# Measurement of flow uniformity in the heat exchanger design for a SFR steam generator

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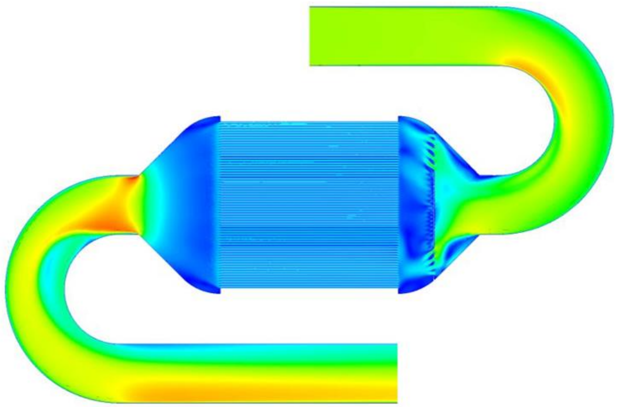
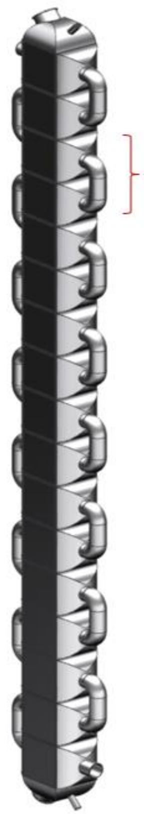
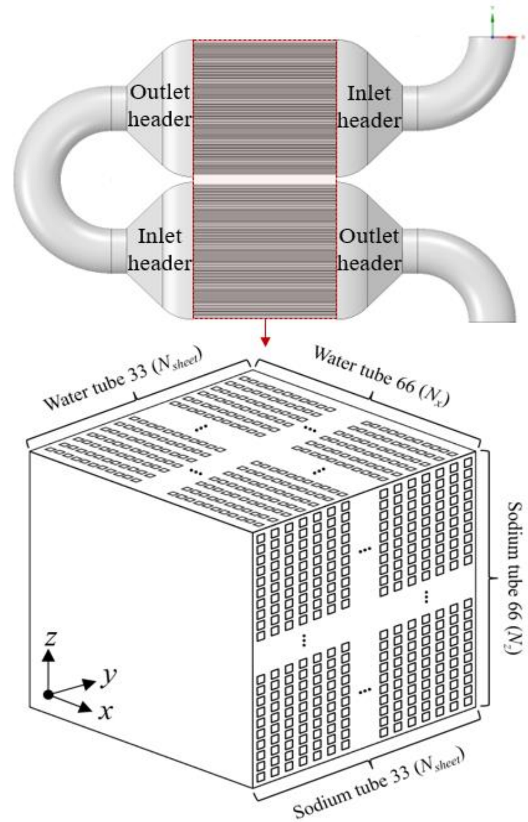
# Contents

- Design headers and a perforated plate through numerical simulation
- Flow uniformity measurement using flow visualization
- Conclusion

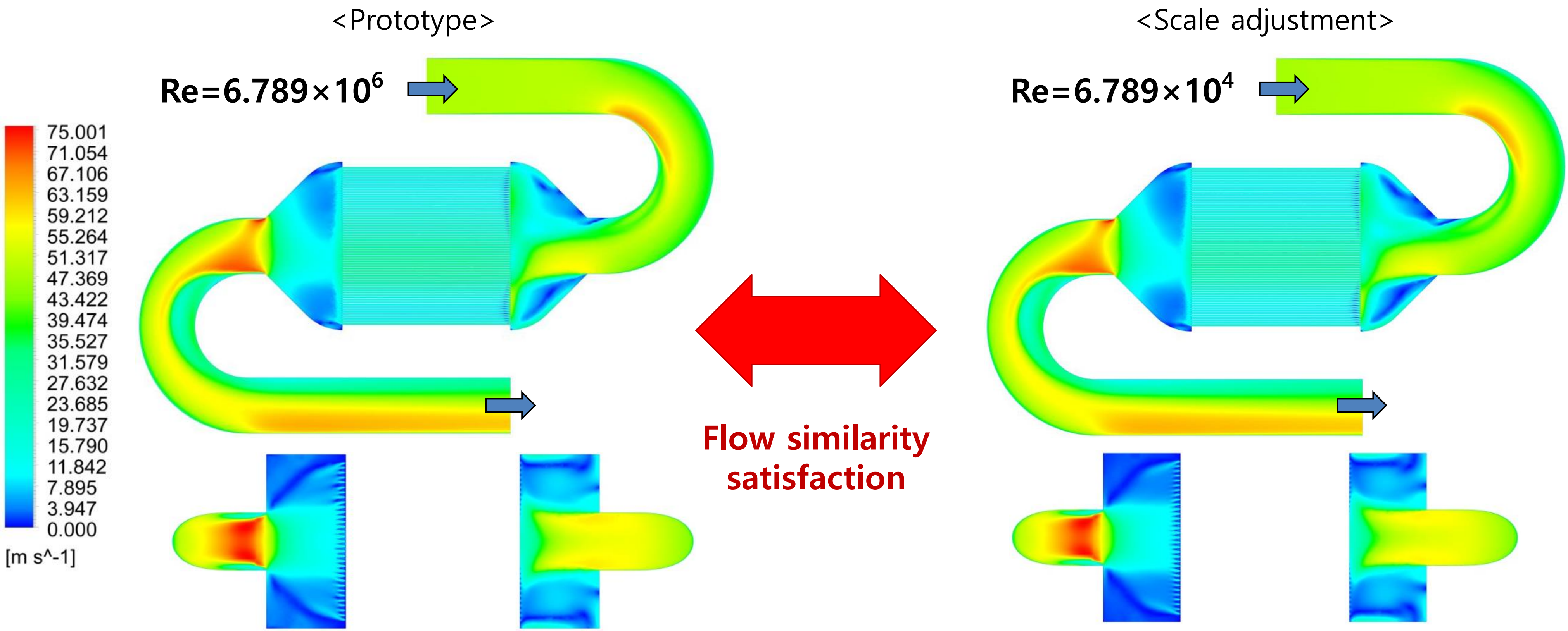






# Simulation results

## ❑ Design the header (k-ε Realizable turbulent flow, Mesh: 100,000,000 level)



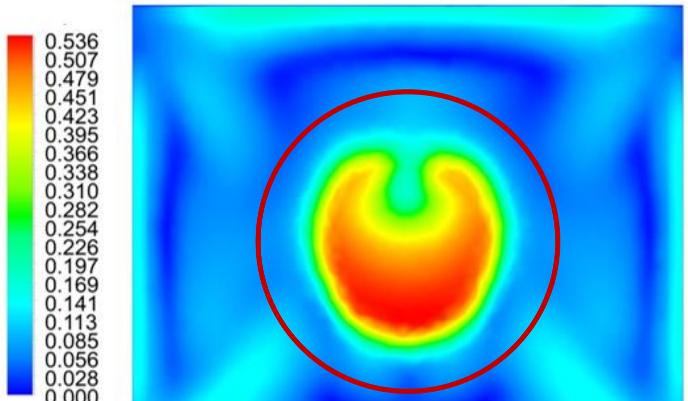

| Model | Reynolds number | CoV | Pressure drop (kPa) | Flow rate ($m^3/s$) |
|---|---|---|---|---|
| Prototype | $6.789\times10^6$ | 0.2614 | 3771.3 | 0.67 |
| Scale adjustment | $6.789\times10^4$ | 0.2536 | 0.3788 | 0.0067 |

## Simulation results

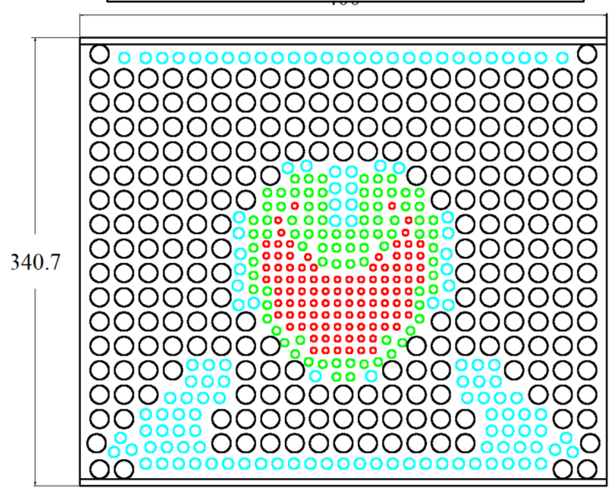
### ❑ Design a perforated plate (1/2)

