Conference Paper, Published Version

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Evaluation of Numerical Method by Fluent for Flow around High Head Slid Gates in Conditions of Operating Two Gates

EVALUATION OF NUMERICAL METHOD BY FLUENT FOR FLOW AROUND HIGH HEAD SLID GATES IN CONDITIONS OF OPERATING TWO GATES

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ABSTRACT

In the research the results of velocity magnitudes due to the FLUENT have been evaluated and compared by data due to experimental model for flow around high head lift gates in different conditions of operating two gates.

Numerically, for prediction of the flow around the gates, I used FLUENT that has a strong technique (Volume of Fluid) for tracing the free surface after last gate.

The experimental velocities was measured by LDV (Laser Doppler Velocimeter) under an experimental model built and taken place in The University of Melbourne. The flow fields were measured as the two-dimensional for seven positions of gates.

Keywords: FLUENT, high head gate, Laser Doppler Velocimeter, numerical model, Volume of Fluid.

1. INTRODUCTION

Bottom outlet leaf gates are one of the most important structures which are used to control the flow for downstream requirements. Therefore, gate should be taken for an accurate design of such structures. The designers should check for any kind risk such as, cavitation, vibration or flow discharge through these outlet conduits. The investigations regarding the design of these structures usually fall into category of physical model or numerical investigations. However, the physical model studies are sometimes very expensive, and thus, numerical studies have attracted the attention of many investigators. FLUENT that serves the numerical method for fluid flow, is based on solving Navier-stokes equations. In the research I executed the FLUENT for eight cases of gates position. The method that I used in FLUENT was SIMPLE Algorithm to solve the government equations (PDE) with κ-ε model. Also for tracing the water surface profile, technique of volume of fluid (VOF) was used. These days VOF method has been successfully applied for free surface flow by many investigations.

2. THE VELOCITY

Because the LDV measures only velocities, the evaluation is based on velocity data.

2.1 Volume of Fluid

In the Volume of Fluid method, as figure1, the flow domain has two phases that blue vectors introduce the water phase and blue vectors introduce the air phase. The volume fractions of 1 shows the pure water and 0 shows the pour air and between 0 and 1 we have air and water mixed.

2.2 Evaluated place

The dimensions of flow domain simulated by FLUENT are presented in figures 2.

According to this figure, the geometry was considered for two gates.

The considered point coordinates are recognizable according to Figure 3 so that the measurable points are made by crossing the dashed lines. According to this Figure X is the horizontal distance from inflow section to desirable measurement point .

