

某项目气液两相流模拟分析过程记录

项目背景:

在装置框架上，两台设备（KA103,VA118）高低布置，液体从高处设备(KA103)通过溢流堰，进入连通管，连通管接入低处设备(VA118)的顶部，VA118 内部设导流管进入设备下部，液体向上返流后通过设备上部的环形堰，堰内液体通过管口流出，两台设备的气相区域设气相连通管，顶部均设排气口，通向外界。

项目目的:

从联通管进入 VA118 的液相，会夹带部分气体进入 VA118，带入的气相在 VA118 内气液分离后会通过气相联通管回到 KA103，核算液相通过连通管时的带气量，气相连通管能否满足气相联通要求。

模型概况:

模型建模采用 GAMBIT，网格划分及计算采用 ANSYS FLUENT 19.0。

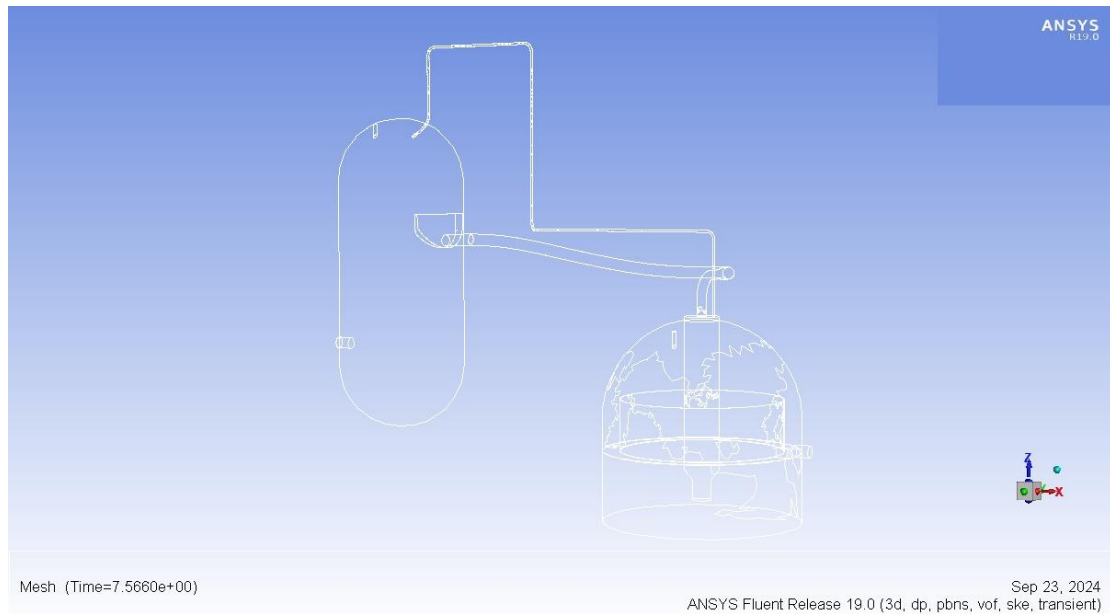
设备基本规格:

KA103 DN3400 H=16390

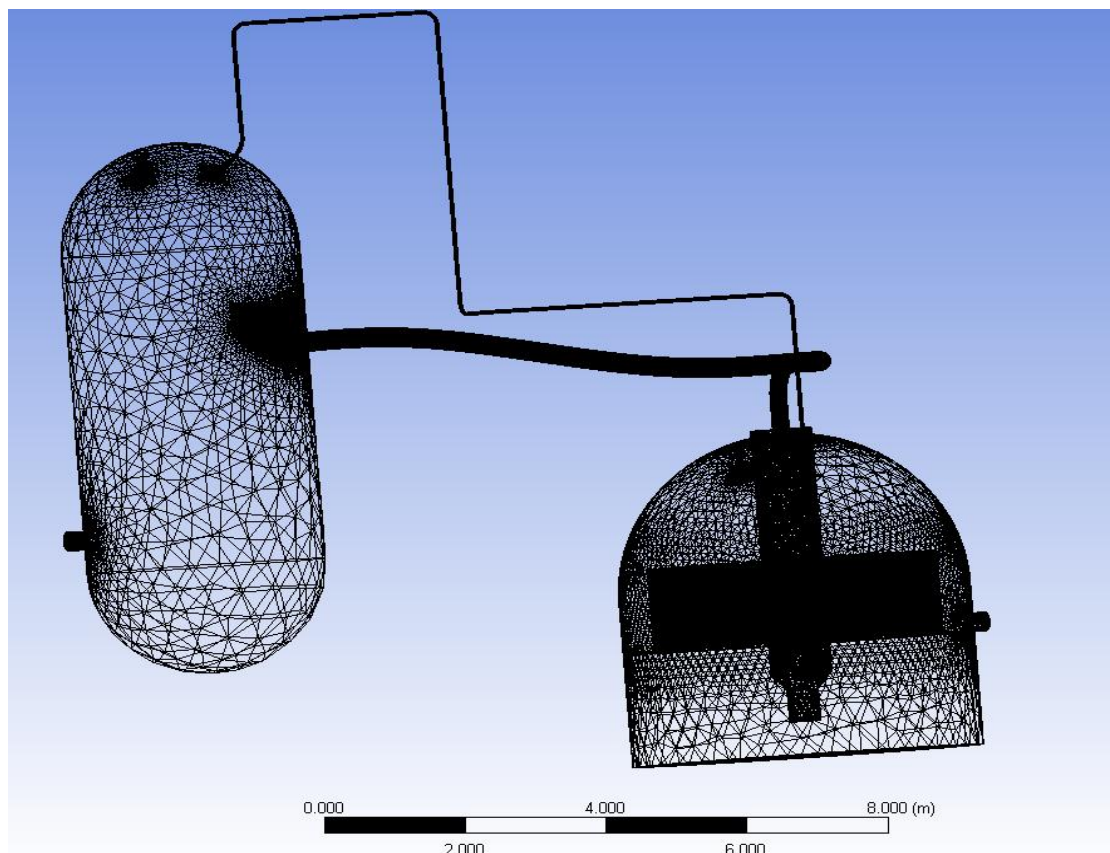
VA118 DN5000 H=12338

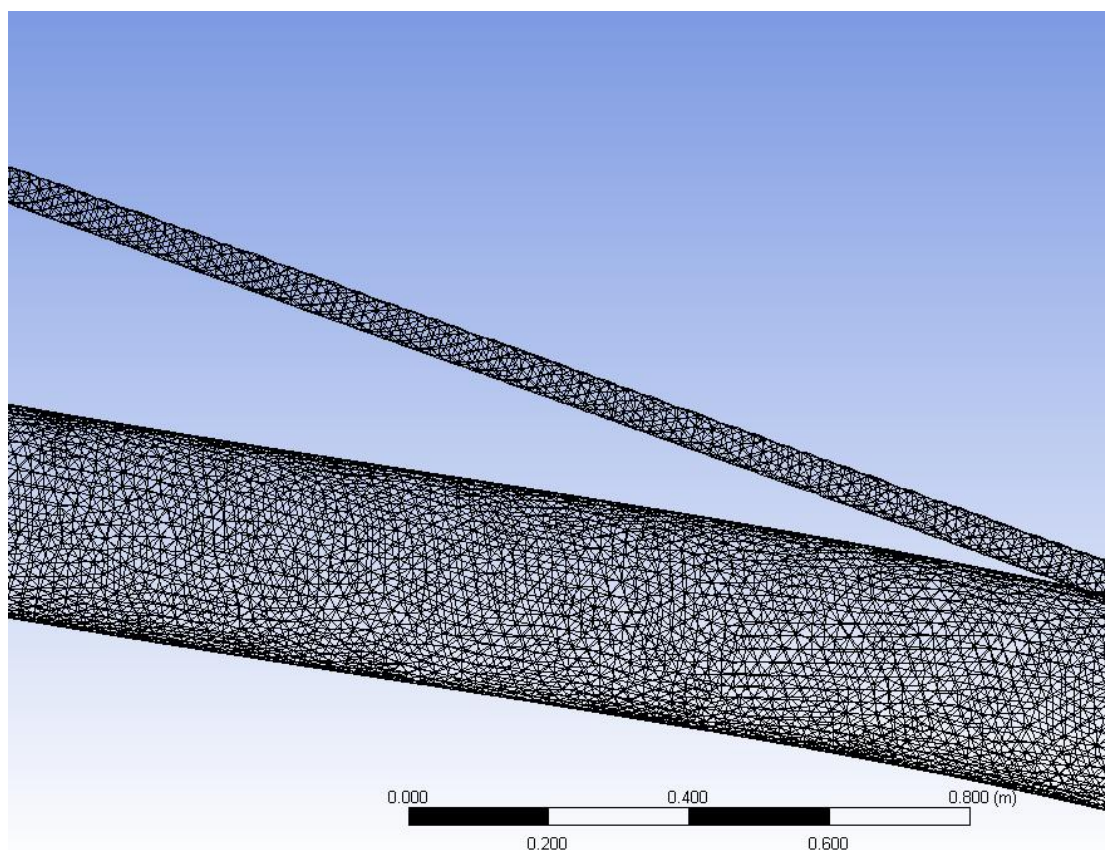
为降低模型的复杂度，对于设备中不必要的管口进行简化，仅保留需要分析的接口及内部结构，具体情况需要对照设备图纸进行说明。

