre-hardened steel was selected due to:
- Good machinability
- Adequate hardness
- Cost effectiveness
- Suitable life expectancy

7. Results and Discussion
The developed two-cavity mould successfully met production and quality objectives.

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Key Results

Parameter	Result
Filling Balance	Excellent
Cycle Time	Reduced
Pressure Requirement	Acceptable
Warpage	Minimal
Surface Finish	Good
Productivity	Increased

The balanced runner system and optimized cooling channels contributed significantly to overall mould performance.

8. Conclusion

This study presented the design and manufacture of a two-cavity injection mould for seat recliner lever production. Mold flow analysis was effectively utilized to optimize the mould design before manufacturing. The simulation results confirmed balanced cavity filling, acceptable pressure requirements, efficient cooling, and minimal warpage. The developed mould achieved improved productivity, reduced cycle time, and enhanced product quality. The methodology can be applied to similar automotive plastic components requiring high-volume production and consistent quality.

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