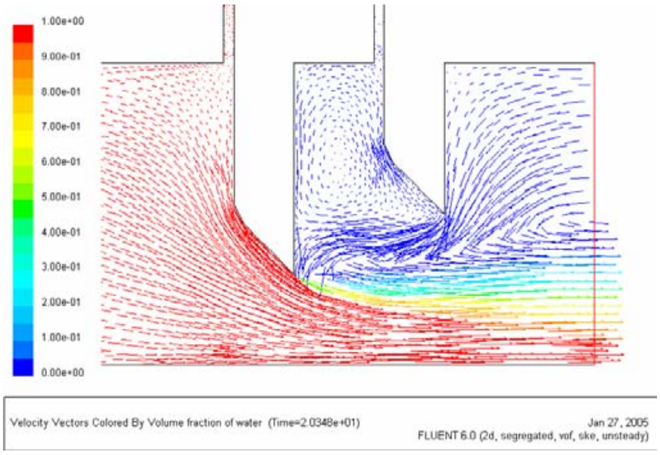


Figure 1 a simple of simulated velocities with regions air and water

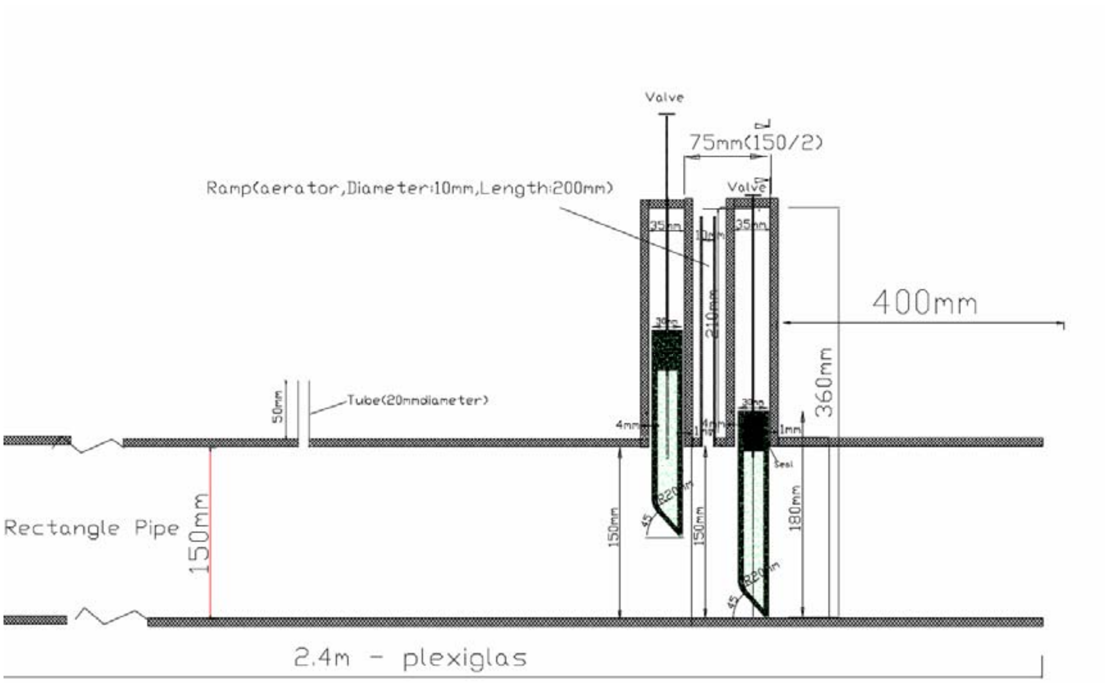


Figure2 Dimensions of flow domain.

2.3 Flow conditions

Simulation was performed for 7 positions gates consisted of 30%-10%, 70%-10%, 30%-30%, 50%-30%, 70%-30%, 50%-50% and 70%-50%. In this format (m%-n%) the first number is related to Opening upstream gate(first gate or Emergency gate) and second one is related to downstream gate(second gate or service gate) as percent. Also there is a constant head behind the first gate (about 3.5m) and flow rate is various (maximum to 0.4 m^3/s). In these conditions, the turbulent flow is considerable.

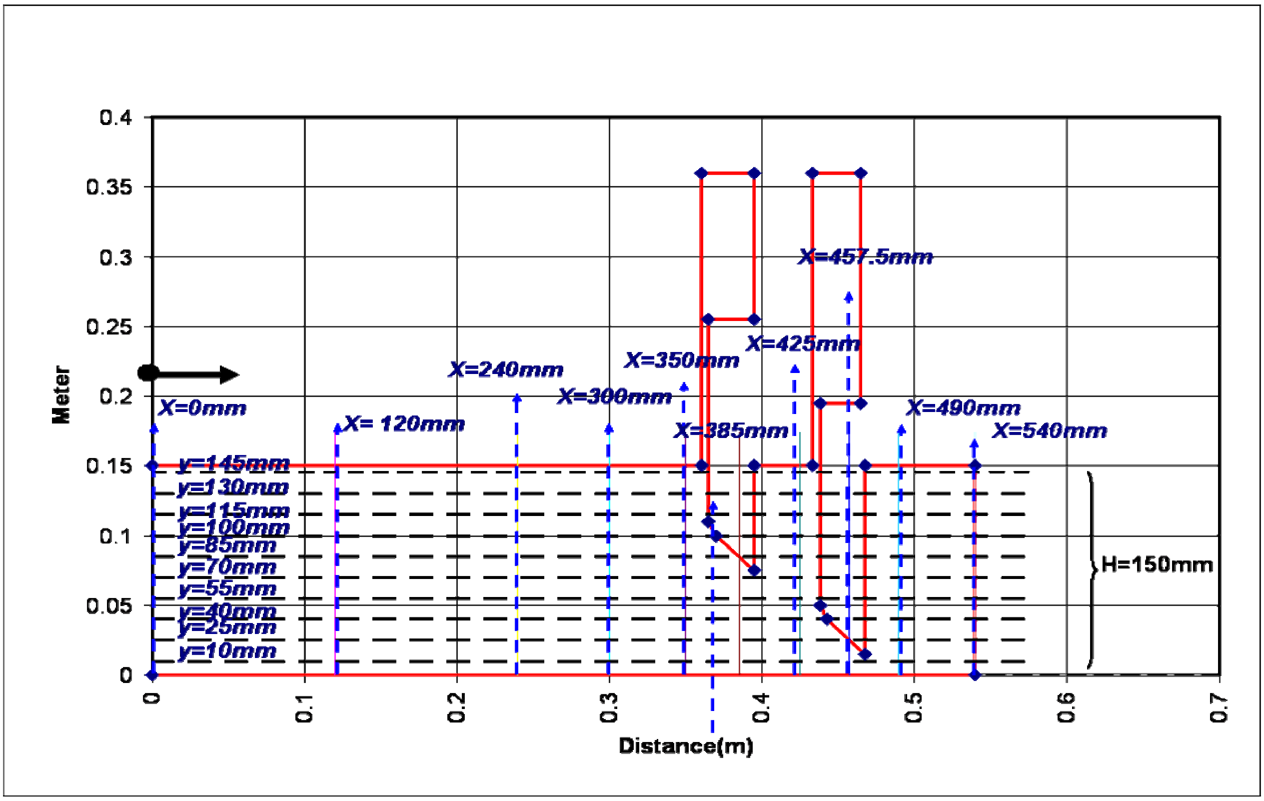


Figure 3 evaluated pointes coordinates

3. ANALYSIS AND RESUALTS

In seven cases of gates position, the velocity magnitudes due to numerical model are compared with the experimental model ones. To compare the velocities in every section(figure 3), relative errors were calculated as bellow:

$$RE = \left[\frac{1}{n} \sum_{i=1}^{n} \left| \ (N_i - E_i) \ \right| \right] / \left[\frac{1}{n} \sum_{i=1}^{n} E_i \right] \tag{1}$$

Where, RE is relative error of velocities on a section, N_i is related to numerical velocity of the point i on a section and E_i is related to experimental velocity of the point i on a section.

Please pay attention to occurring the super turbulence between two high head gates so the research intends to evaluate the model of κ-ε with VOF technique for these kinds of flow.

3.1 Gate position of 30%-10%

According to figure 4, in this gates position, velocity magnitudes due to numerical and experimental data show the average of REs in each section are less than 23% except in between and under gates in where RE reaches up to 64% that take place under gate of opening %10 (minimum opening). The unsteady fluctuation is so high that it has made such inaccuracy.

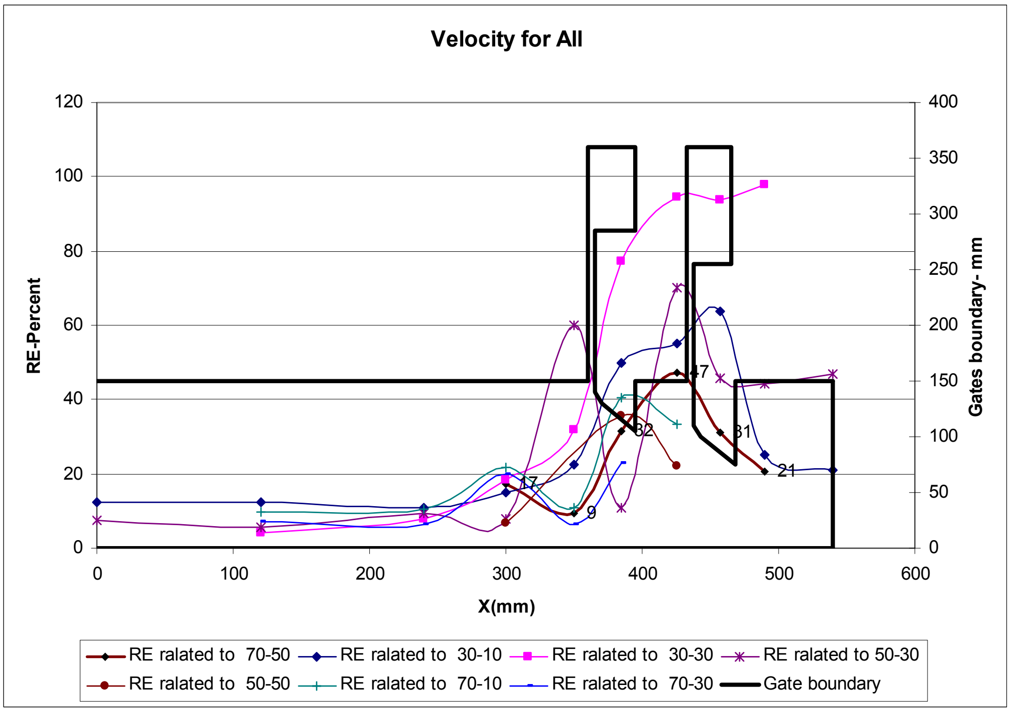


Figure 4 comparisons of the relative errors (RE) of Velocities for all gates positions

3.2 Gate position of 30%-30%

In this case because of both gates are same opening thus the flow after left gate will be free and there isn't any water flow between two gates filled by air phases. According to figure 4, after the left gate, It seems the model of κ-ε, couldn't simulate an accuracy flow so that there RE reaches from 32% to 98%, because strong eddies between two gates have made a unstable fluctuations.

3.3 Gate position of 50%-30%

In this case according to figure 4, after the left gate, the RE varies from 23% to 64% but RE related to flow jet after second gate (right gate), returns to about 21%. Similarity this shows the strong eddies between two gates have made a unstable fluctuations.

3.4 Gate position of 50%-50%

According to figure 4, In this case because of both gates are same opening , the flow after left gate will be free and there isn't any water flow between two gates filled by air phases. The maximum RE is 36% under first gate and it seems in the more opening thr conditions are better to simulate the flow more accuracy.