以下图片为设备的基本结构和内部结构的简图（忽略其中的不规则锯齿线，软件生成的，非结构线）



网格划分基本按照软件默认进行，四面积，未处理边界层，只在连通管等小直径区域进行了适当的加密处理，总体网格数量在 161 万左右，详细内容见软件生成的网格报告。



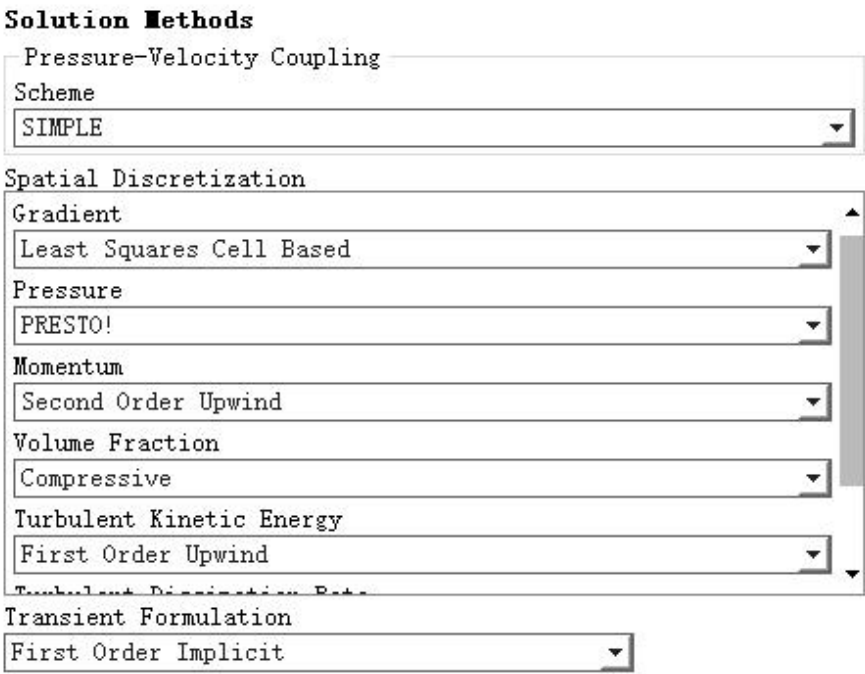


计算设定:

- 1, 总体设定: 采用基于压力的模型, 瞬态, 设置 Z 轴向重力 -9.81m/s^2 ;
- 2, 计算模型: 湍流模型采用标准 $k-\varepsilon$ 模型, 多相流采用 VOF 模型, 气相为主相, 液相为第二相, 两相的交互系数考虑表面张力系数 0.075n/m ; 其它系数保持默认;
- 3, 介质: 液相介质采用水, 气相介质采用空气, 介质性质来源于软件自带参数, 未做修改;
- 4, 单元区域条件: 操作压力: 101325pascal (绝压), 其余保持默认;
- 5, 边界条件: 液相进口采用速度进口, 流速 1.7m/s , 液体分率 0.9 ; 液体出口按自由流出口; 两个气相出口按压力出口, 设置参数为表压为 0 , 与外界环境压力保持一致;

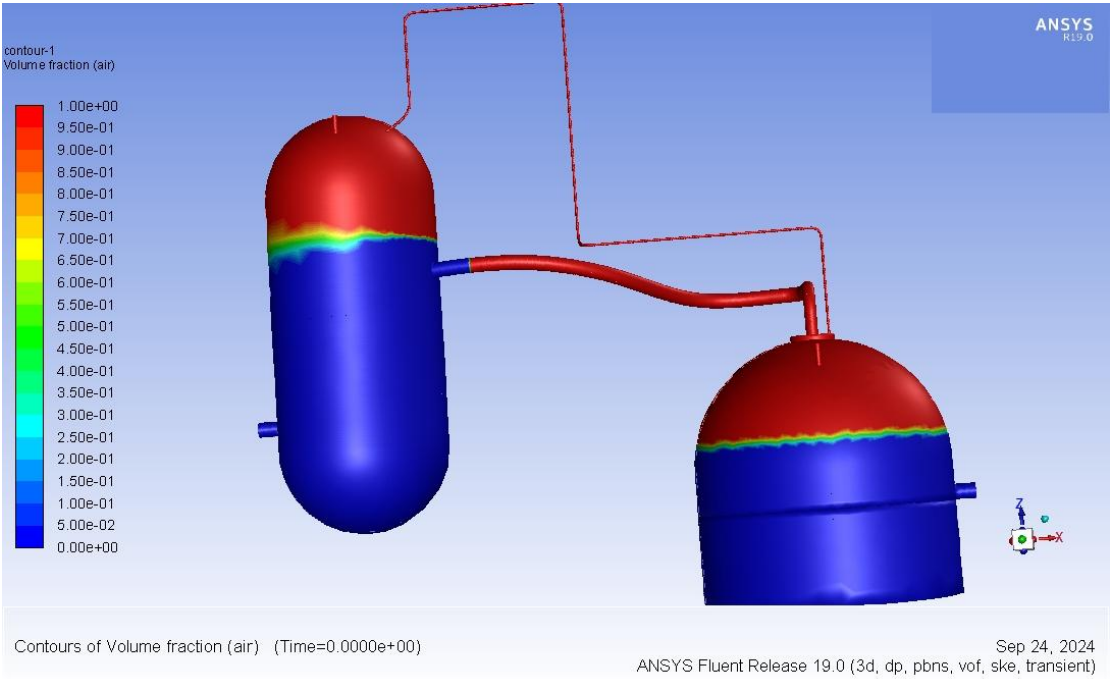
模型计算设定:

解算模型采用 SIMPLE，压力采用 PRESTO!，其余参数未更改，保持默认；



初始化设置：

初始压力设定为表压 0pascal（表压），对两台设备的两相界面进行 patch 操作，完成初始液面位置的设定





说明：界面不平滑，是因为靠近连通管位置网格

```
Updating solution at time level N... done.

iter continuity x-velocity y-velocity z-velocity k epsilon vf-water time/iter
!36285 solution is converged
36285 1.8870e-04 2.3235e-05 2.1989e-05 2.3369e-05 1.2822e-05 7.9204e-04 9.3384e-07 0:01:27 19

reversed flow in 169 faces on pressure-outlet 11.
36286 2.1230e-04 3.5152e-04 3.4368e-04 4.7327e-04 8.9772e-04 1.1646e-02 1.1586e-05 0:01:24 18

reversed flow in 169 faces on pressure-outlet 11.
36287 2.3090e-04 1.3011e-04 1.2538e-04 1.6412e-04 2.2802e-04 4.9482e-03 6.1243e-06 0:01:21 17

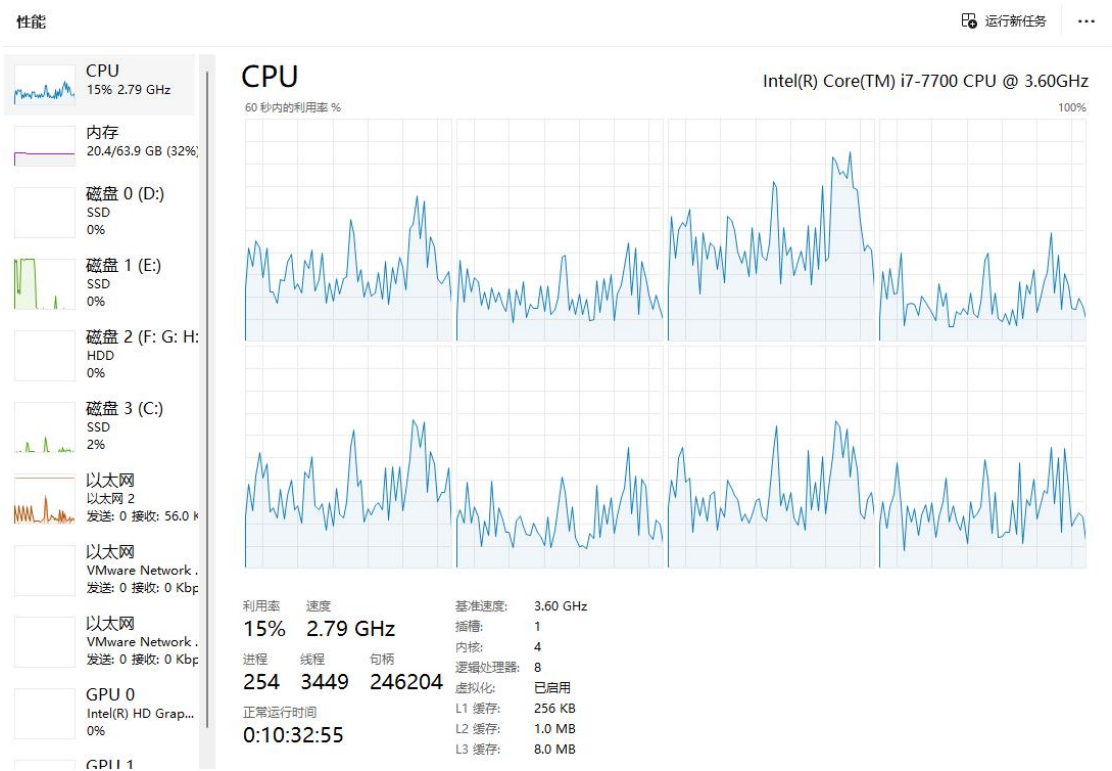
reversed flow in 169 faces on pressure-outlet 11.
36288 2.2294e-04 5.2472e-05 4.8838e-05 6.0290e-05 6.6123e-05 2.3234e-03 3.2528e-06 0:01:13 16

reversed flow in 169 faces on pressure-outlet 11.
36289 2.0765e-04 2.5571e-05 2.3251e-05 2.6798e-05 2.6988e-05 1.4394e-03 1.7367e-06 0:01:10 15

reversed flow in 169 faces on pressure-outlet 11.
!36290 solution is converged
36290 1.9492e-04 2.2842e-05 2.1396e-05 2.3228e-05 1.5347e-05 9.6669e-04 9.3287e-07 0:01:04 14
(update-animation-object "animation-5") ()
Flow time = 7.463999999999999s, time step = 7464
102 more time steps

Updating solution at time level N... done.
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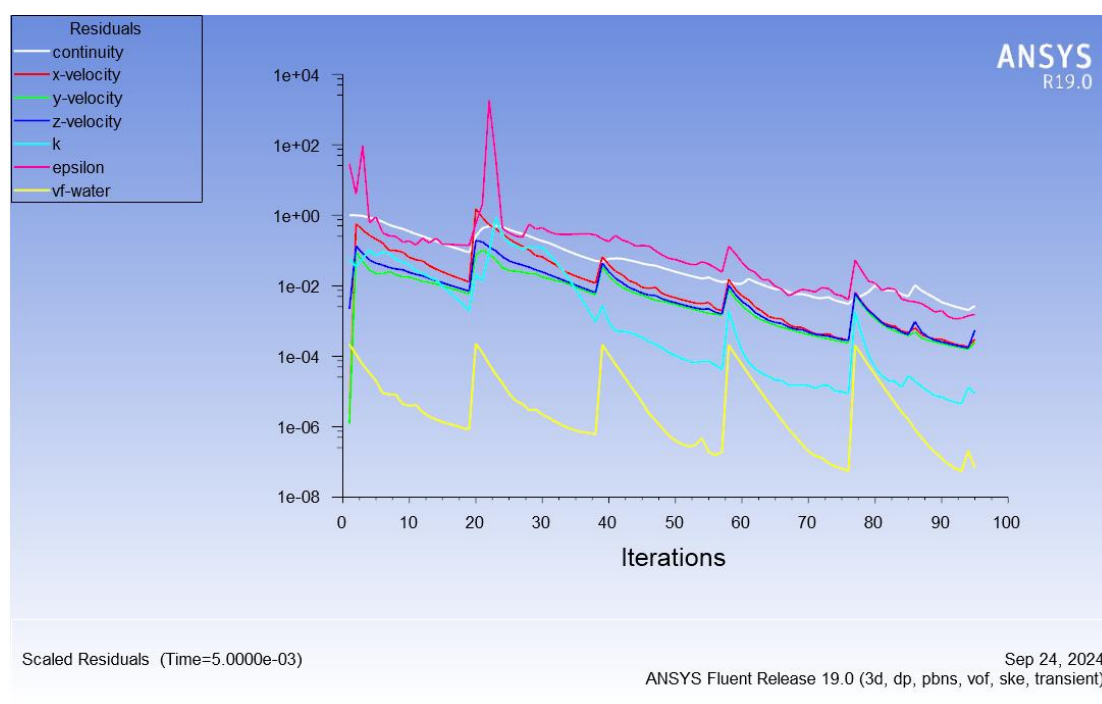
计算机的基本配置



计算中发现的问题：

计算开始的 0.005s 内，每 0.001s，20 步迭代计算后未收敛，设定的两个气体出口存在气相回流，猜测的引发原因是两台设备内出现的低压，压力严重偏离初始设定的 0.000 pascal，设备内部出现负压的原因未知。之前尝试调整出口的边界条件，包括自由流，压力出口等，均出现以上问题。在后续计算的过程中，甚至出现了连通管内液体逆向回流的问题（可以参看生成的过程动画）。

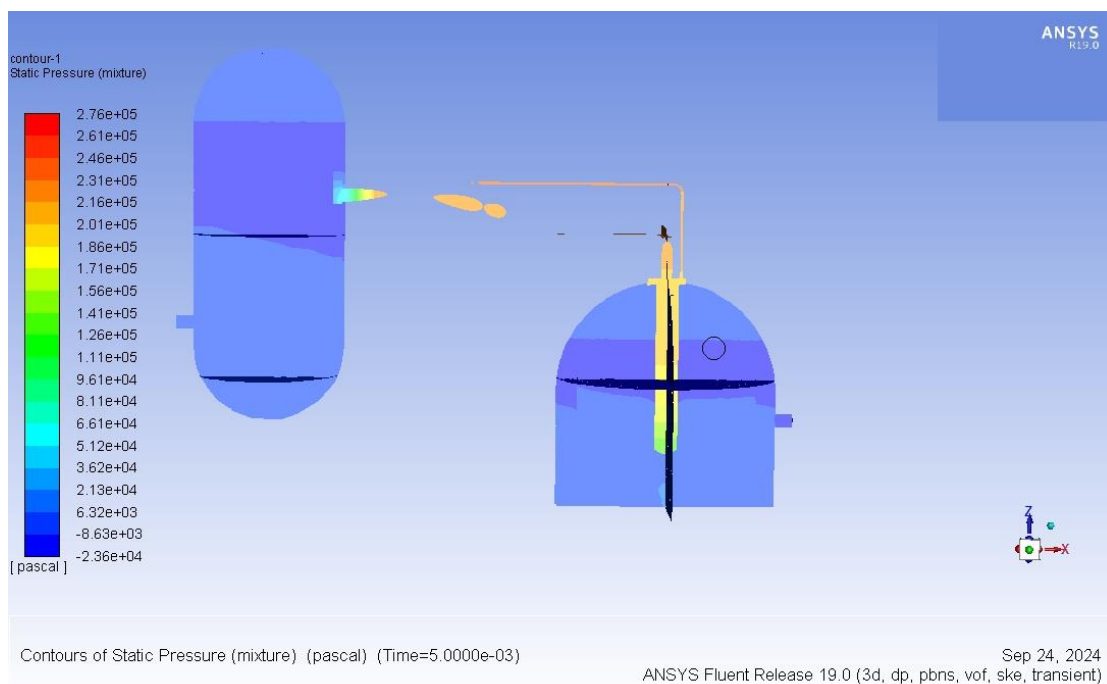
以下为初始阶段的几张软件截图



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reversed flow in 113 faces on pressure-outlet 11.
90 3.4415e-03 3.0292e-04 2.2703e-04 2.5588e-04 7.0098e-06 1.9833e-03 1.2528e-07 0:00:23 5
reversed flow in 29 faces on pressure-outlet 10.
reversed flow in 141 faces on pressure-outlet 11.
91 2.9729e-03 2.5828e-04 2.0516e-04 2.3045e-04 5.7249e-06 1.3391e-03 8.7593e-08 0:00:18 4
reversed flow in 28 faces on pressure-outlet 10.
reversed flow in 141 faces on pressure-outlet 11.
92 2.5865e-03 2.2322e-04 1.8886e-04 2.0707e-04 4.9999e-06 1.1477e-03 6.7073e-08 0:00:13 3
reversed flow in 27 faces on pressure-outlet 10.
reversed flow in 141 faces on pressure-outlet 11.
93 2.2941e-03 2.0342e-04 1.7224e-04 1.8833e-04 4.5187e-06 1.1996e-03 5.4278e-08 0:00:09 2
reversed flow in 27 faces on pressure-outlet 10.
reversed flow in 125 faces on pressure-outlet 11.
94 2.0553e-03 1.9043e-04 1.5653e-04 1.7183e-04 1.3231e-05 1.4187e-03 2.0880e-07 0:00:04 1
reversed flow in 27 faces on pressure-outlet 10.

