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Simulation Study of Sand Casting by Using Runner & Gates Modification in Gating System

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Abstract: Sand casting remains a prevalent method for manufacturing complex metal components due to its cost-effectiveness and versatility. However, optimizing the gating system, particularly through runner riser modification, is crucial for enhancing casting quality and minimizing defects. This study employs computer simulation techniques to investigate the effects of various modifications in the gating system on the solidification behavior and quality of castings. Through numerical simulations using advanced software tools, different configurations of the gating system are analyzed and compared, focusing on parameters such as flow rate, velocity distribution, and solidification patterns. The results reveal insights into the effectiveness of runner riser modification strategies in reducing defects like shrinkage and porosity, thereby improving the overall casting quality. Additionally, the study explores the trade-offs between different modification approaches in terms of cost, complexity, and performance. These findings contribute to the optimization of sand-casting processes, offering practical guidance for engineers and manufacturers aiming to enhance product quality and efficiency.
Keywords: Gate Modification, Gate Angle, Flow Velocity, Runner, Riser, Gate.

I. INTRODUCTION

1) Sand casting stands as one of the oldest and most widely used methods for the production of intricate metal components across various industries. its enduring popularity stems from its versatility, cost-effectiveness, and ability to accommodate complex geometries.
2) However, the quality of sand castings is intricately linked to the efficiency of the gating system, which governs the flow of molten metal into the mold cavity. inadequate gating system design often results in defects such as shrinkage, porosity, and misruns, which can compromise the integrity and functionality of the final product.
3) Optimizing the gating system, particularly through runner riser modification, has emerged as a critical strategy for improving casting quality and minimizing defects. runner and riser systems play pivotal roles in regulating metal flow, promoting uniform solidification, and mitigating defects during the casting process.
4) Strategically modifying the dimensions, shapes, and placements of runners and risers, engineers can tailor the flow dynamics and thermal characteristics of the molten metal, thereby optimizing casting quality and yield.
5) Despite the significant impact of runner riser modification on casting performance, the design process often relies on empirical trial-and-error methods, which can be time-consuming, costly, and prone to suboptimal outcomes. computer simulation offers a powerful alternative for comprehensively evaluating gating system designs, predicting solidification behavior, and optimizing process parameters in a virtual environment.
6) Through numerical simulations, engineers can efficiently explore a wide range of design variations, assess their performance under different operating conditions, and identify optimal solutions with enhanced precision and confidence.
7) In this study, we utilize advanced simulation techniques to investigate the effects of runner riser modification in the gating system on the quality and integrity of sand castings. by systematically analyzing various design configurations and their implications on flow dynamics, solidification patterns, and defect formation, we aim to provide valuable insights into the optimization of sand-casting processes.
8) The findings of this research are expected to inform practical strategies for enhancing casting quality, reducing production costs, and improving overall manufacturing efficiency in industries reliant on sand casting methodologies.

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II. METHODOLOGY

A. Water Modeling

Many researchers have studied fluid flow in gating systems and mould cavities with the aid of transparent models usually made of Perspex or other plastics, in which the flow of metal is simulated by that of water. This method has the substantial advantage that the pattern of flow is clearly visible in all parts of the gating system and the cavity, but its validity, depends entirely upon the correctness of the assumption that the flow of water is closely analogous to that of the molten metal in simulation model.