3.5 Gate position of 70%-10%

According to figure 4 the RE is varied from about 10% (before gates) to 41%(under left gate).

3.6 Gate position of 70%-30%

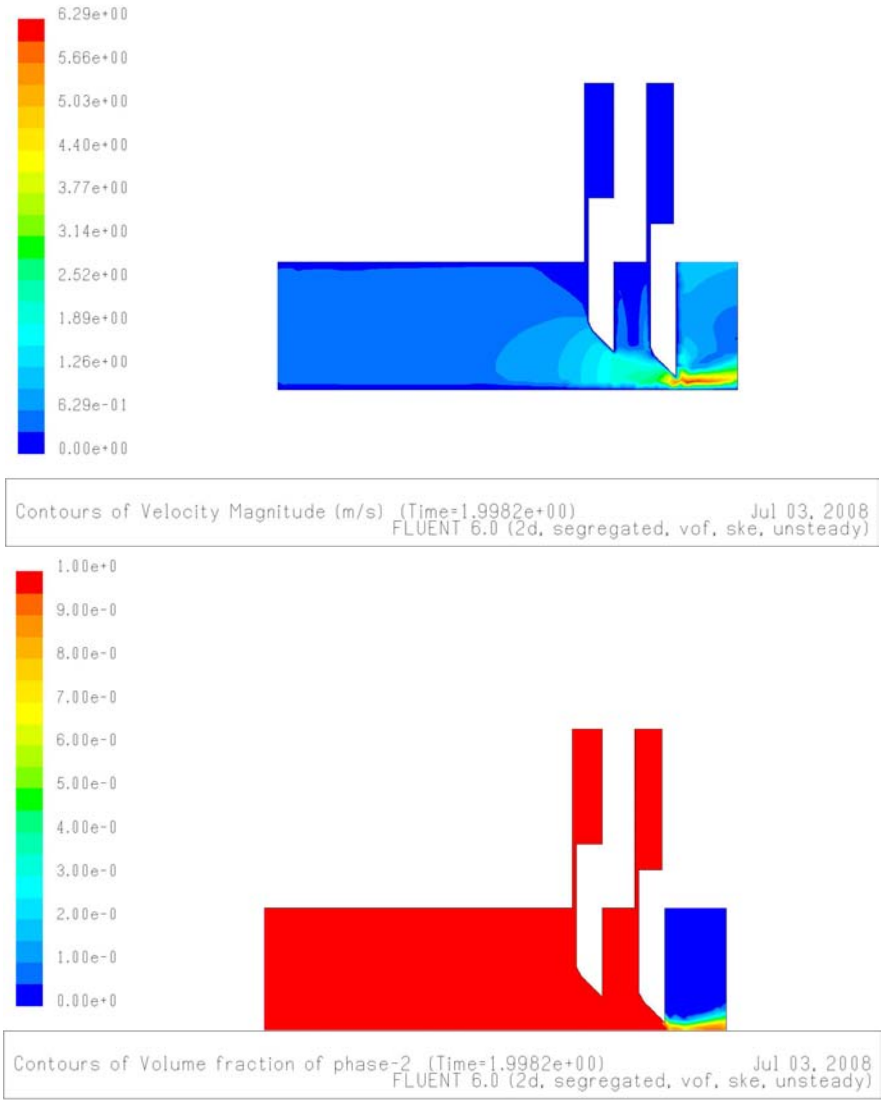
According to figure 4, the RE is varied from 7% (before gates) to 23%(under left gate).

3.7 Gate position of 70%-50%

According to figure 4, after the left gate, the RE varies from 9% to 47% but RE related to flow jet after second gate (right gate), returns to about 21%. Similarity this shows the strong eddies between two gates have made a unstable fluctuations.