```



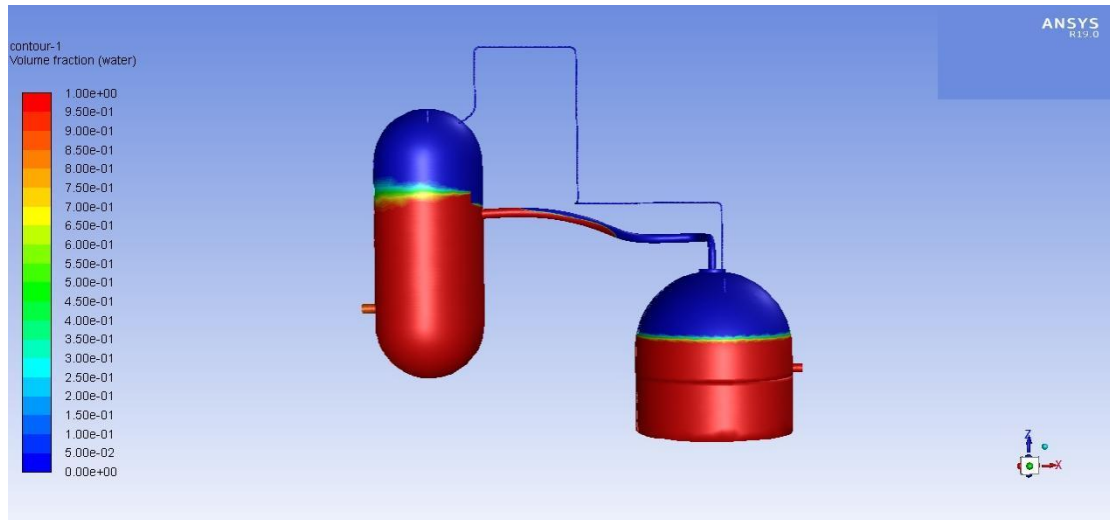
联系人：逯振飞

联系电话：18866537699

职务：工艺设计工程师

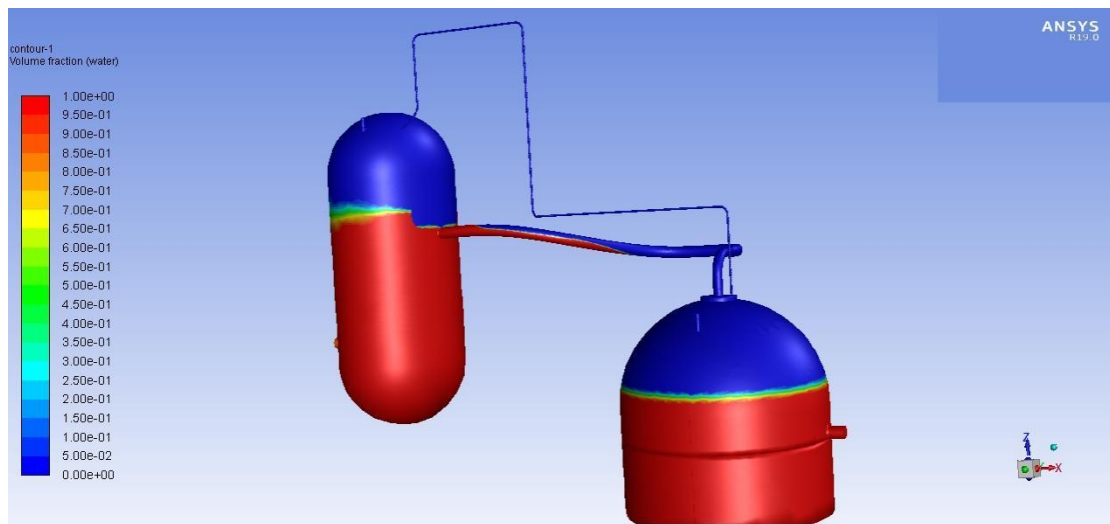
2024 年 9 月 24 日星期二

以下附图中为计算过程中截取的状态画面，便于开展过程状态的分析



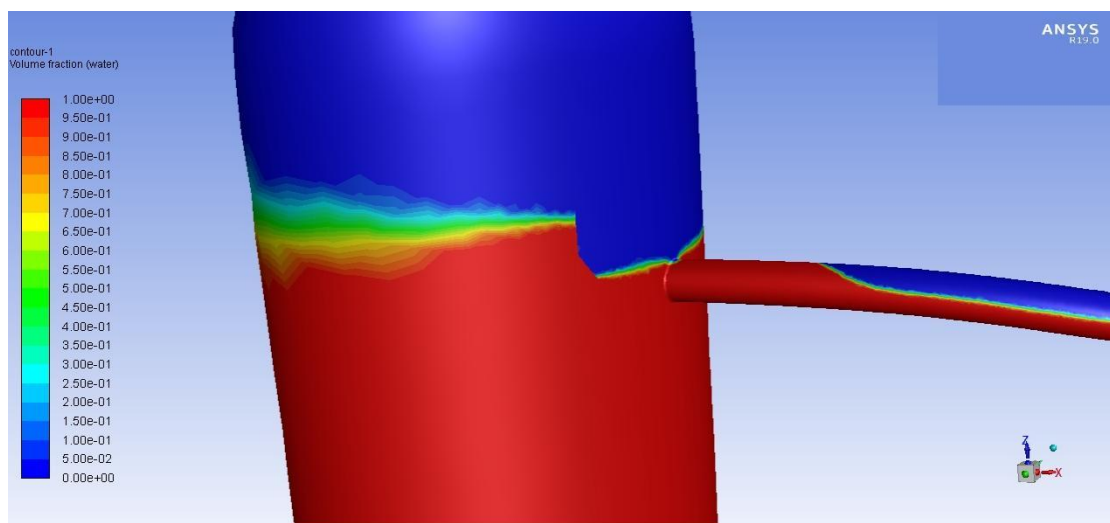
Contours of Volume fraction (water) (Time=1.7210e+00)

