유로 형상 및 가스켓에 따른 고분자 전해질 연료전지 금속분리판의 변형 해석

우주최강 팀

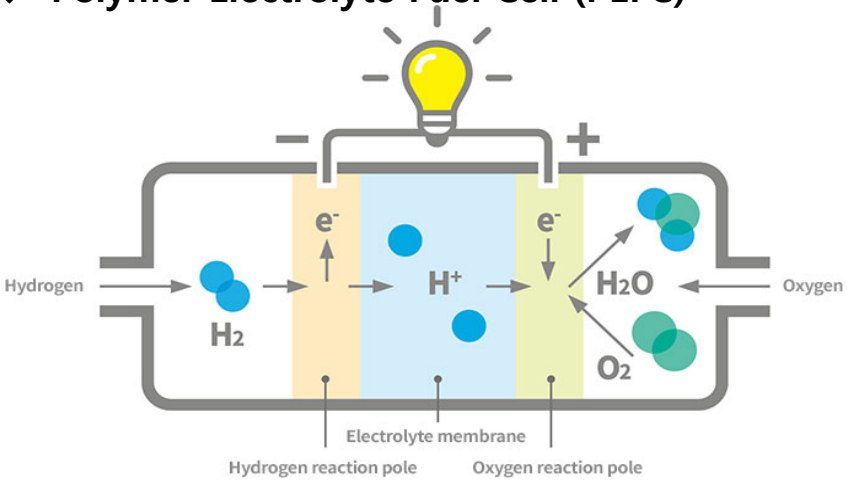
Team ‘The strongest in the universe’