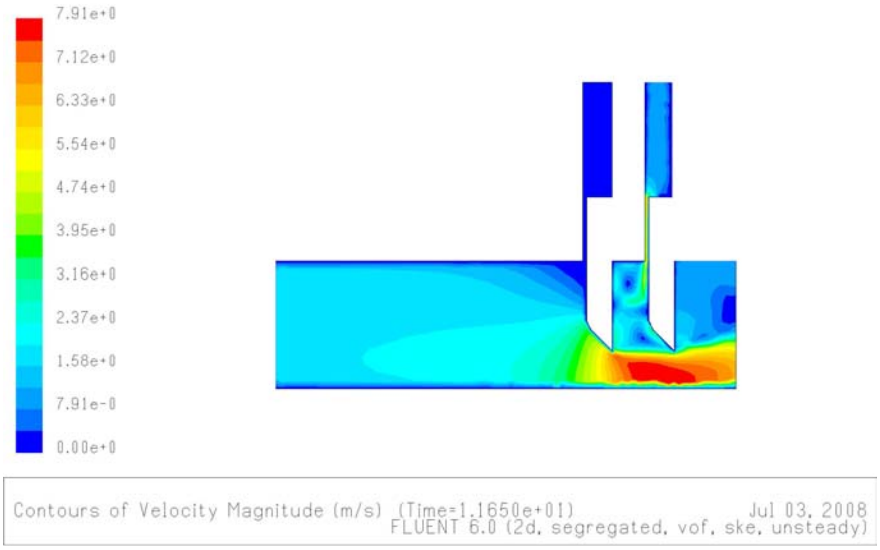
4. DEMONSTRATING THE EXECUTED RESULTS

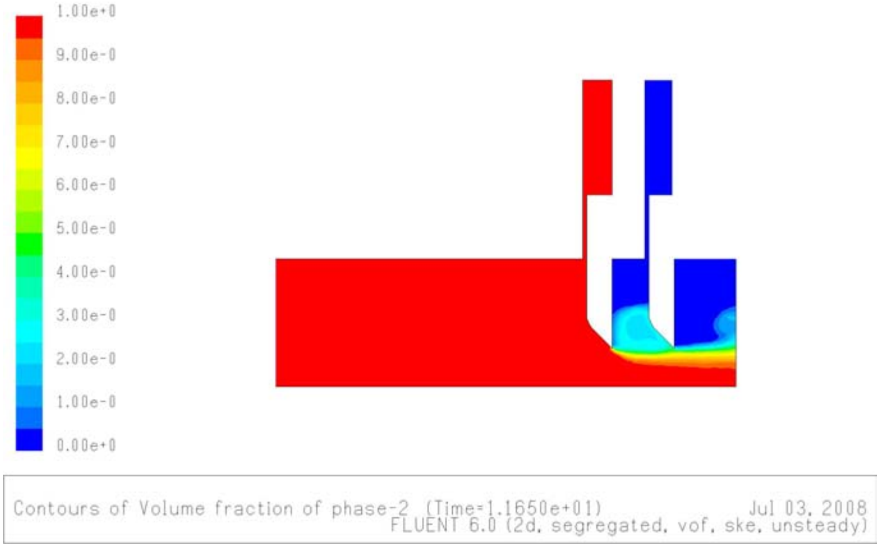
The contours of velocity magnitude and volume related to phase of water have been demonstrated in figure 5. these are due to executed results from FLUENT.



opening gates of 30%-10%

Figure 5 Contours of velocity magnitude and volume fraction (phase 2 is water) for all opening gates