Sep 18, 2024
ANSYS Fluent Release 19.0 (3d, dp, pbns, vof, ske, transient)



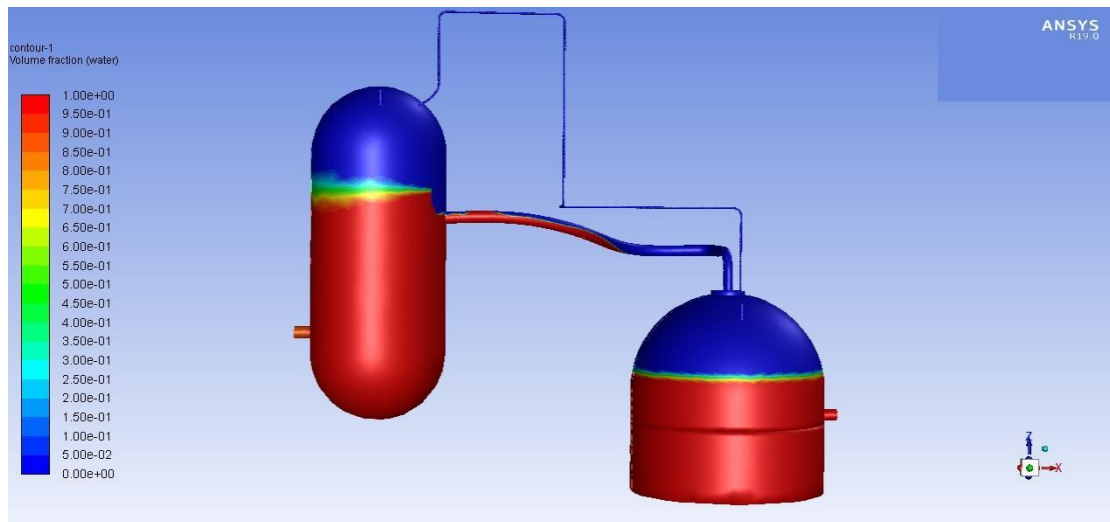
Contours of Volume fraction (water) (Time=2.2210e+00)

Sep 18, 2024
ANSYS Fluent Release 19.0 (3d, dp, pbns, vof, ske, transient)



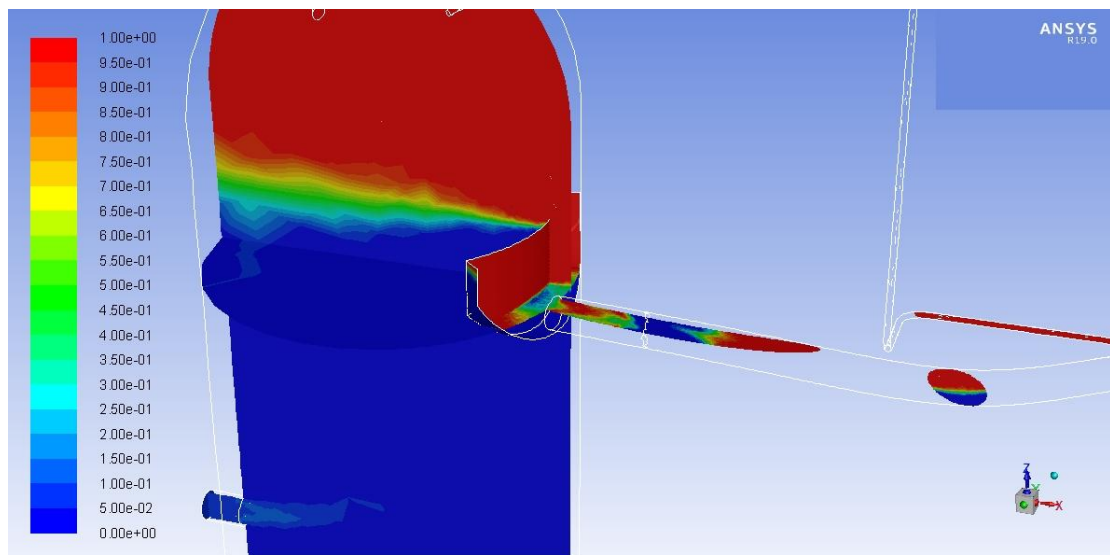
Contours of Volume fraction (water) (Time=2.2210e+00)

Sep 18, 2024
ANSYS Fluent Release 19.0 (3d, dp, pbns, vof, ske, transient)



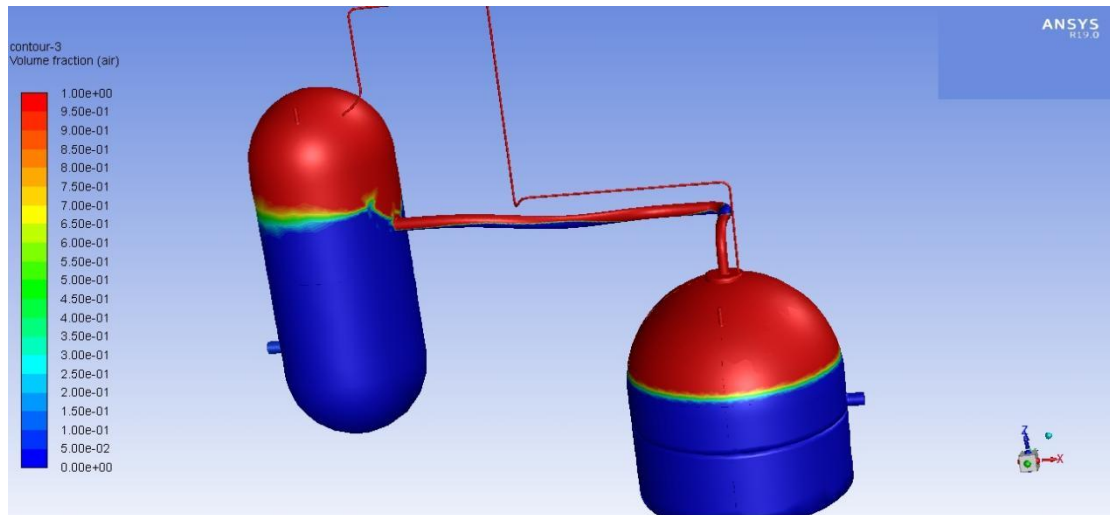
Contours of Volume fraction (water) (Time=2.7210e+00)

Sep 18, 2024
ANSYS Fluent Release 19.0 (3d, dp, pbns, vof, ske, transient)