UOS Energy Laboratory

Contents

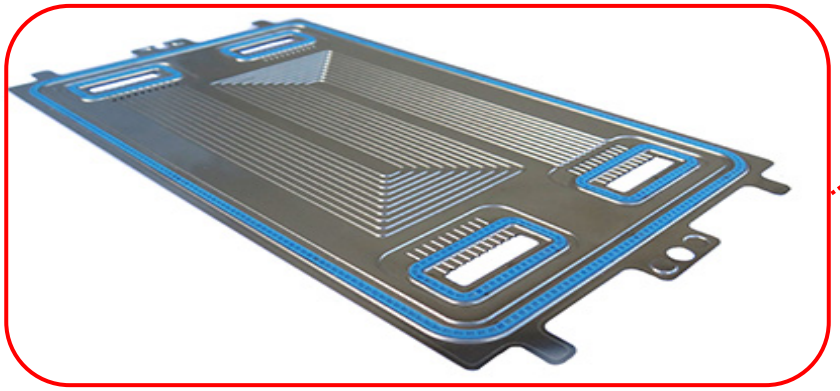
Introduction

◆ **Polymer Electrolyte Fuel Cell (PEFC)**

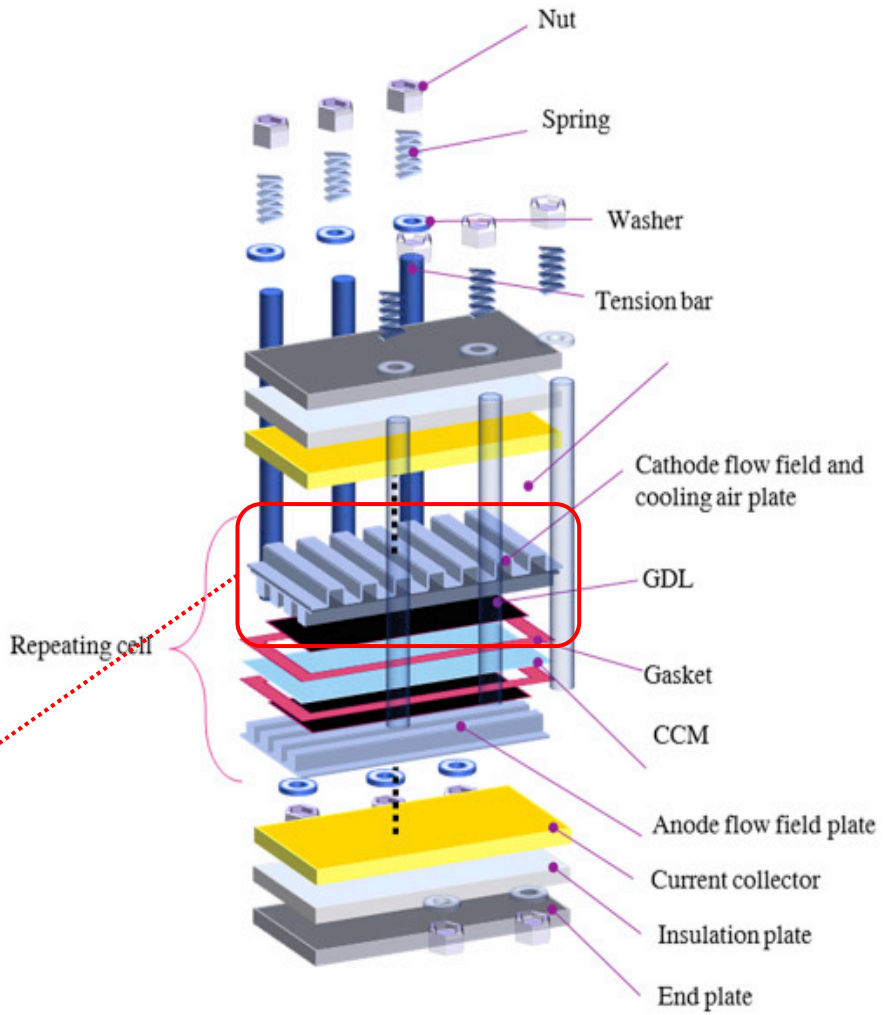


◆ **Metal Bipolar Plate for Automobiles**

⇒ **Weight ↓ Volume ↓ Safety ↑**

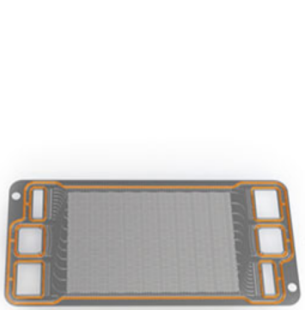


◆ **Fastening Structure of PEFC**

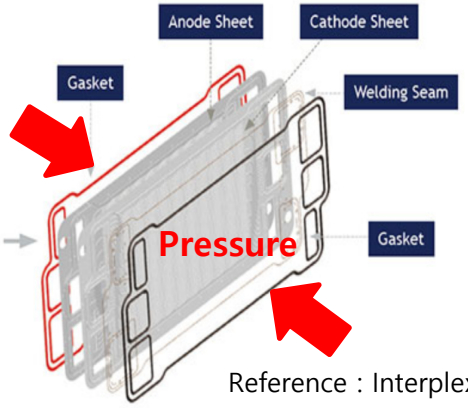


Introduction

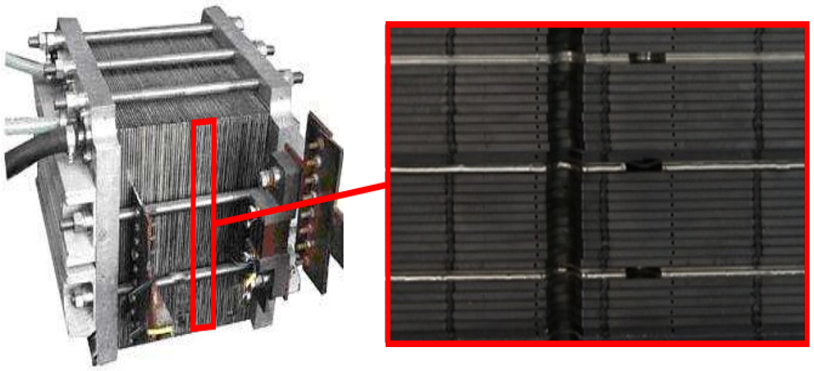
◆ **Problem of Metal Bipolar Plate**



t : 0.1mm



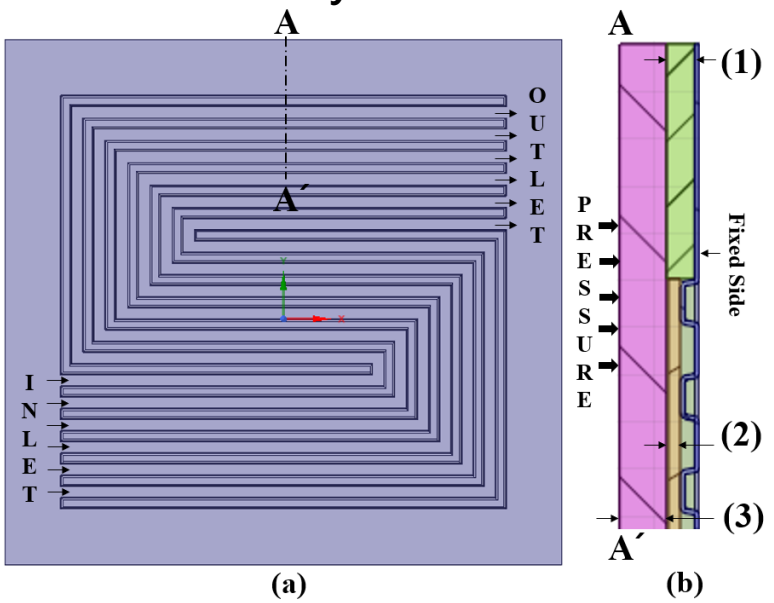
Reference : Interplex



Referece : wikitree

Buckling Phenomenon of Stack

◆ **Structural Analysis**



⇒ **Single Cell (50mm×50mm)**

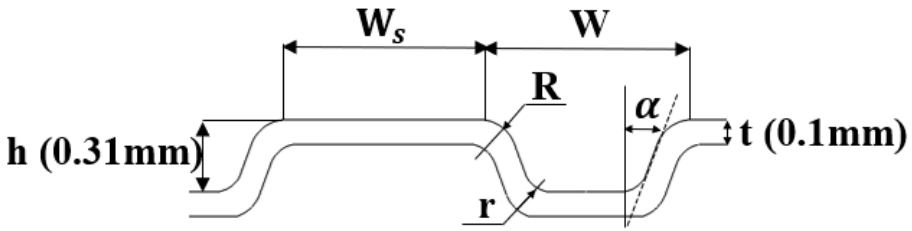
(1) Gasket (0.6mm)
(2) GDL (0.29mm)
(3) End-Plate (1mm)
(4) Bipolar Plate

⇒ **Case Study**

(1) Shape of Flow path
(2) Material of Gasket
(3) Width of Gasket