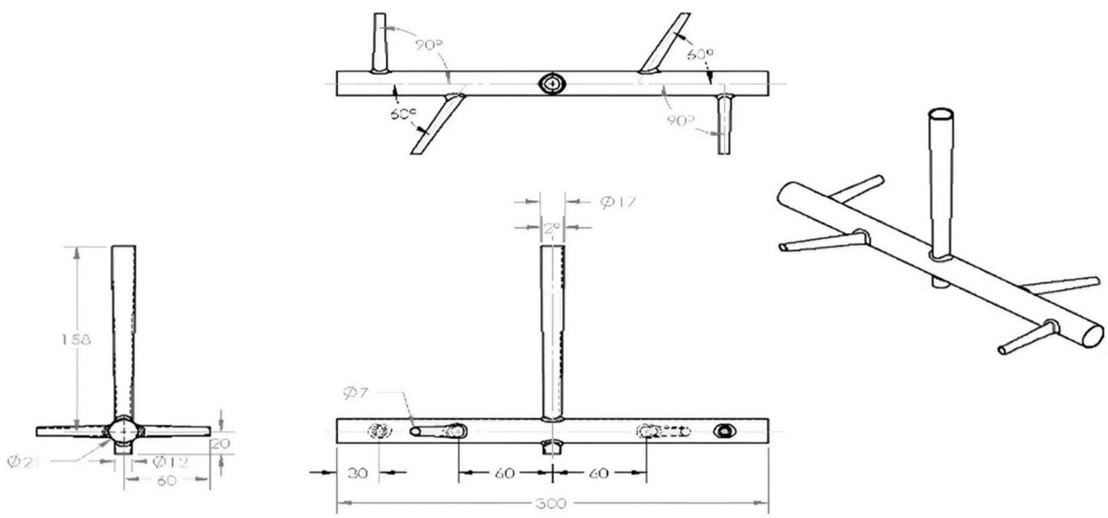

Figure 2.1: Schematic of the considered gating system

Table 1: Detailed specification of considered four gating system designs

Design	Runner	Runner's Dimensions	Sprue Position	Gate Position w.r.t Spue	Gate Angle
Design 1	Parallel	Ø 21 mm Through	centre	Two- two on both side	90 deg
Design 2	Parallel	Ø 21 mm Through	centre	Two- two on both side	60 deg
Design 3	Parallel	Ø 21 mm Through	centre	Two- two on both side	50 deg
Design 4	Parallel	Ø 21 mm Through	centre	Two- two on both side	45 deg

B. In the Experiment water as a used For Pouring Materials

In this experimental setup water is used as a substitute material to simulate the pouring phase of the casting process. that water is not representative of the properties of molten metal and this is a simplified simulation for experimental purposes. due to safety concerns and the impracticality of working with molten metal in certain experimental settings, water is employed to simulate the pouring phase. This approach allows for a safer and more accessible experimental environment, especially in educational or introductory settings. recognize that the water simulation is a simplified representation and may not fully capture the complexities of the actual casting process**.**

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C. Simulation Study

The whole filling process for each considered design were simulated using SolidWorks 2022 to determine the optimum one. It was based on a transient to the 3D situation. Used material for simulation was water and used properties for simulation was listed below. Before initializing the whole model, required conditions were being applied. Since, we only want to focus on the flow behaviour of the Velocity and Flowrate, therefore the energy and viscous model were used to simulate the flow. Simulation was run for 73 iterations with 1000 mesh size for each design concept under the same conditions. Whole filling process was considered to be as gravity casting. All the properties used were listed as bellow

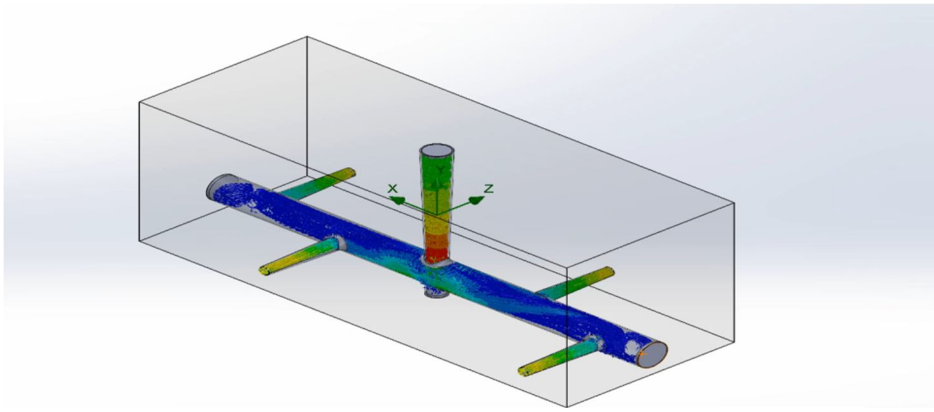

Figure 2.3.1: SolidWorks Simulation 90 deg gate water modelling of considered four Gating Systems.