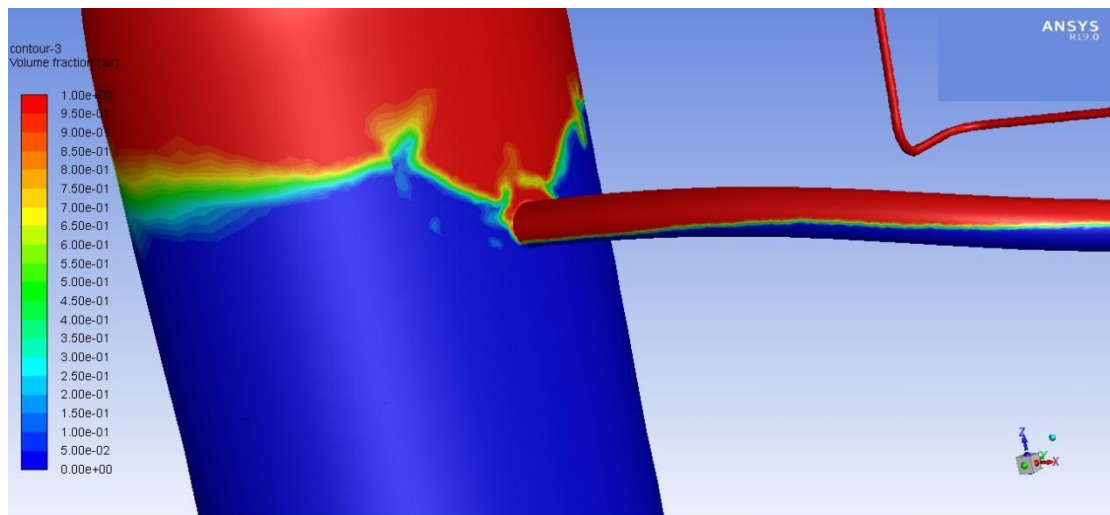
Sweep Surface: Contours of Volume fraction (air)

Sep 18, 2024
ANSYS Fluent Release 19.0 (3d, dp, pbns, vof, ske, transient)



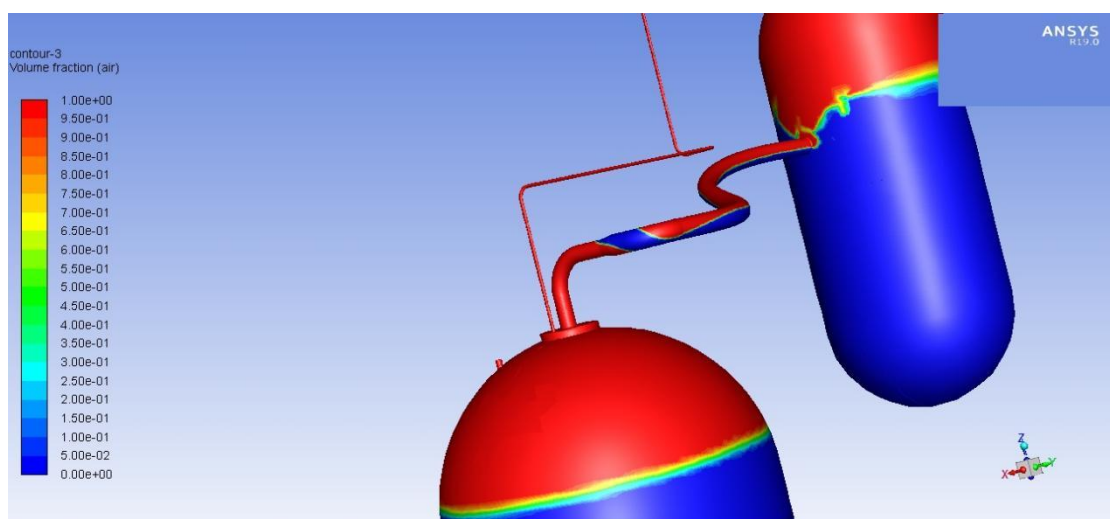
Contours of Volume fraction (air) (Time=3.4160e+00)

Sep 20, 2024
ANSYS Fluent Release 19.0 (3d, dp, pbns, vof, ske, transient)



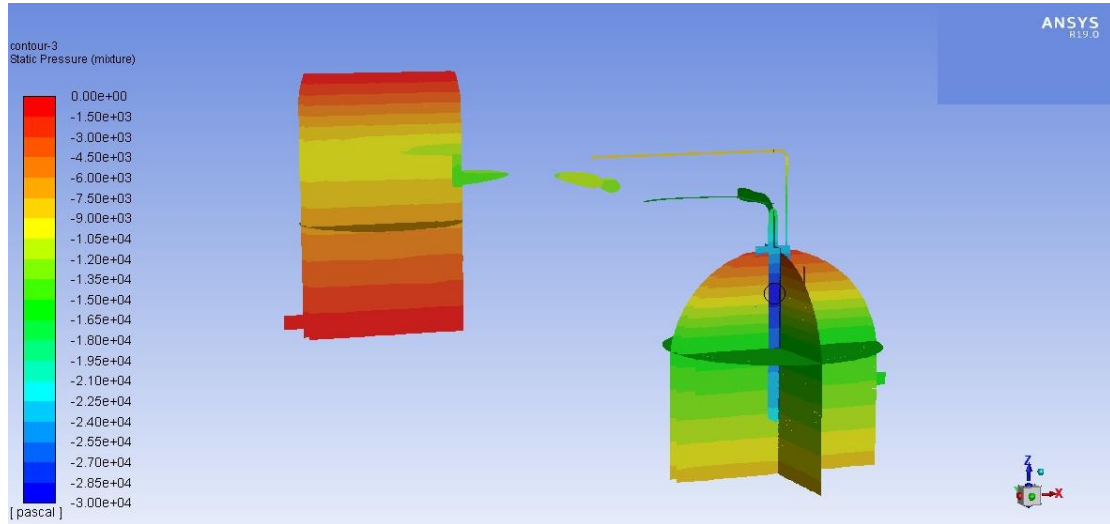
Contours of Volume fraction (air) (Time=3.4160e+00)

Sep 20, 2024
ANSYS Fluent Release 19.0 (3d, dp, pbns, vof, ske, transient)



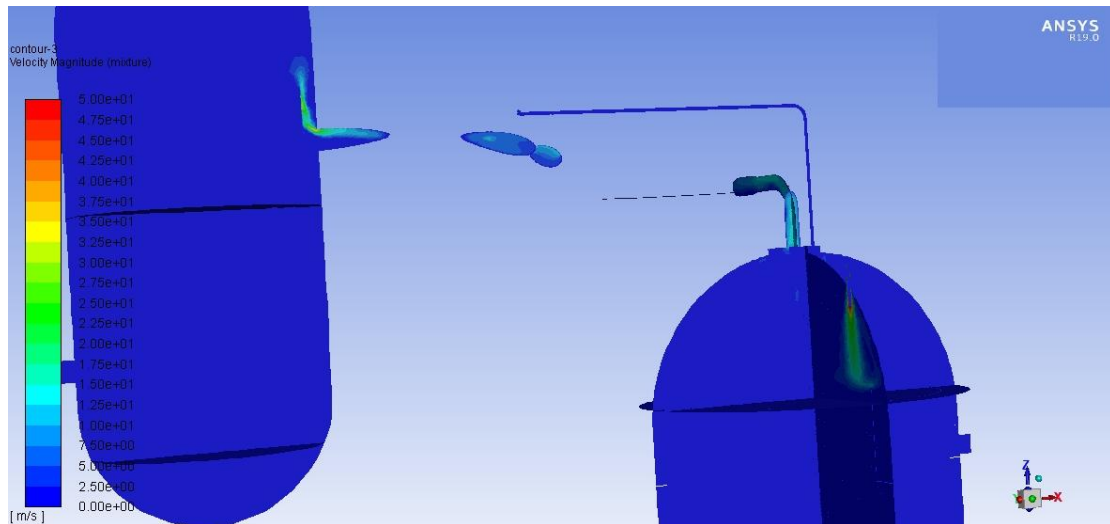
Contours of Volume fraction (air) (Time=3.4160e+00)

Sep 20, 2024
ANSYS Fluent Release 19.0 (3d, dp, pbns, vof, ske, transient)