opening gates of 30%-30%

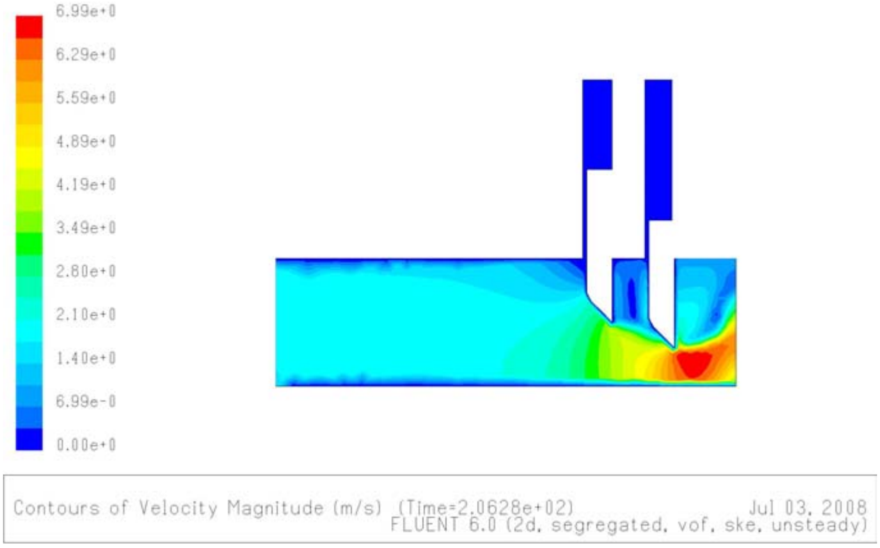
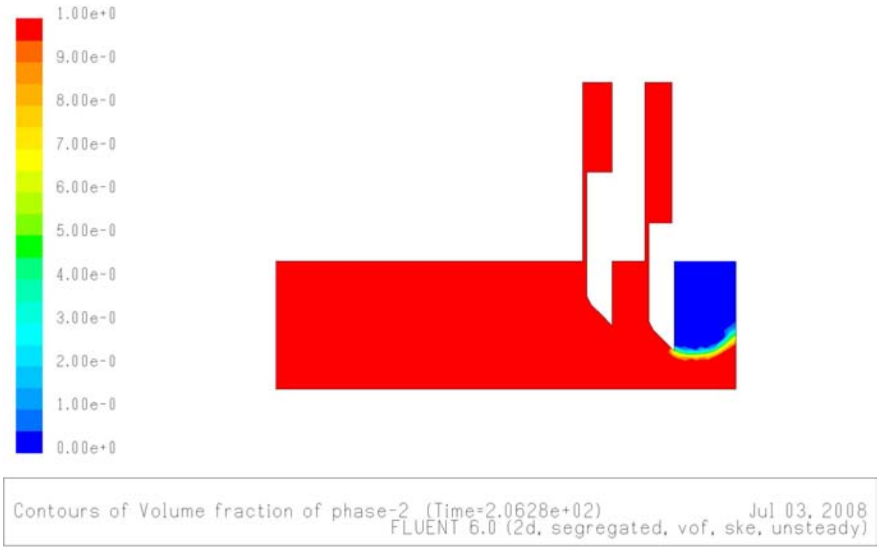
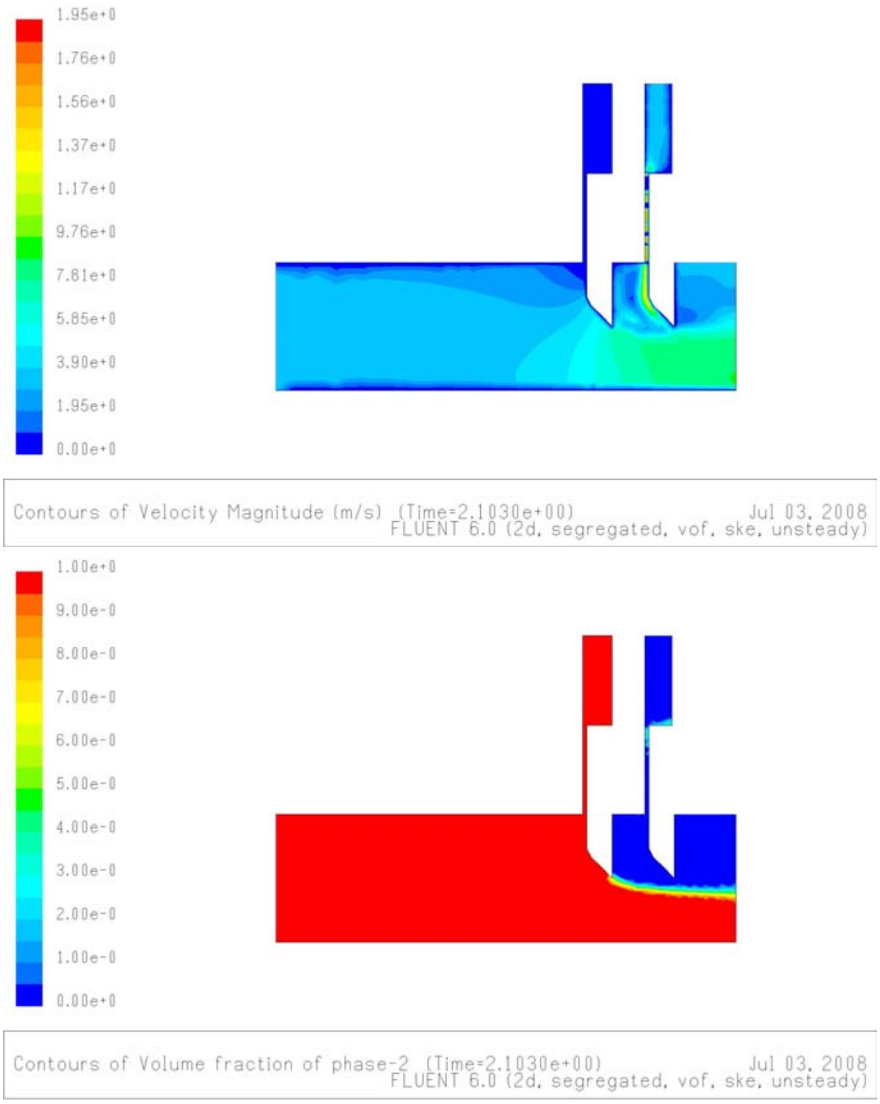


Figure 5 Contours of velocity magnitude and volume fraction (phase 2 is water) for all opening gates