- The optimal location is 80mm from a heat exchanger inlet of the inlet header through 2-D simulation

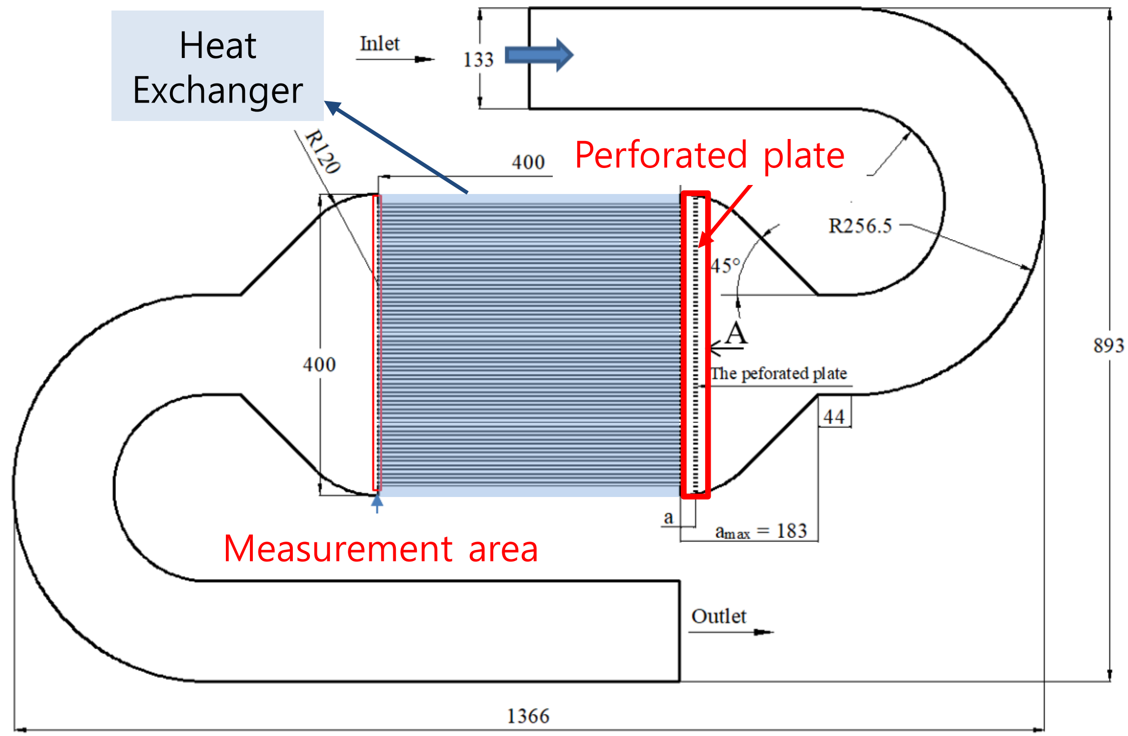
<Flow velocity distribution>




Flow velocity is concentrated in the center




<Positioning of a plate>

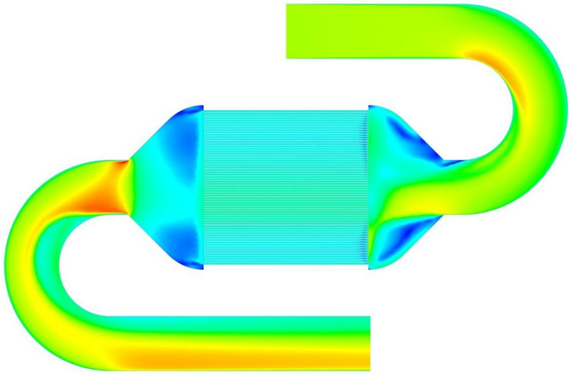



- Design a perforated plate based on flow velocity
- Arrange the plate by selecting a optimal position to improve the flow maldistribution

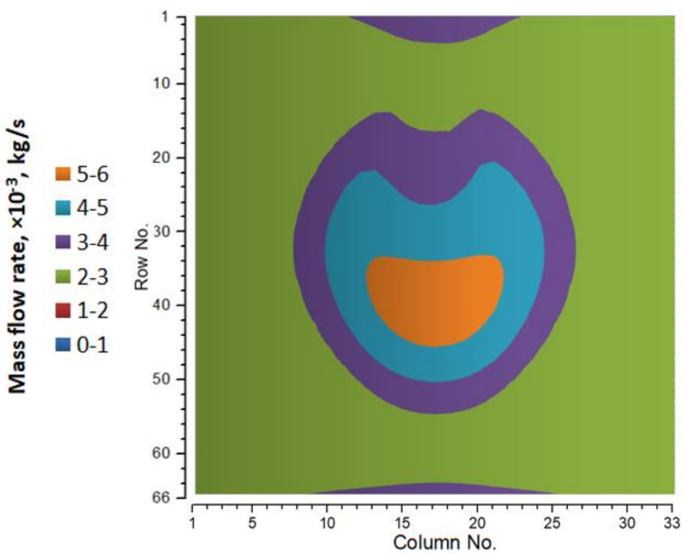
# Simulation results

## ❑ Design a perforated plate (2/2)

<Original model>



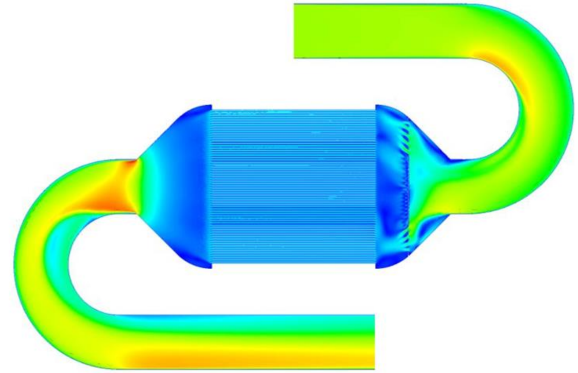
Vertical and middle cross-sectional velocity



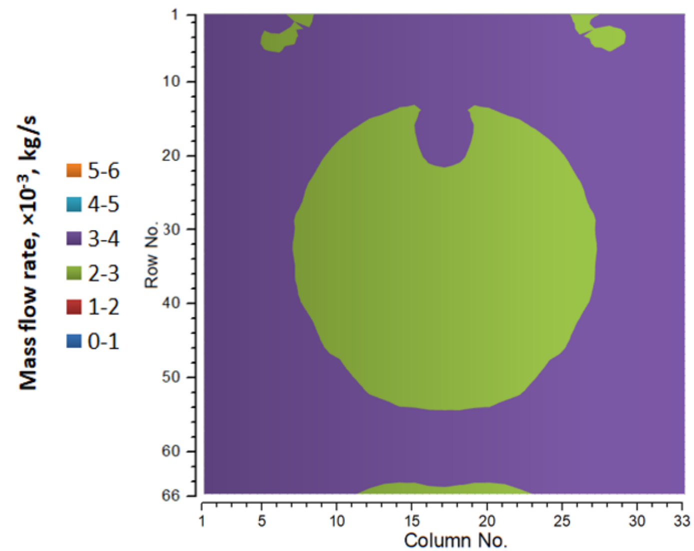

Flow distribution in the 33 X 66 channel

**Improved flow maldistribution**

**<Presented model>**



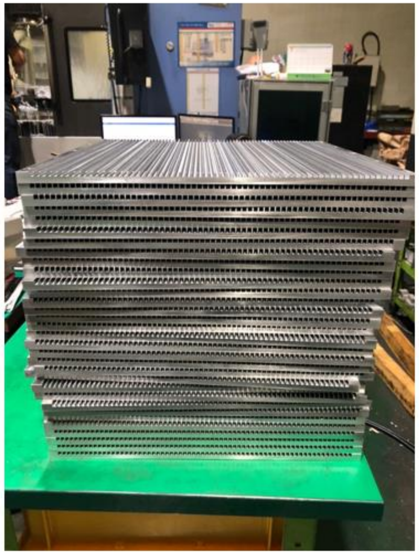
Vertical and middle cross-sectional velocity