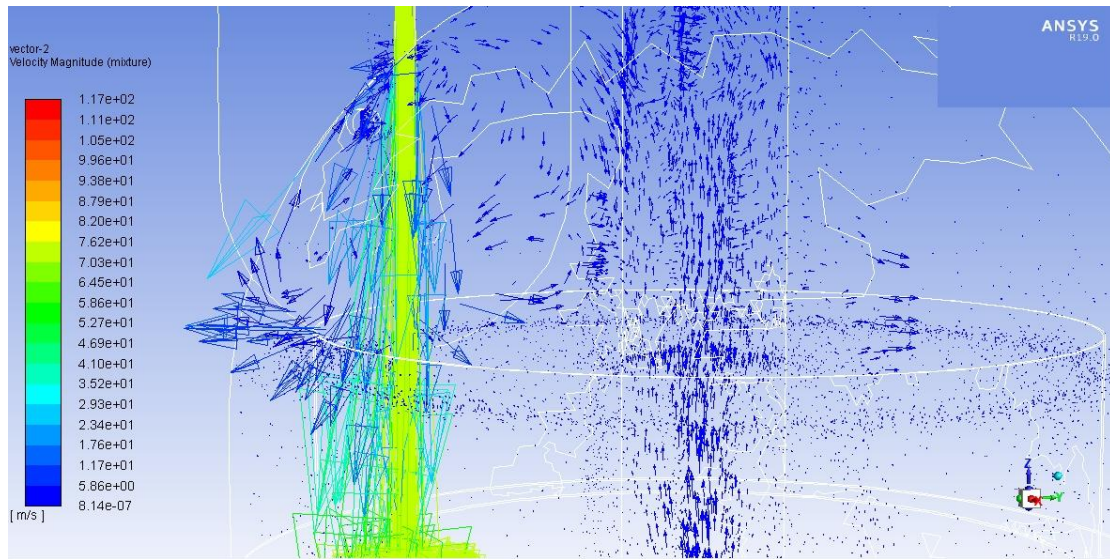
Contours of Static Pressure (mixture) (pascal) (Time=5.0980e+00)

Sep 21, 2024
ANSYS Fluent Release 19.0 (3d, dp, pbns, vof, ske, transient)



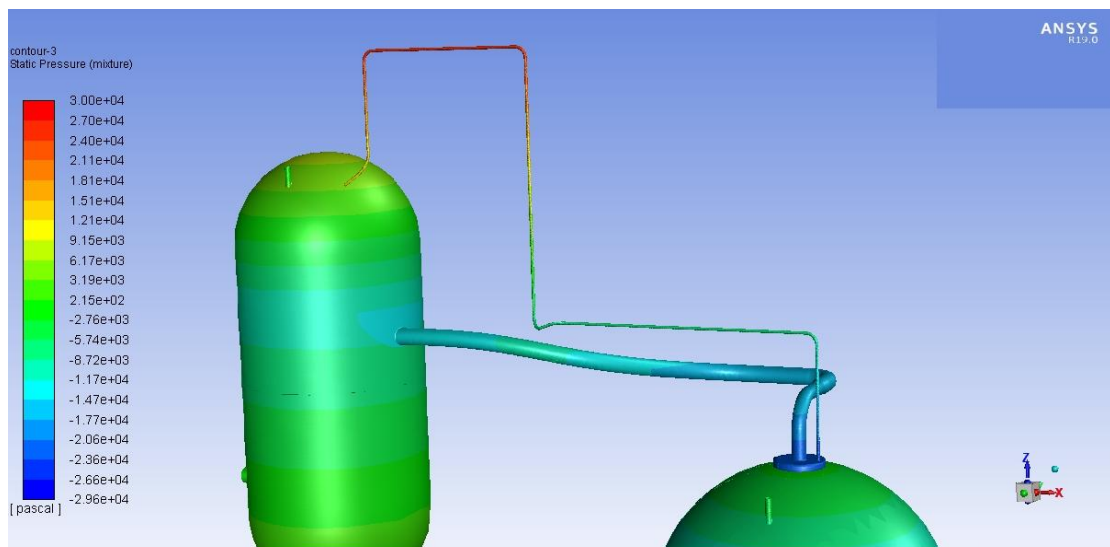
Contours of Velocity Magnitude (mixture) (m/s) (Time=5.0980e+00)

Sep 21, 2024
ANSYS Fluent Release 19.0 (3d, dp, pbns, vof, ske, transient)



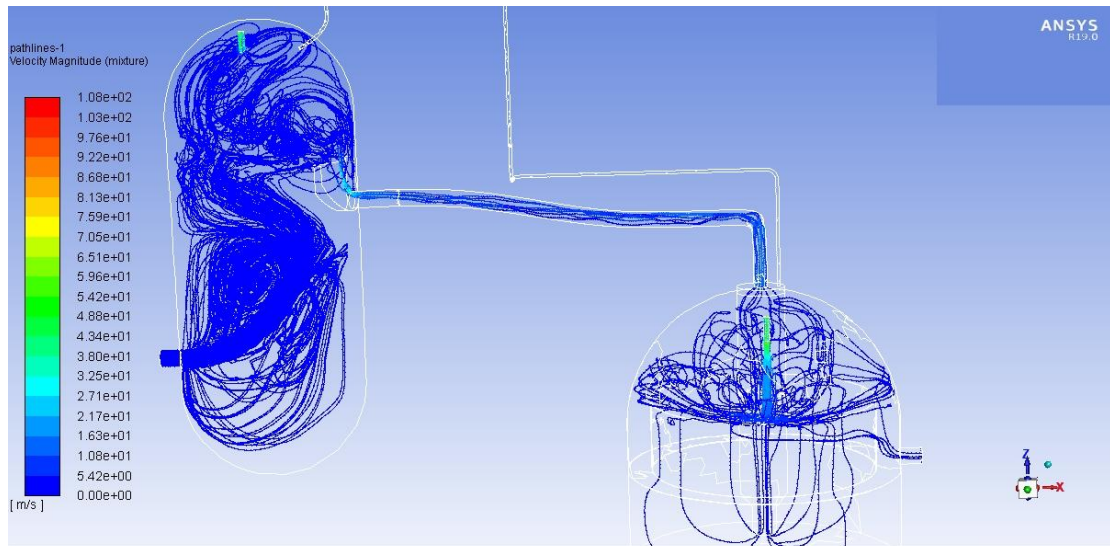
Velocity Vectors Colored By Velocity Magnitude (mixture) (m/s) (Time=5.0980e+00)

Sep 21, 2024
ANSYS Fluent Release 19.0 (3d, dp, pbns, vof, ske, transient)



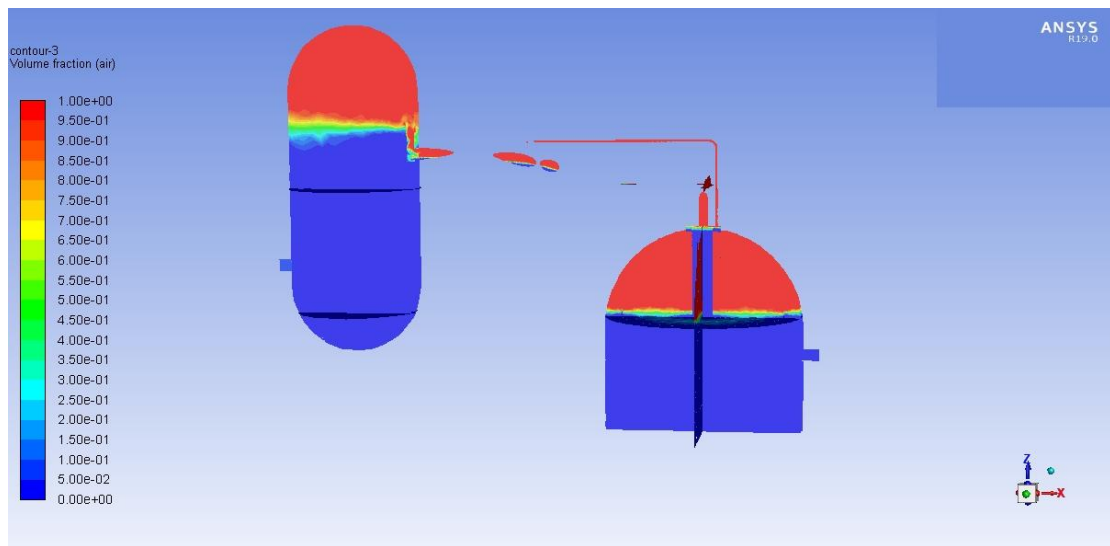
Contours of Static Pressure (mixture) (pascal) (Time=5.0980e+00)