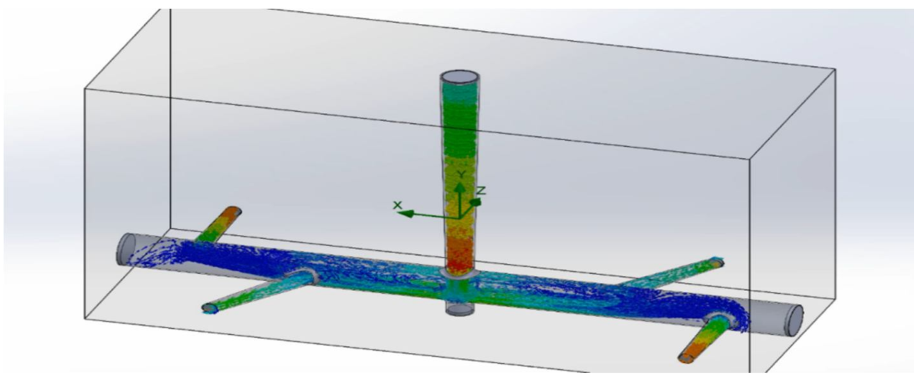

Figure 2.3.2: SolidWorks Simulation 60 deg gate water modelling of considered four Gating Systems.

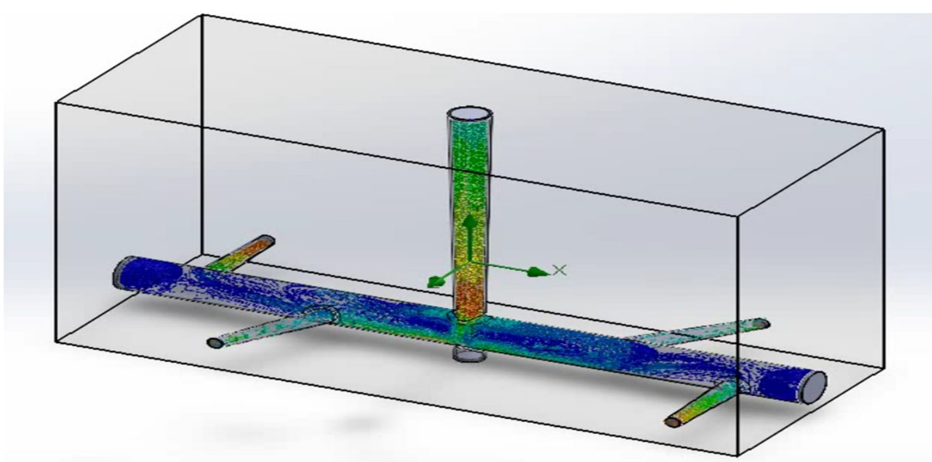

Figure 2.3.3: SolidWorks Simulation 50 deg gate water modelling of considered four Gating Systems.

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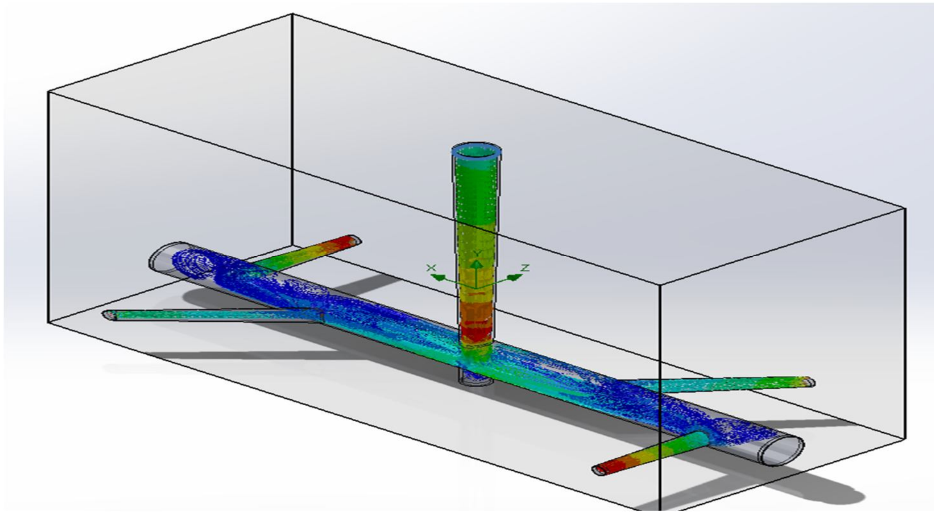