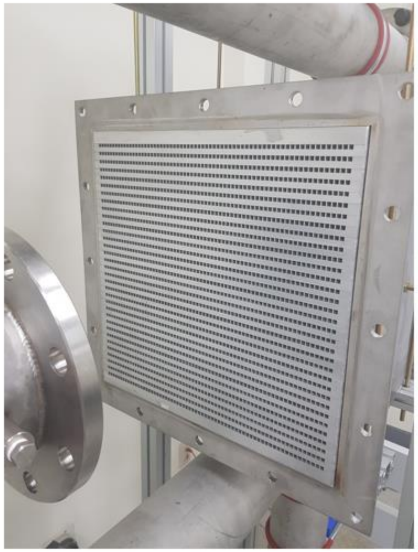



Flow distribution in the 33 X 66 channel

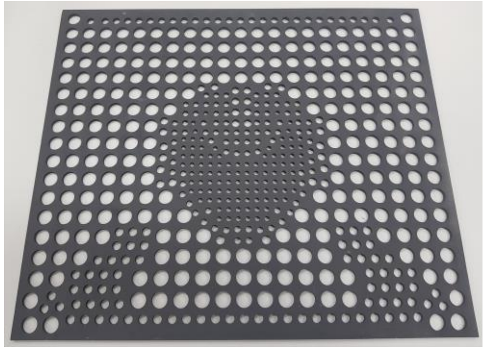
# Experimental results

## ❑ Configuration of experimental system





<33x66 channel heat exchanger>

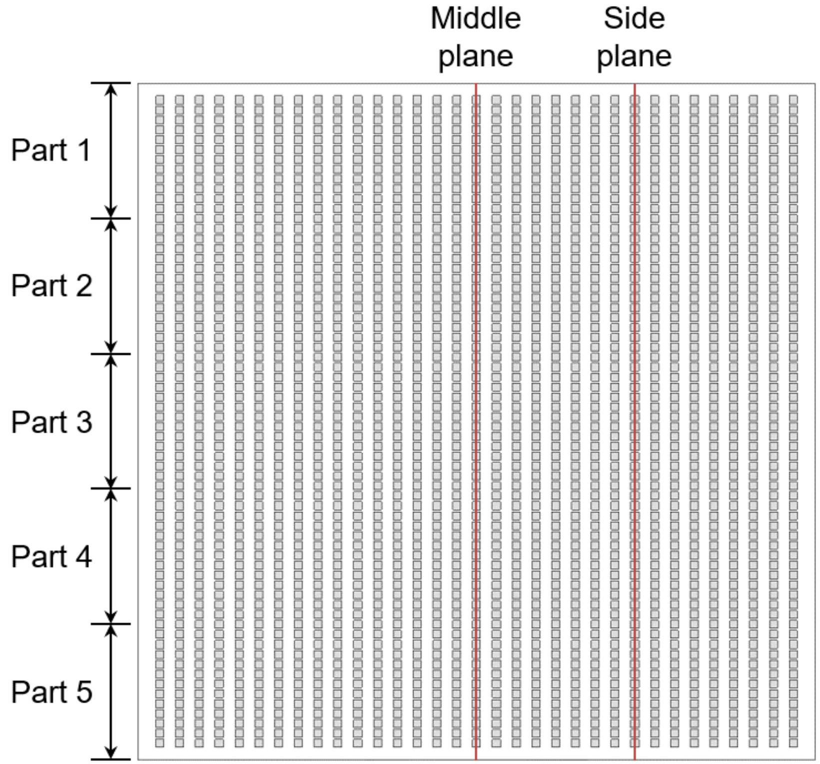


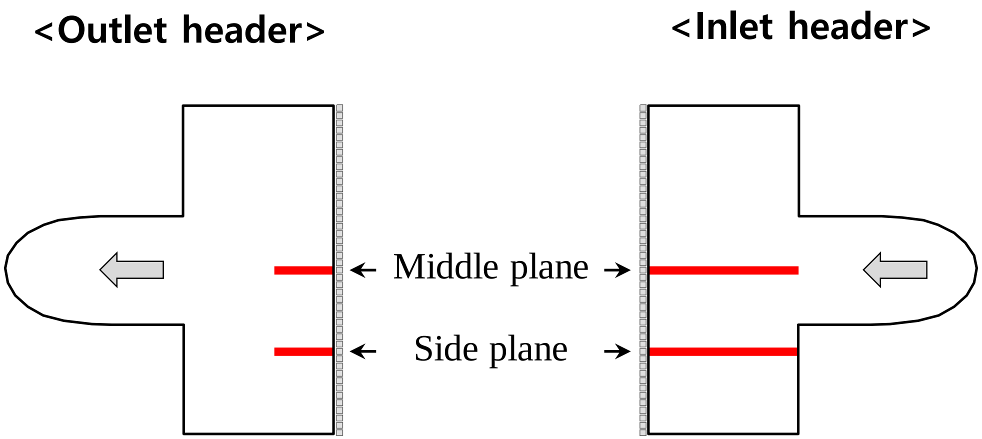
<Perforated plate>

<Experimental loop and PIV configuration>

# Experimental results

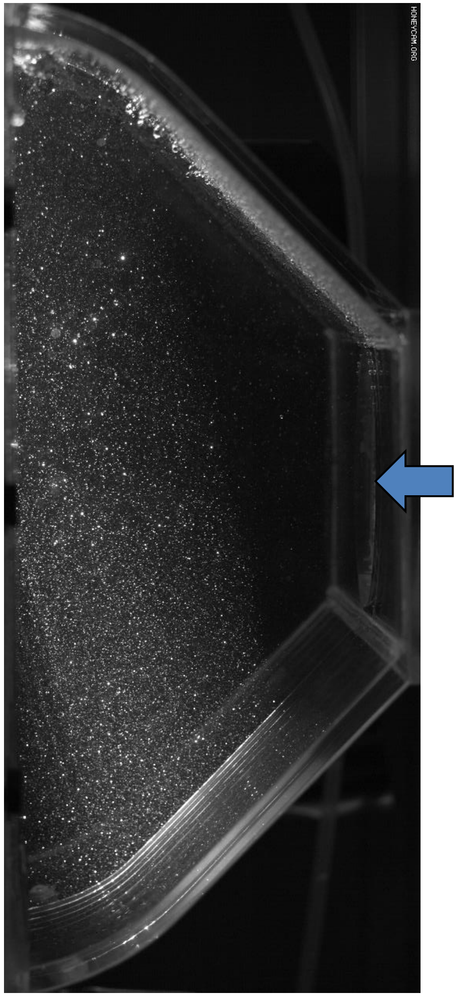
## ❑ Measurement position



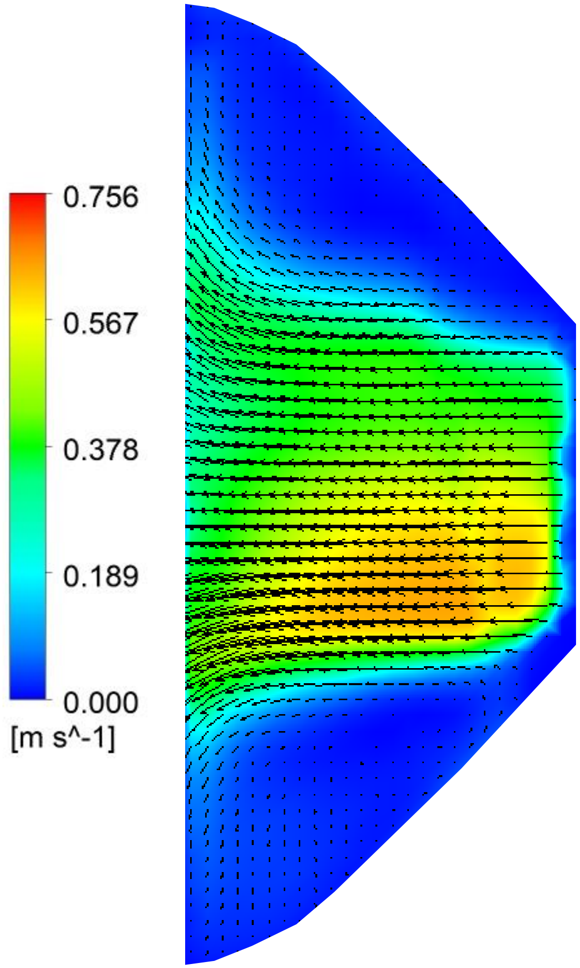




- Outlet header: **Check the flow uniformity** according the the presence or absence of the perforated plate
- **Divided the heat exchanger outlet area into 5 sections** to measure the flow rate accurately