Sep 21, 2024
ANSYS Fluent Release 19.0 (3d, dp, pbns, vof, ske, transient)



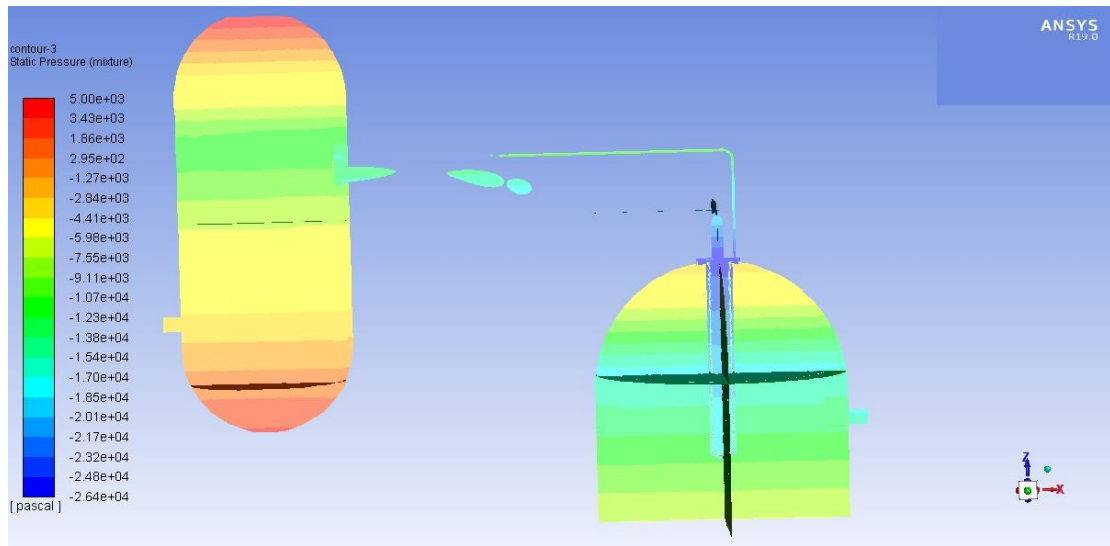
Pathlines Colored by Velocity Magnitude (mixture) (m/s) (Time=5.0980e+00)

Sep 21, 2024
ANSYS Fluent Release 19.0 (3d, dp, pbns, vof, ske, transient)



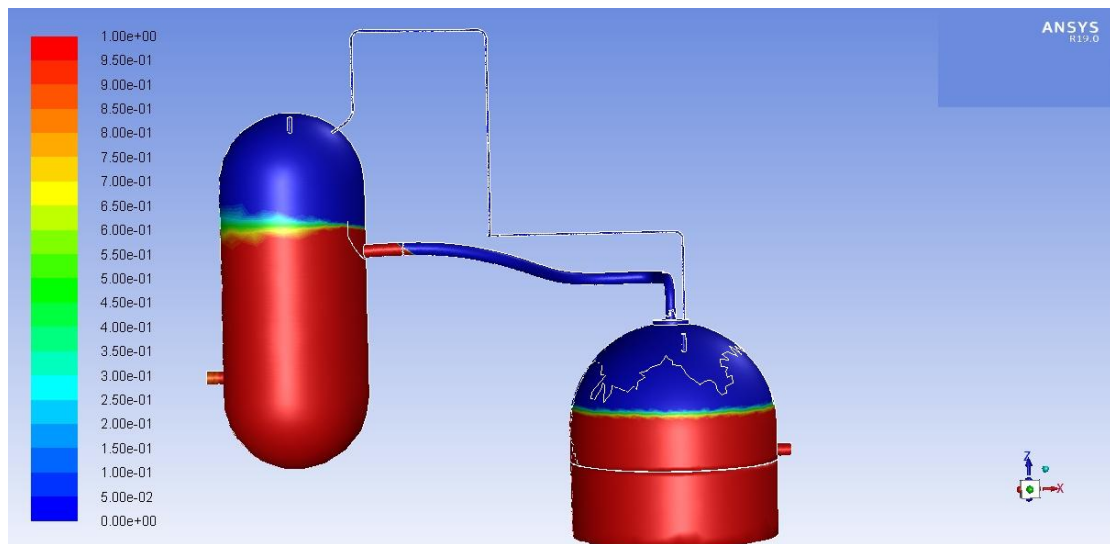
Contours of Volume fraction (air) (Time=6.5660e+00)

Sep 23, 2024
ANSYS Fluent Release 19.0 (3d, dp, pbns, vof, ske, transient)



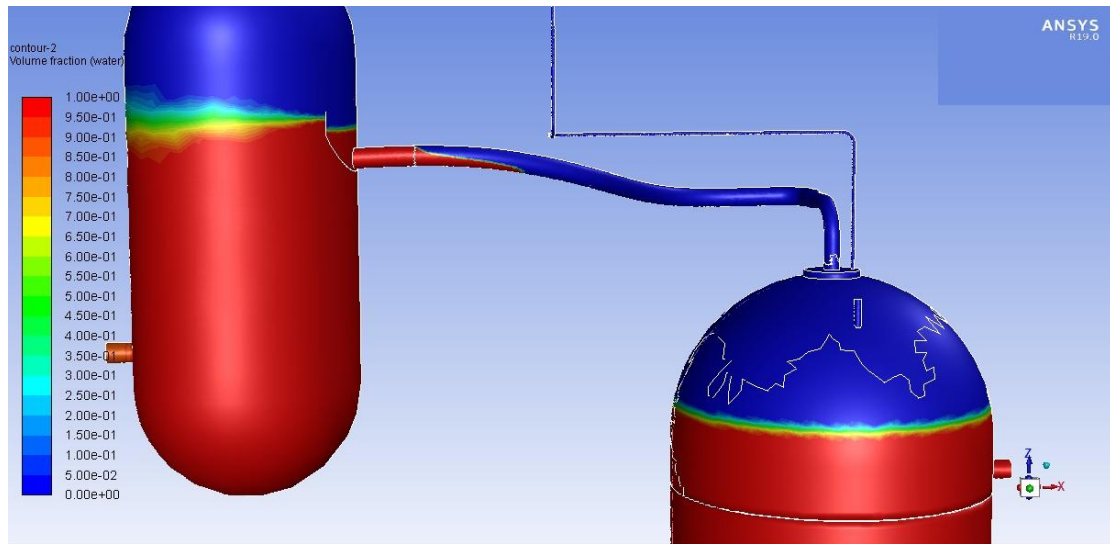
Contours of Static Pressure (mixture) (pascal) (Time=6.5660e+00)

Sep 23, 2024
ANSYS Fluent Release 19.0 (3d, dp, pbns, vof, ske, transient)



Contours of Volume fraction (water) (Time=2.2100e-01)

Sep 14, 2024
ANSYS Fluent Release 19.0 (3d, dp, pbns, vof, ske, transient)



Contours of Volume fraction (water) (Time=7.2100e-01)

Sep 14, 2024
ANSYS Fluent Release 19.0 (3d, dp, pbns, vof, ske, transient)