Figure 2.3.4: SolidWorks Simulation 45 deg gate water modelling of considered four Gating Systems.

III. RESULTS AND DISCUSSION

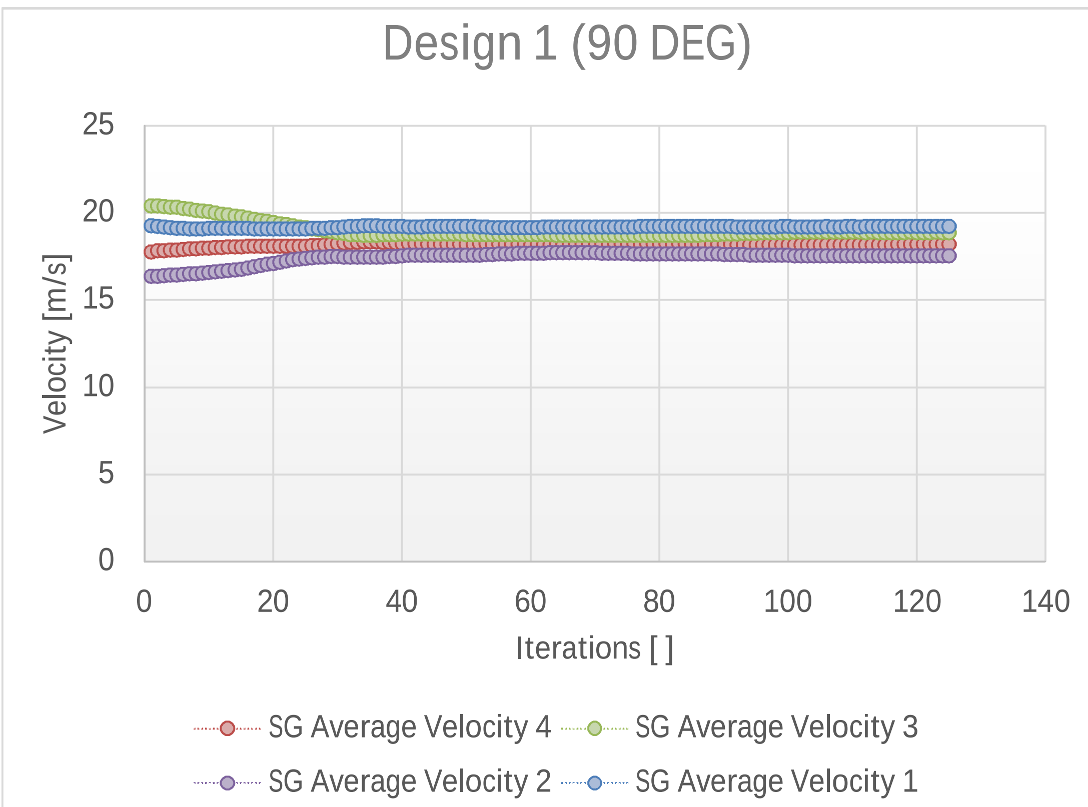

Figure 3.1: Flow velocity through different gates in water model.