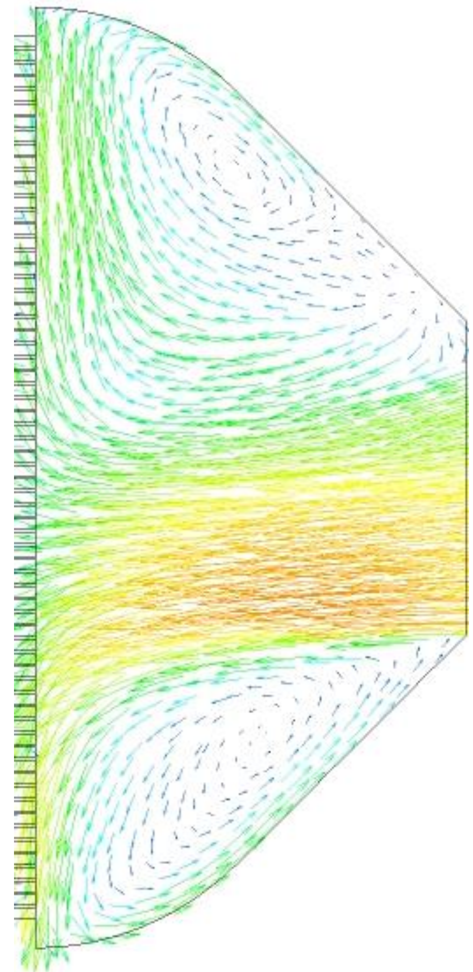
## ❑ Original model results[Inlet header] (1/5)



<Inlet header>



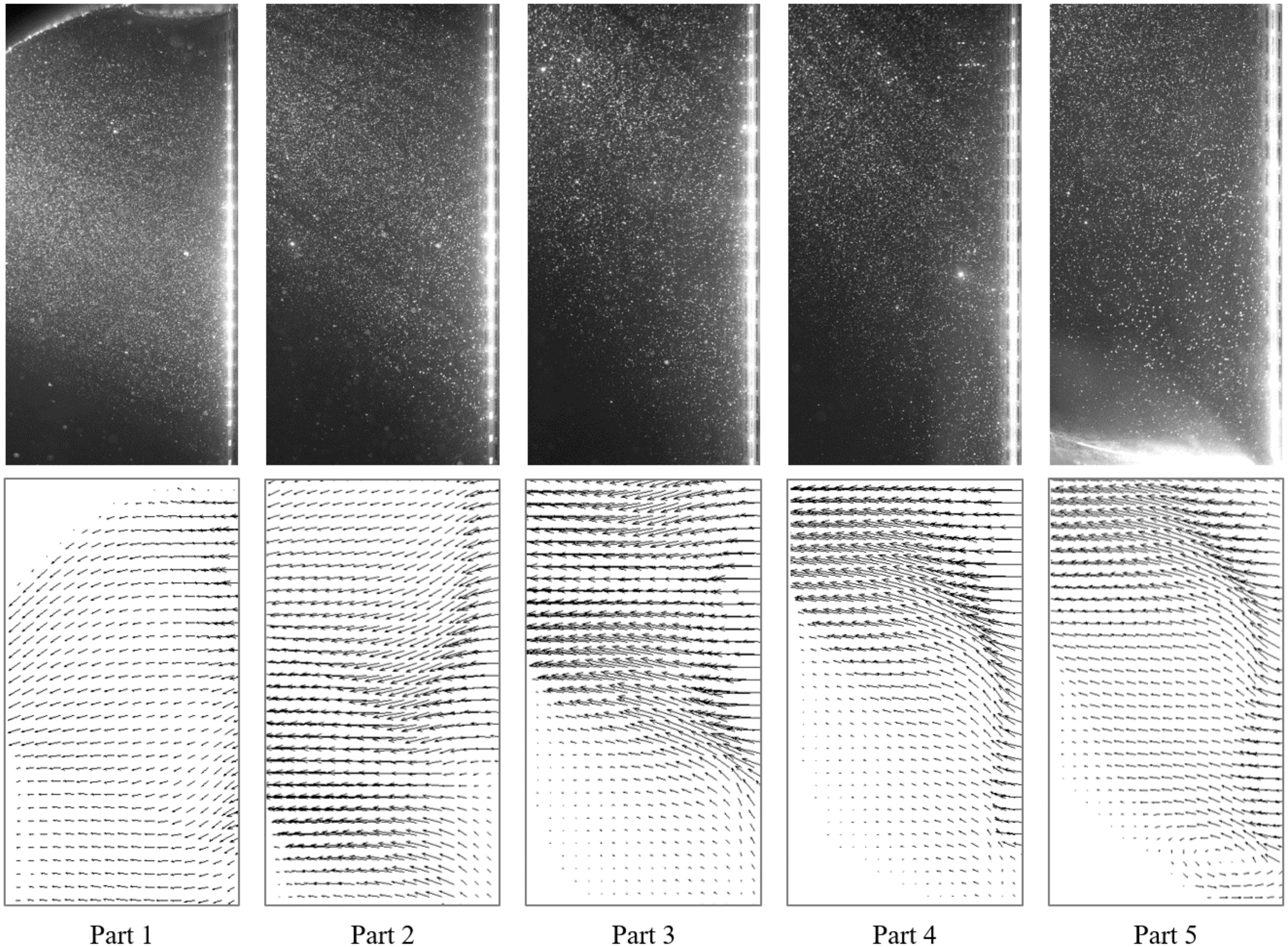

Experimental result
(velocity vector, contour)

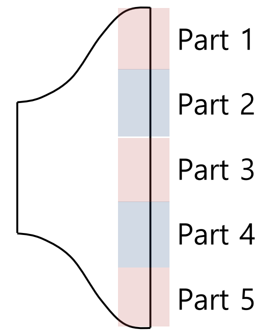


Simulation result
(velocity vector, contour)