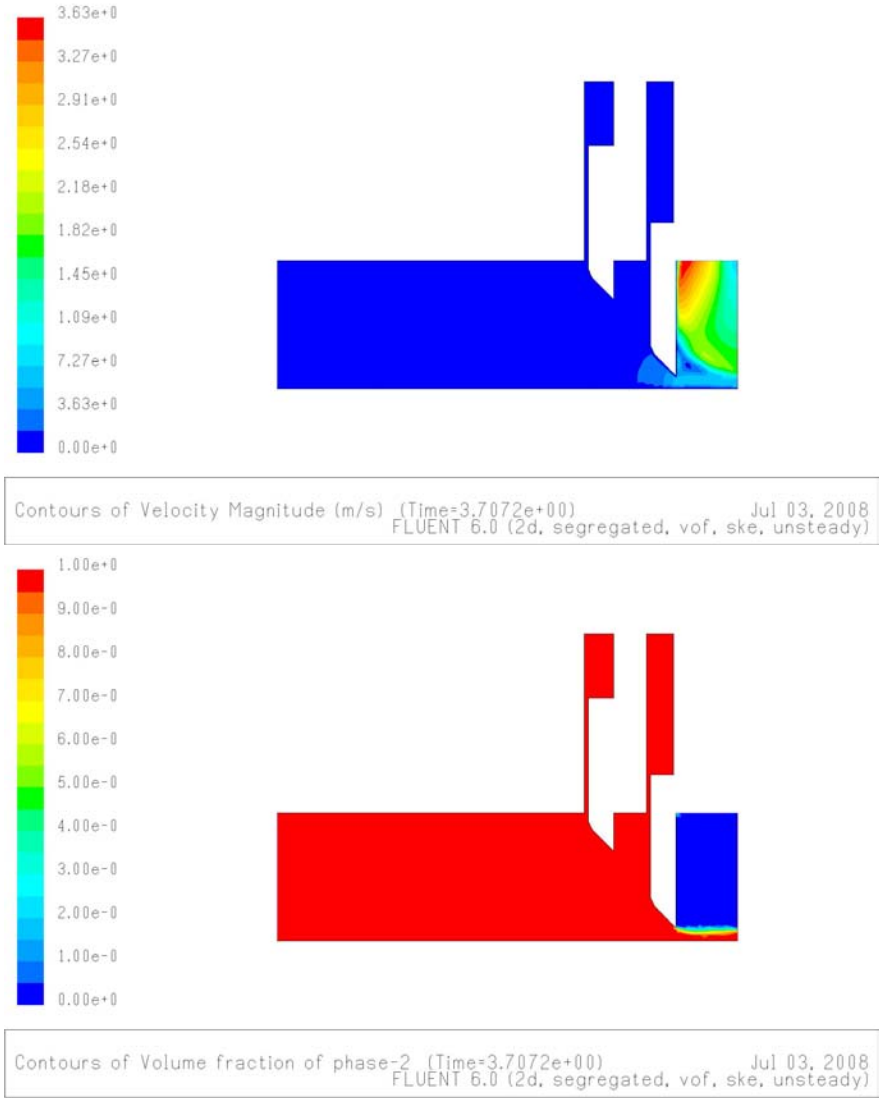


opening gates of 50%-30%



opening gates of 50%-50%

Figure 5 Contours of velocity magnitude and volume fraction (phase 2 is water) for all opening gates