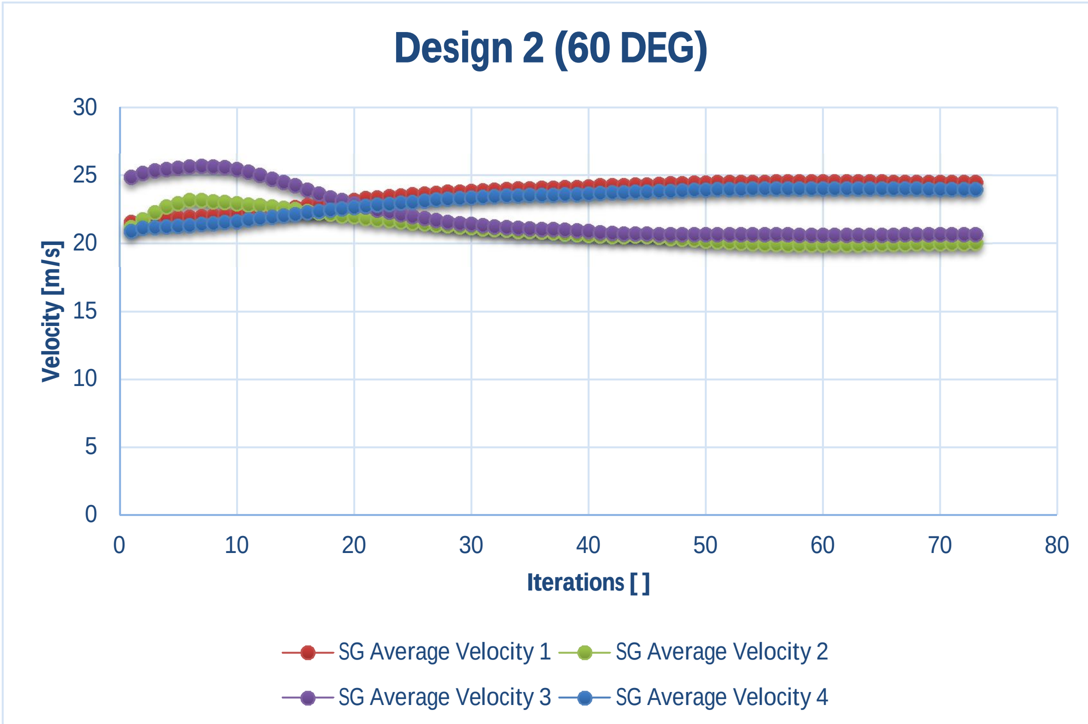

Figure 3.2: Flow velocity through different gates in water model.