# Experimental results

## ❑ Original model results[Outlet header_middle] (2/5)

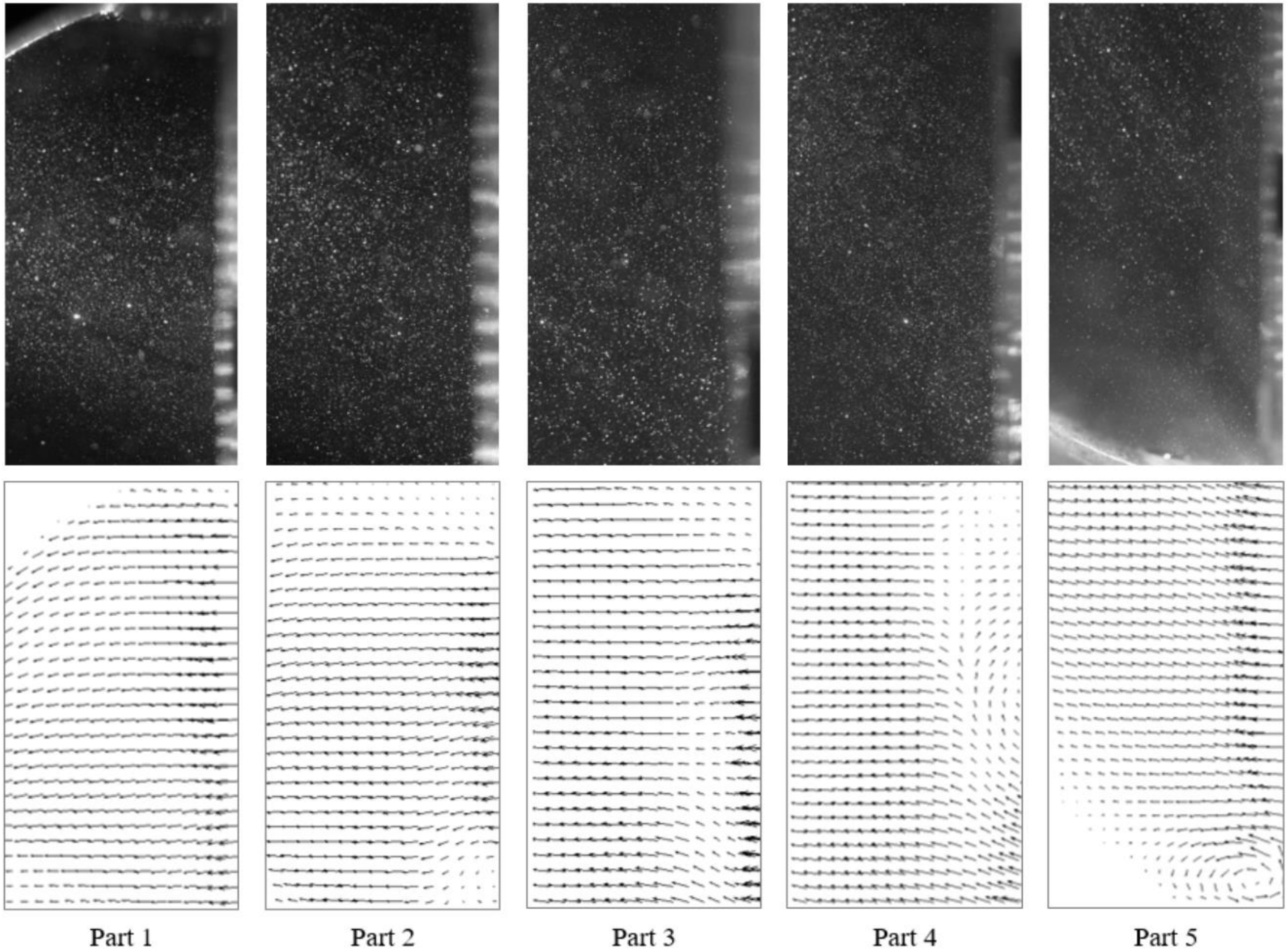


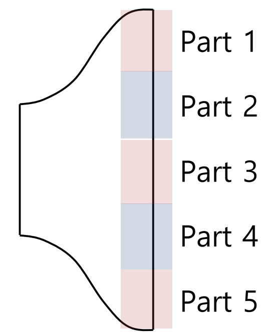




<The velocity fields at the vertical middle planes of the channel exit area for original design>

# Experimental results

## ❑ Original model results[Outlet header_side] (3/5)

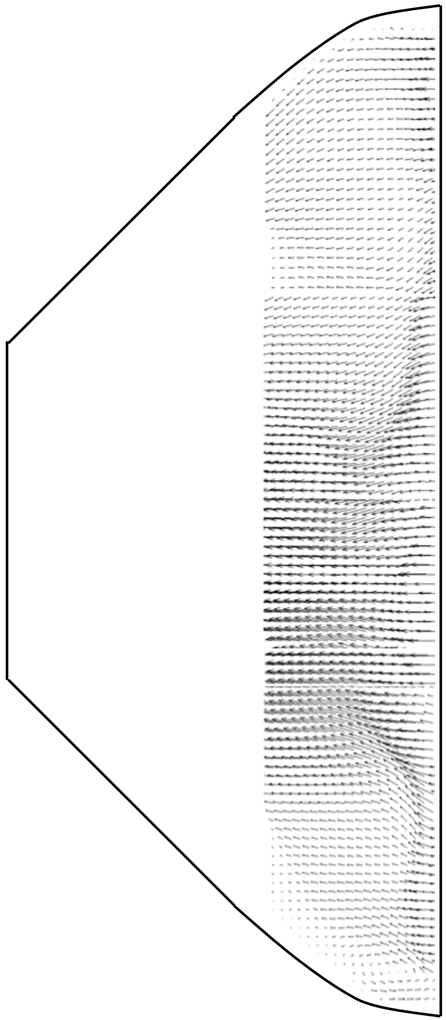


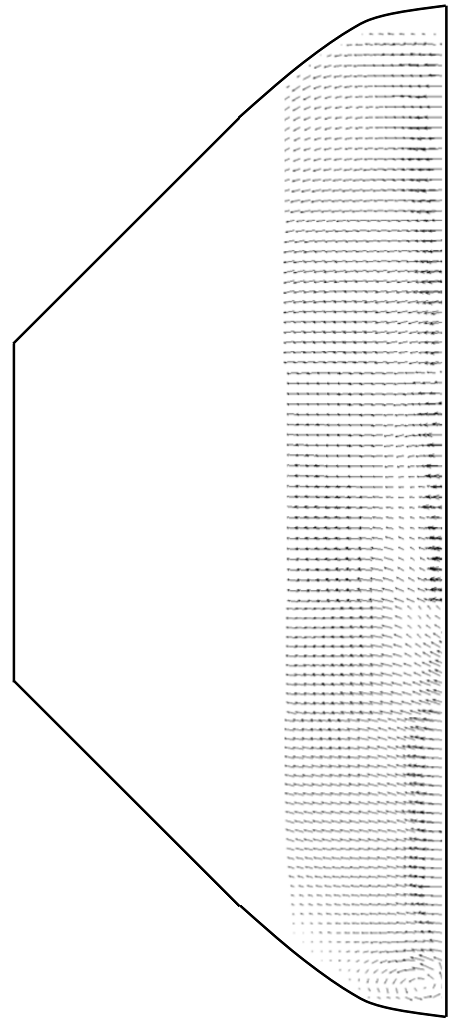

<The velocity fields at the vertical side planes of the channel exit area for original design>