opening gates of 70%-10%

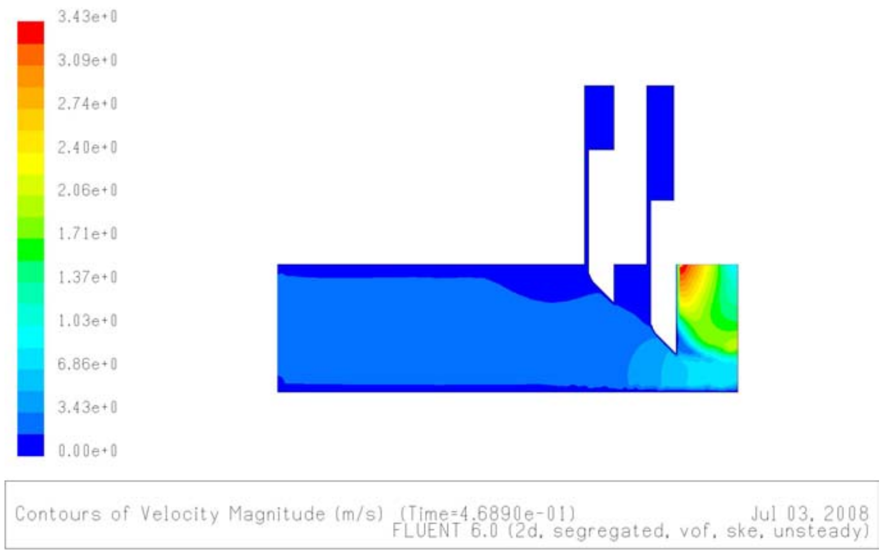
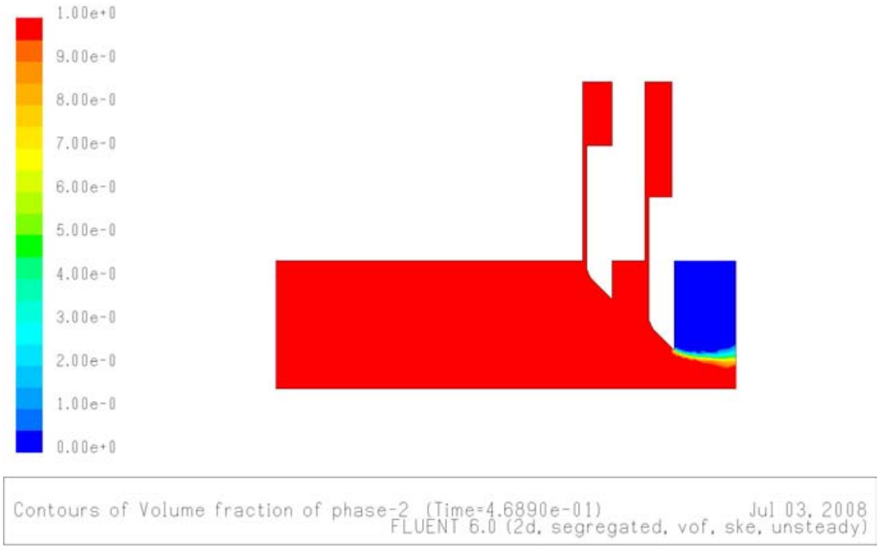
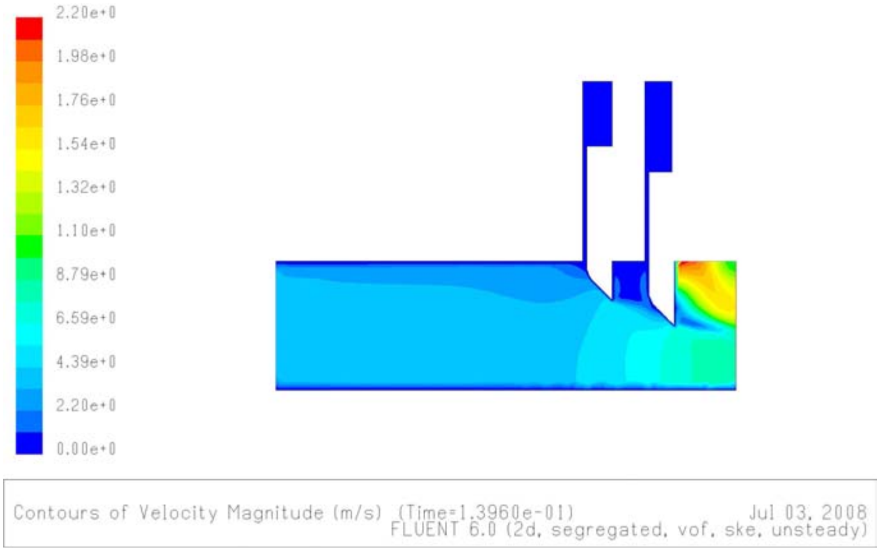


Figure 5 Contours of velocity magnitude and volume fraction (phase 2 is water) for all opening gates



opening gates of 70%-30%



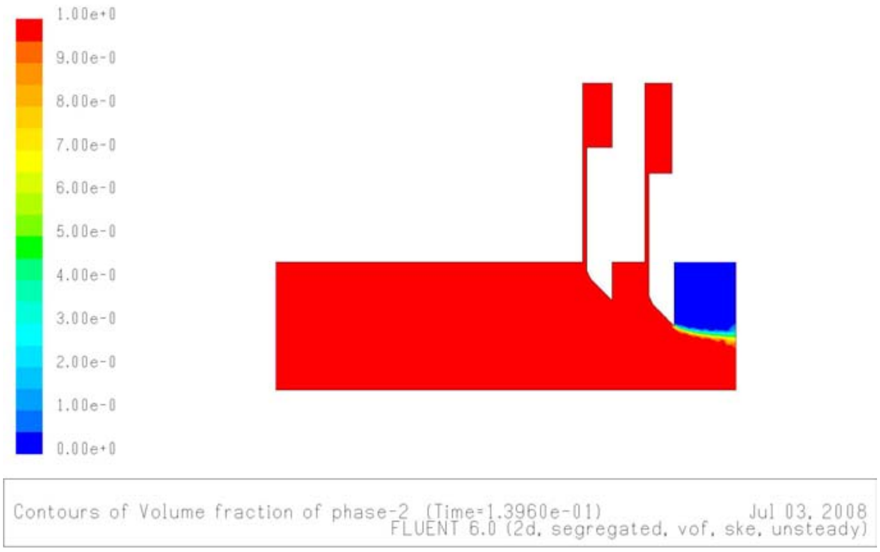


Figure 5 Contours of velocity magnitude and volume fraction (phase 2 is water) for all opening gates

5. CONCLUSIONS

According to figure 4 spatially for gates of 30%-30%, 50%-30% and 30%-10%, the model has simulated the flow in between and under two gates with RE of more than 40%. This can be because of generating the strong eddies between two gates that make an unstable fluctuation for flow. Off course other original errors such as measurement and reading can have been added to the error but they are lower.

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