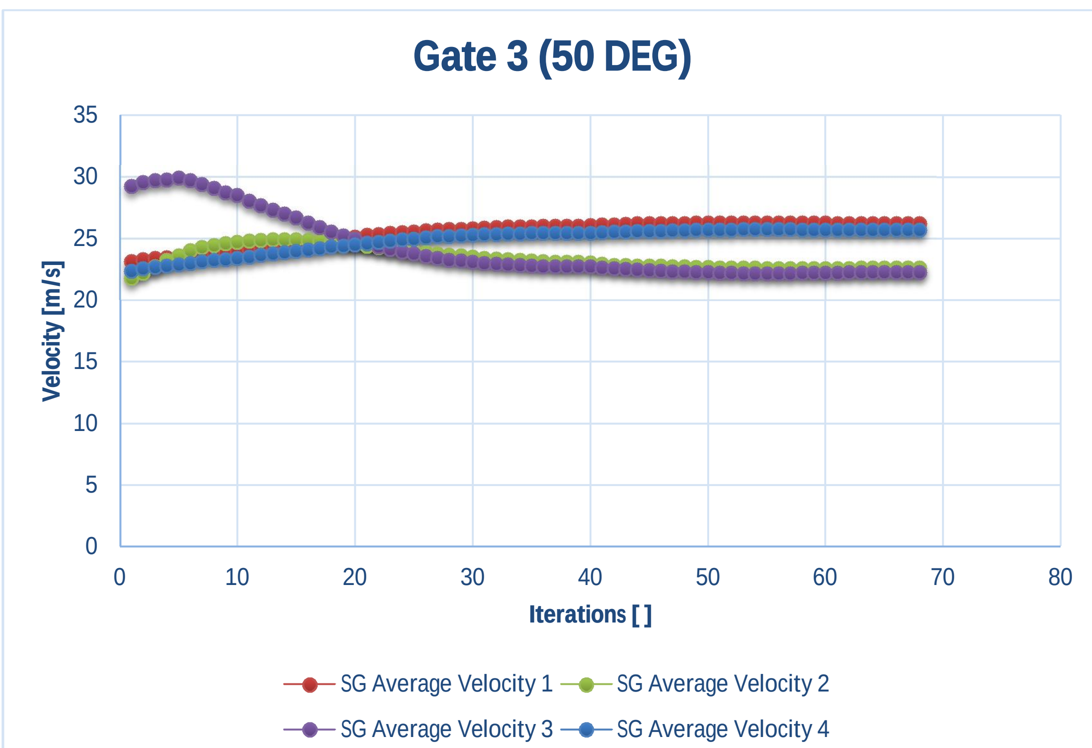

Figure 3.3: Flow velocity through different gates in water model.

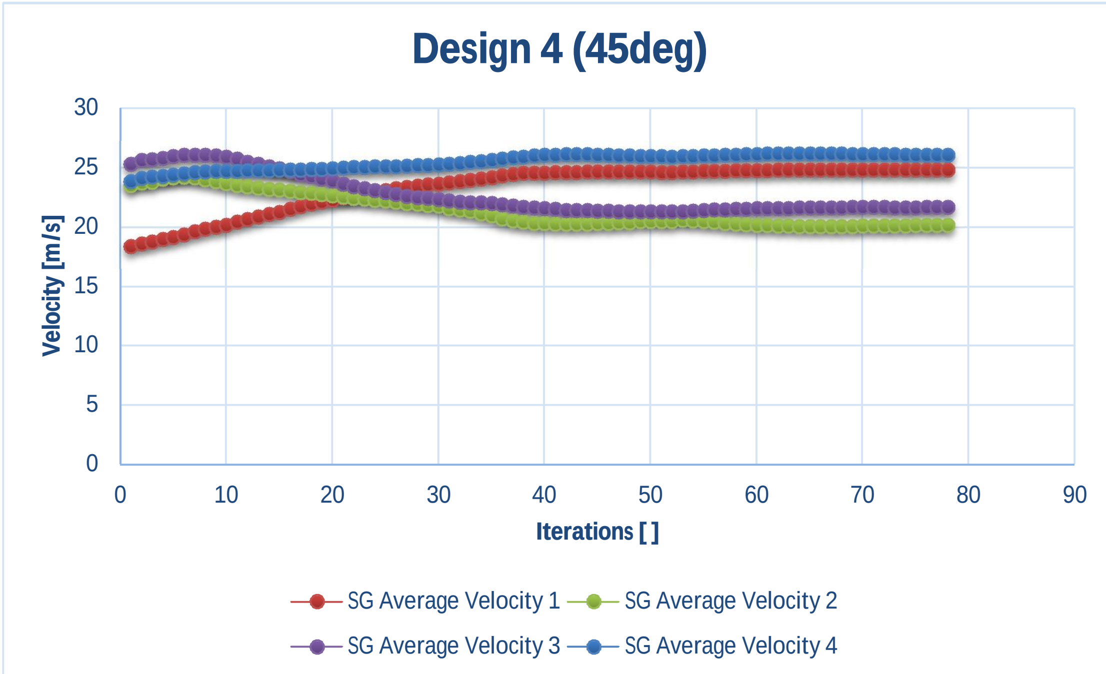

Figure 3.4: Flow velocity through different gates in water model.