# Experimental results

## ❑ Original model results[Outlet header] (4/5)



Middle plane



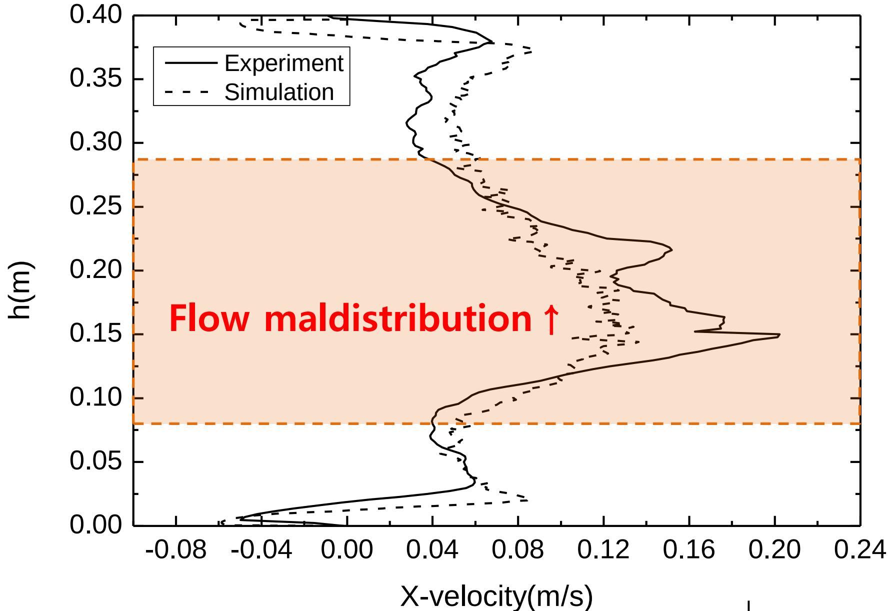
Side plane

<Outlet header>

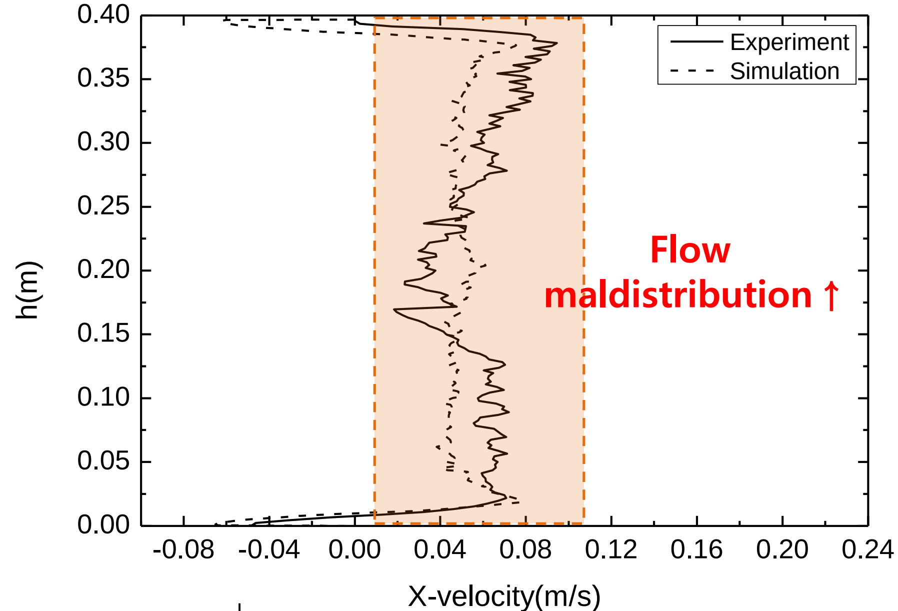
## ❑ Original model results (5/5)

- Calculation of the horizontal flow velocity at 20mm from the channel exit considering the PIV accuracy

<Middle plane>




<Side plane>




Flow **"difference"**

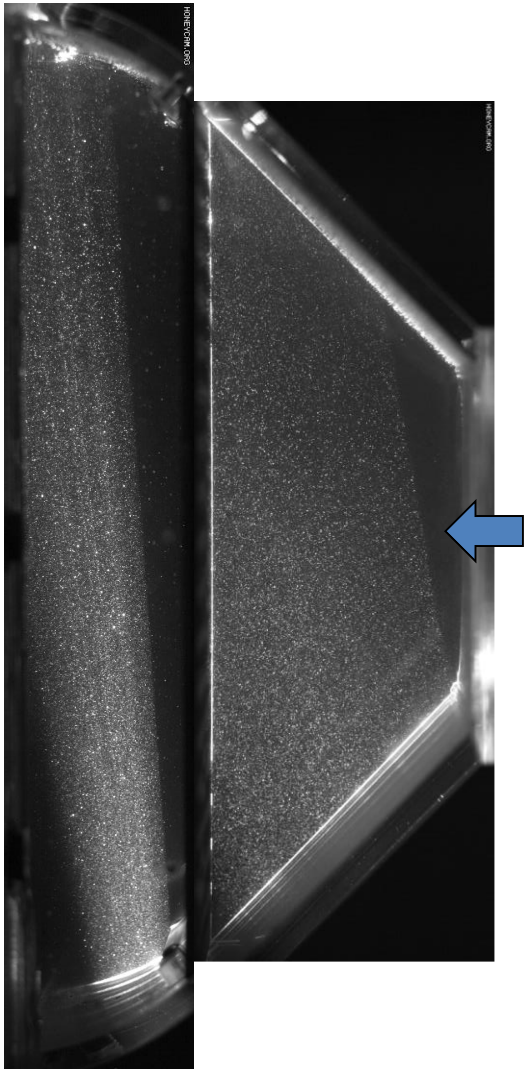
↓

**Flow maldistribution ↑**

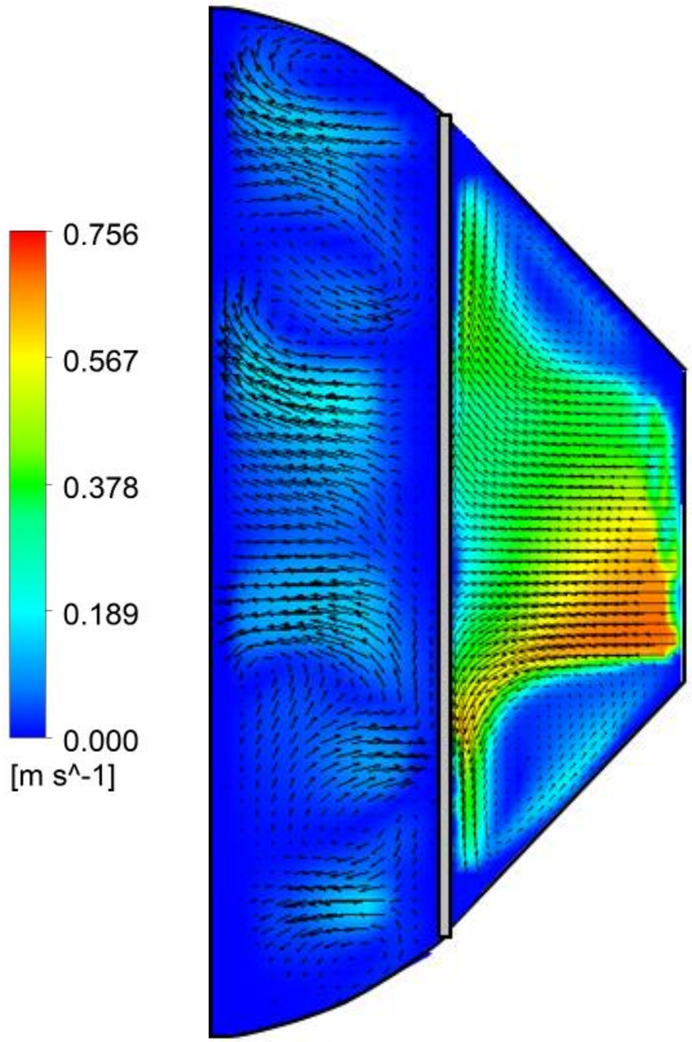
- Both results are similar
- If there is no perforated plate, flow maldistribution is large

## Experimental results

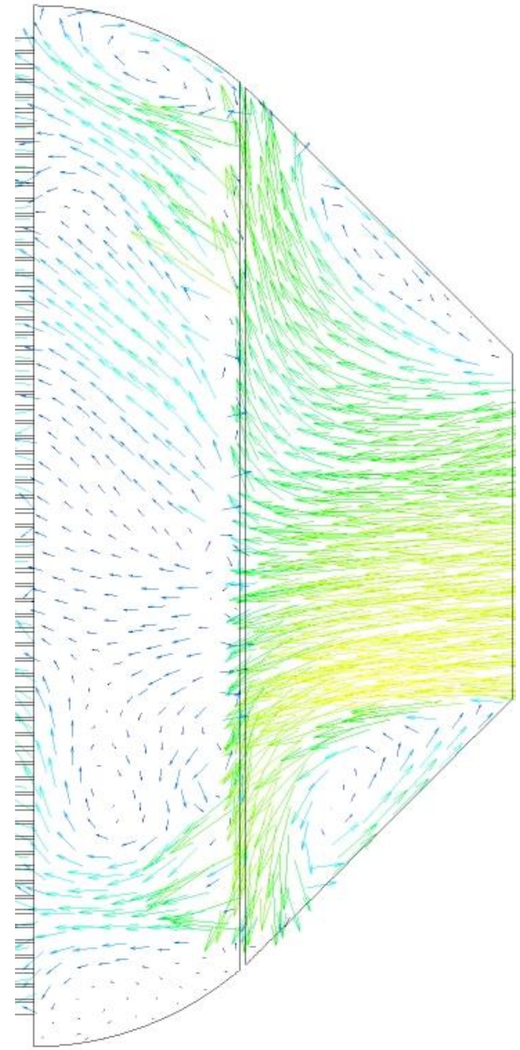
### ❑ Presented model results[inserting a plate, Inlet header] (1/5)