A. *Comparison of All Designs*

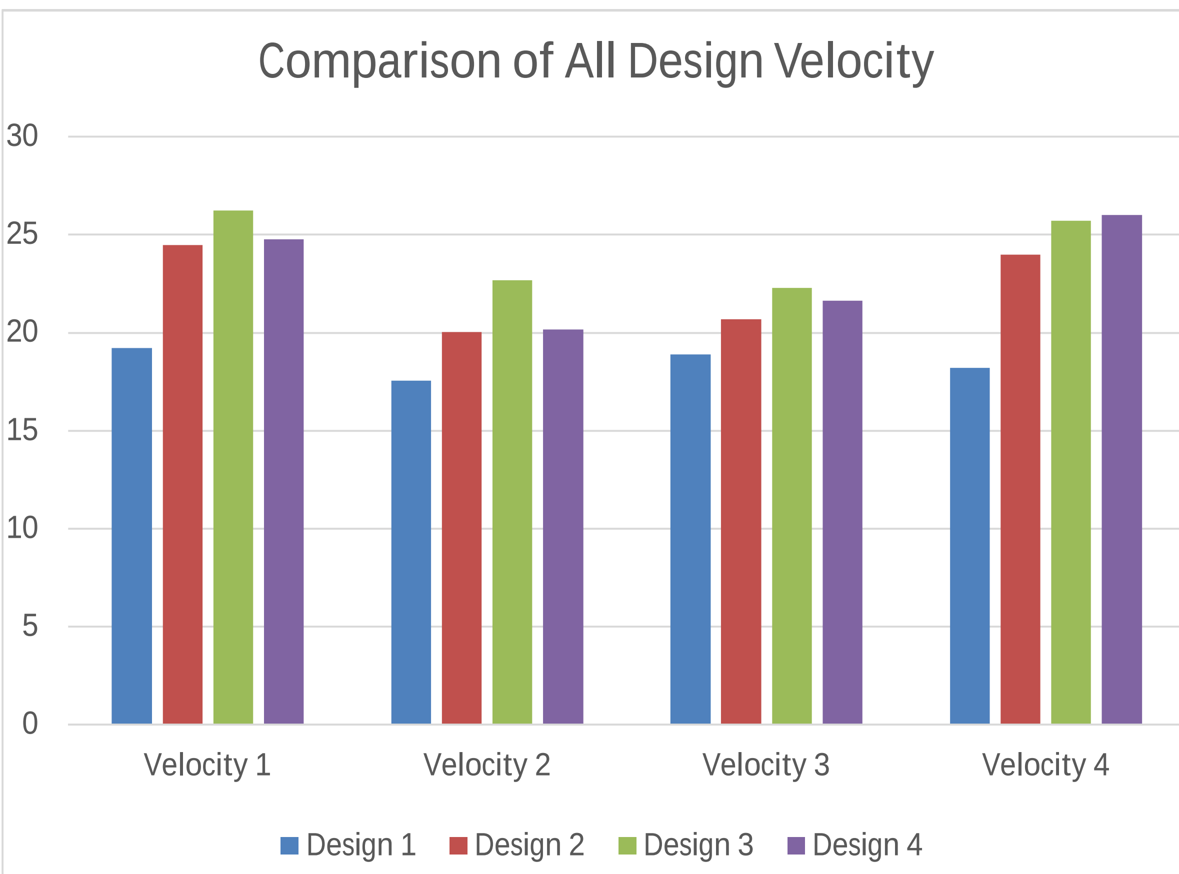

Figure 3.1.1: Flow velocity Comparation in water model.

Above all design velocity is shown in fig design 1 gate 1 velocity is 19m/s, and design 2 gate 1 velocity is 24m/s or design 3 gate 1 velocity is 26m/s, design 4 gate 1 velocity is 24.5m/s. design 1 gate 2 velocity is 17m/s, and design 2 gate 2 velocity is 20m/s or design 3 gate 2 velocity is 23m/s, design 4 gate 1 velocity is 21.2m/s.
When design 1 gate 3 velocity is 18m/s, and design 2 gate 3 velocity is 21m/s or design 3 gate 3 velocity is 23m/s, design 4 gate 3 velocity is 21m/s. when design 1 gate 4 velocity is 18.2m/s, and design 2 gate 4 velocity is 24m/s or design 3 gate 4 velocity is 26m/s, design 4 gate 4 velocity is 26.1m/s**.** So, get the all of the data and conclusion is design 3 is better than design 1, design 2, and design 4, design 3 in all gate value is higher than all gate value.

IV. CONCLUSION

1) The flow velocity from the four proposed designs of gating systems, design 2 and 3 are highly varying whereas design concept 1 and 4 gives somewhat uniform flow velocity hence on the basis of flow velocity criteria design 1 and 4 comes out to be worst while 2 and 3 gives more satisfactory results.
2) Hence design concept 3 fits best in both the deciding criteria i.e. flow velocity at ingate.
3) Simulation of this modified version of design concept 3 gives better results as shown below.

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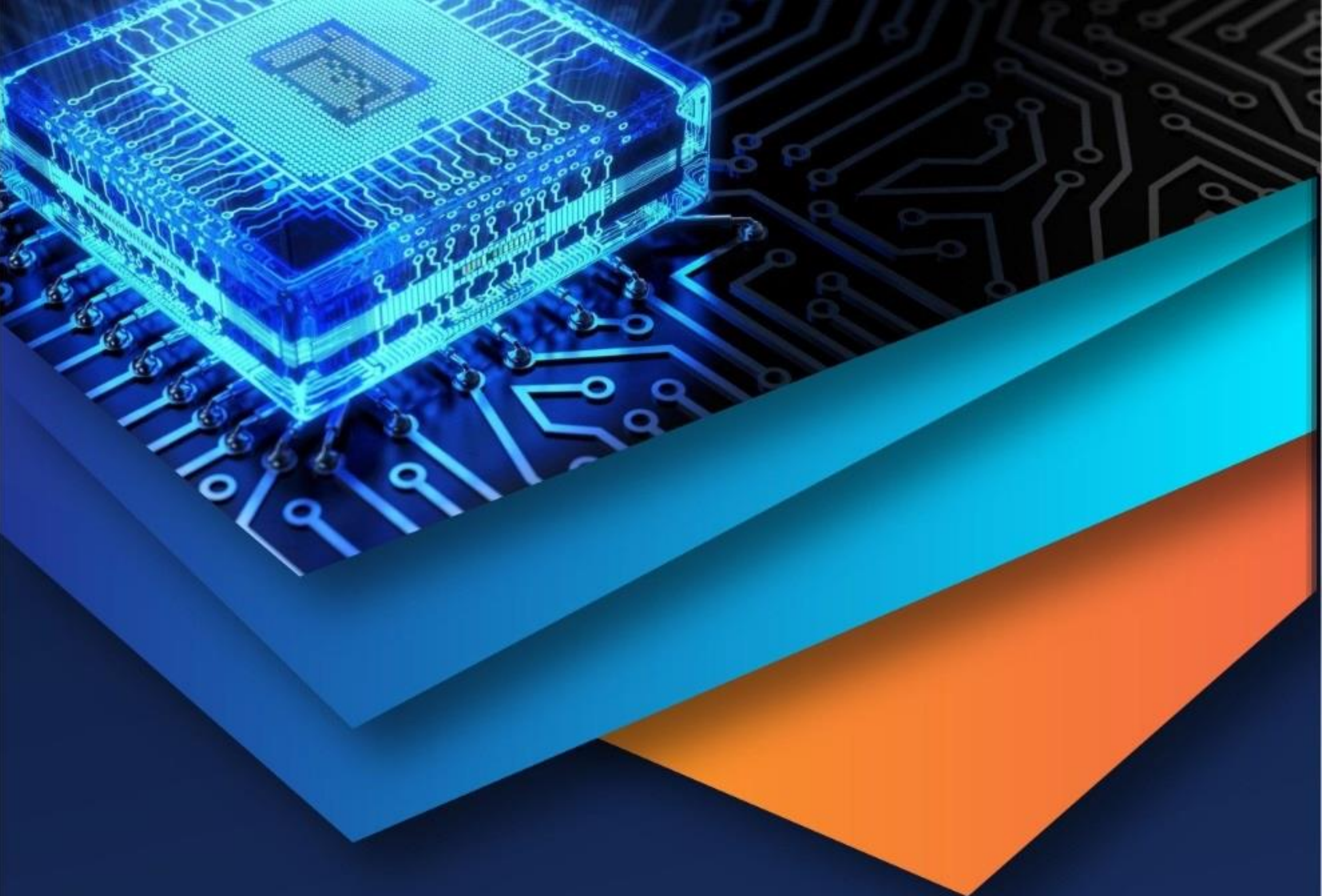

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