<Inlet header>



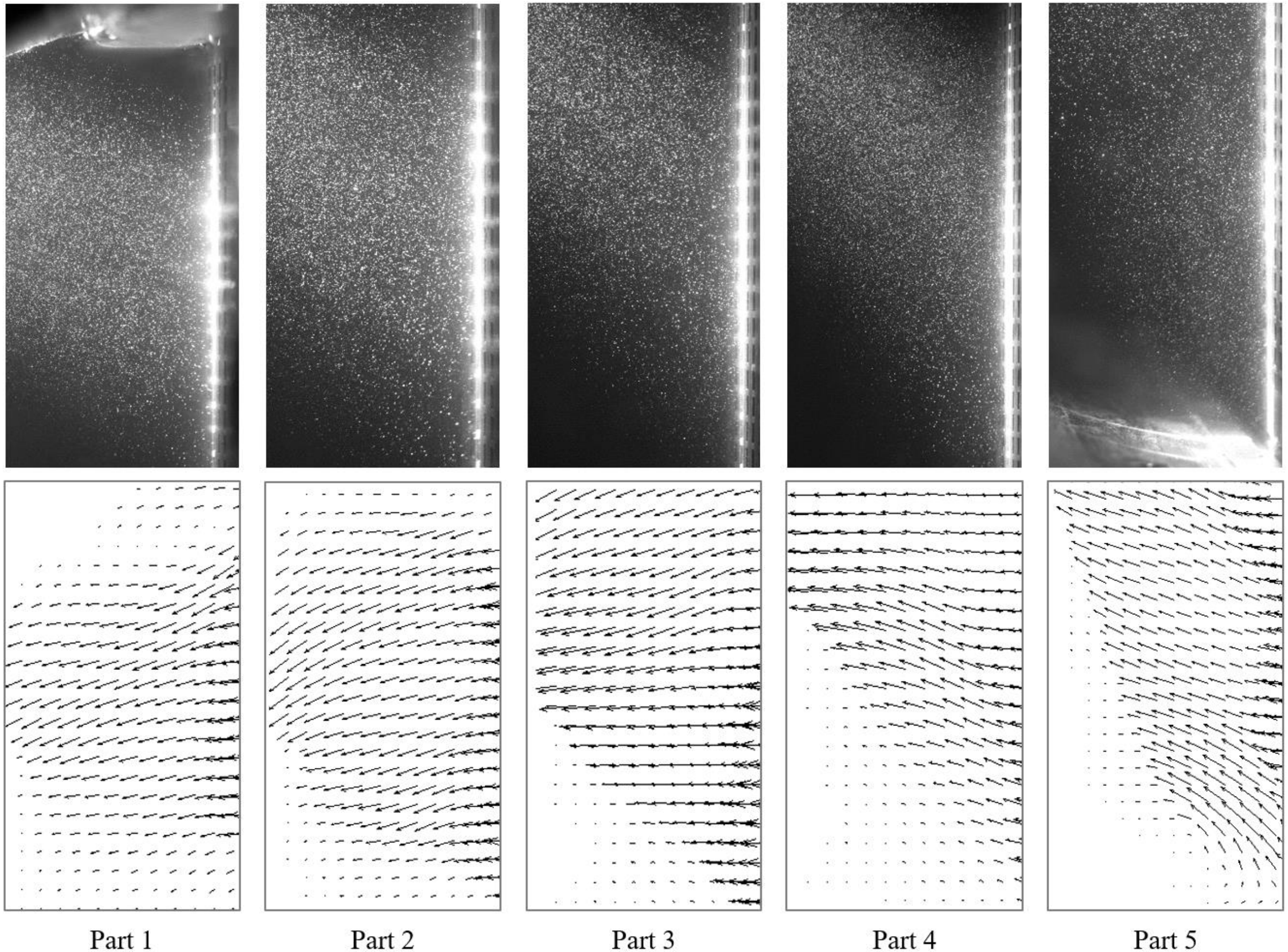

Experimental result
(velocity vector, contour)

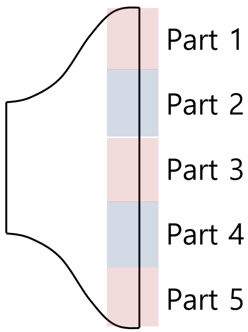


Simulation result
(velocity vector, contour)

# Experimental results

## ❑ Presented model results[inserting a plate, Outlet header_middle] (2/5)

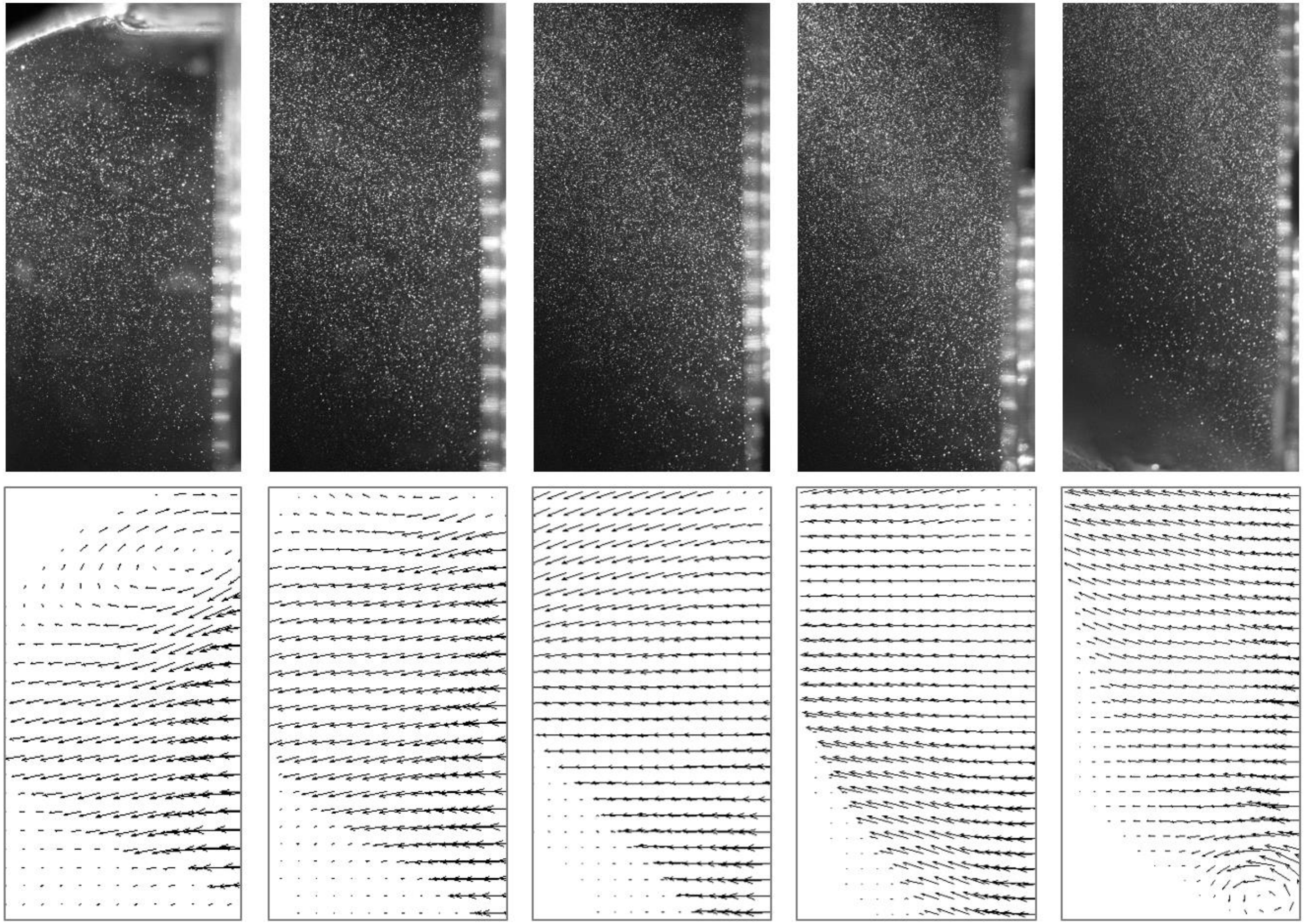



<The velocity fields at the vertical middle planes of the channel exit area for presented model>

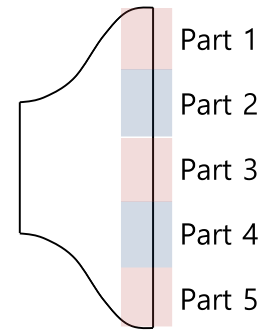
# Experimental results

## ❑ Presented model results[inserting a plate, Outlet header_side] (3/5)

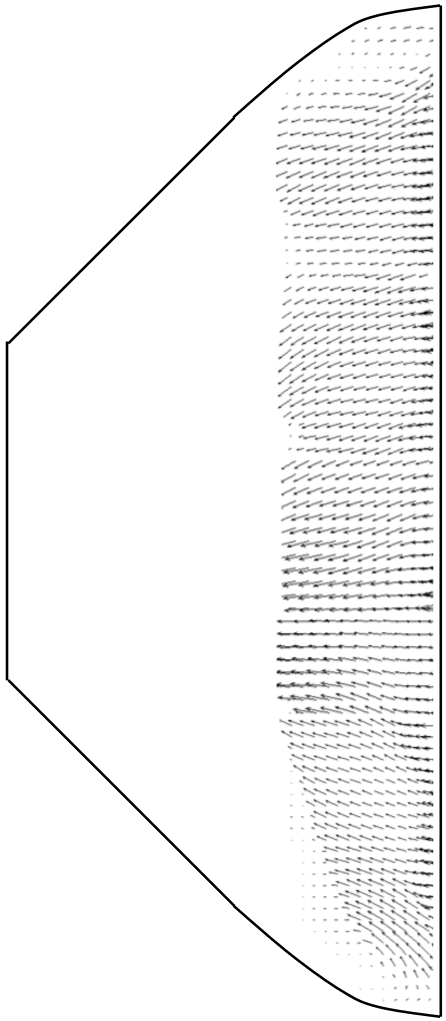



Part 1 Part 2 Part 3 Part 4 Part 5

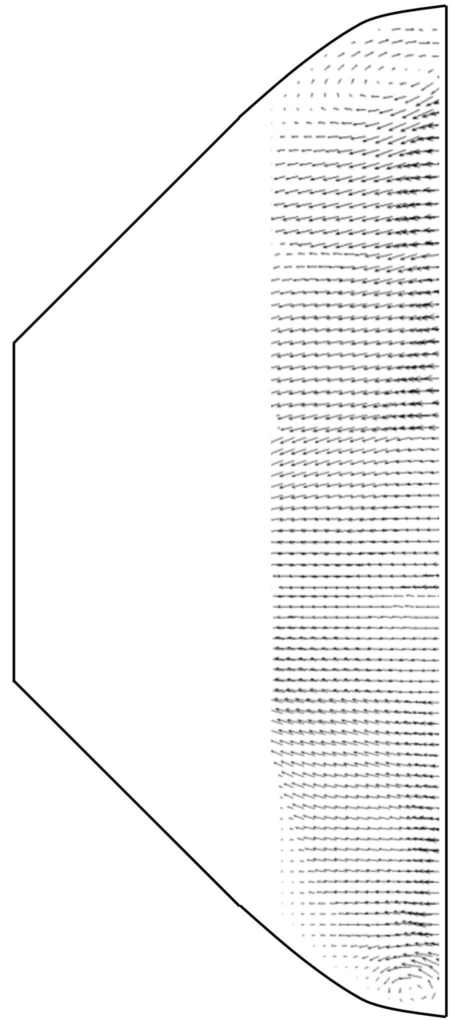
<The velocity fields at the vertical side planes of the channel exit area for presented model>



## ❑ Presented model results[inserting a plate, Outlet header] (4/5)



Middle plane



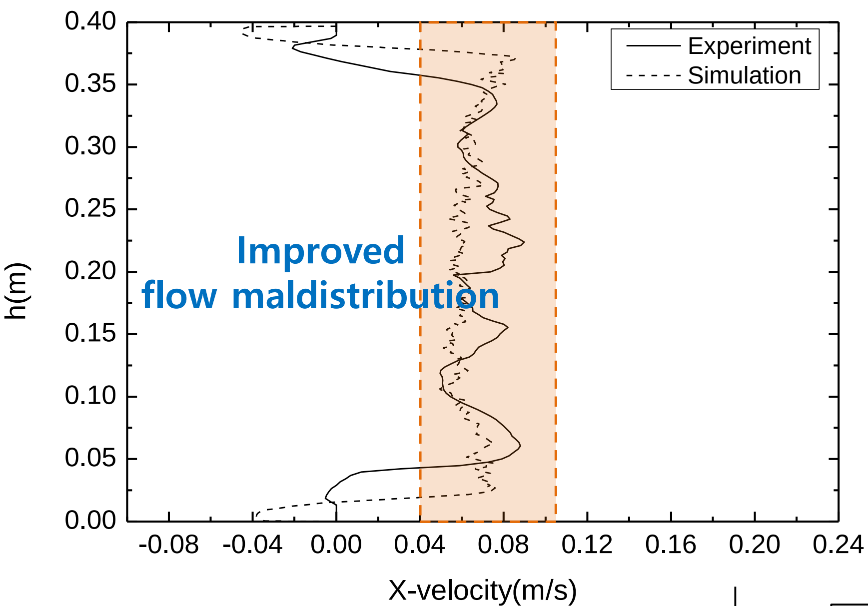
Side plane

<Outlet header>

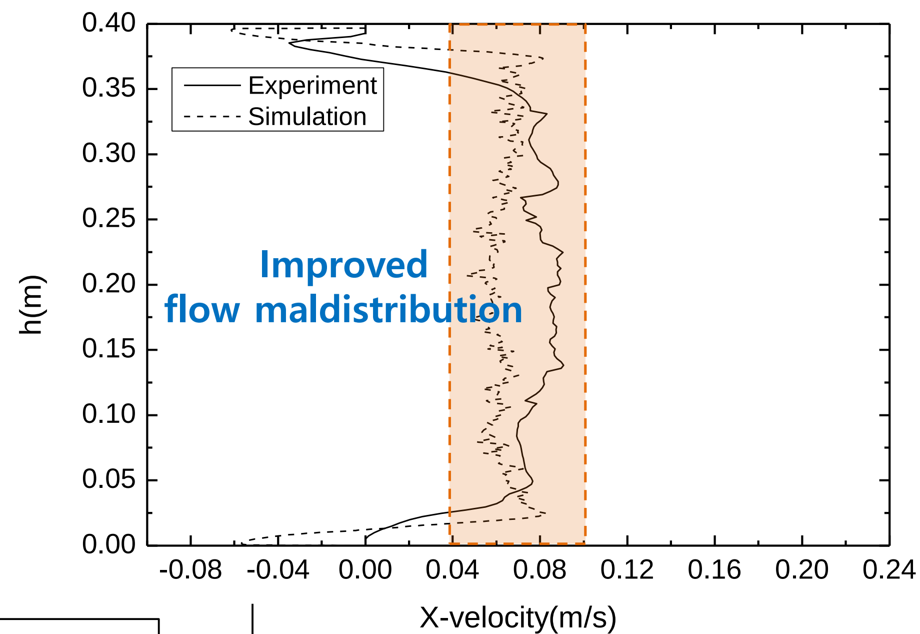
## ❑ Presented model results[inserting a plate, Outlet header] (5/5)

- Calculation of the horizontal flow velocity at 20mm from the channel exit considering the PIV accuracy

<Middle plane>




<Side plane>




Flow **"Similar"**

↓

**Improved**
**flow maldistribution**

- Both results are similar
- Confirmed that the flow velocity in the middle and side planes became uniformly by inserting a perforated plate

# Conclusion

## ❑ Summary

- Experimental verification that the flow maldistribution was improved by inserting a perforated plate
- When a perforated plate is installed, the pressure drop increases by about 13%
- Experiment and simulation results are well matched

<Comparison with experimental and simulation results>

| | | CoV | Pressure drop |
|---|---|---|---|
| Original model | Simulation | 0.2536 | 378.8Pa |
| | Experiment | - | 388.1Pa |
| Presented model | Simulation | 0.0481<br>(81%p decrease<br>compared to the original model) | 477.2Pa<br>(26%p increase<br>compared to the original model) |
| | Experiment | - | 436.7Pa<br>(13%p increase<br>compared to the original model) |