Flow Path Analysis

◆ Dimensions



(1) Height (h) : 0.31 [mm]
(2) Width (W, W_s) : 1 [mm]
(3) Thickness (t) : 0.1 [mm]
(4) Draft Angle (α) : 10 ~ 30 [°]
(5) Fillet Radius (R) : 1.5 ~ 2 [mm]

⇒ 15 Cases

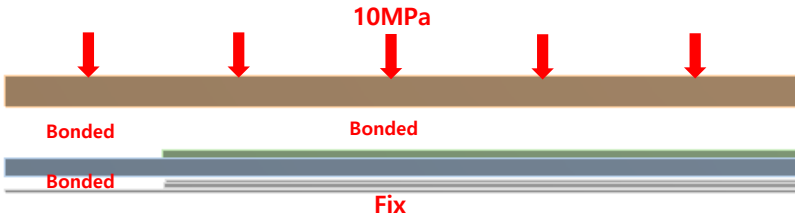
α [°] / R [mm]	10	15	20	25	30
0.150	Case 1	Case 2	Case 3	Case 4	Case 5
0.175	Case 6	Case 7	Case 8	Case 9	Case 10
0.200	Case 11	Case 12	Case 13	Case 14	Case 15

◆ Material Properties of Components

Component	B.P.	Gasket	GDL
material	SS430	EPDM Rubber	Carbon Paper
Density ($kg \cdot m^{-3}$)	7700	1430	7850
Young's modulus E (MPa)	195000	6.0	225000
Poisson's ratio ν	0.275	0.49	0.3

◆ Conditions

(1) All bonded conditions
(2) 10MPa Pressure to Endplate
(3) Same contact surfaces on all cases
(4) Use EPDM Rubber Sheet



Flow Path Analysis

◆ **Results**

Fig. 1 Deformation of Bipolar plate (a) Top view, (b) Side view

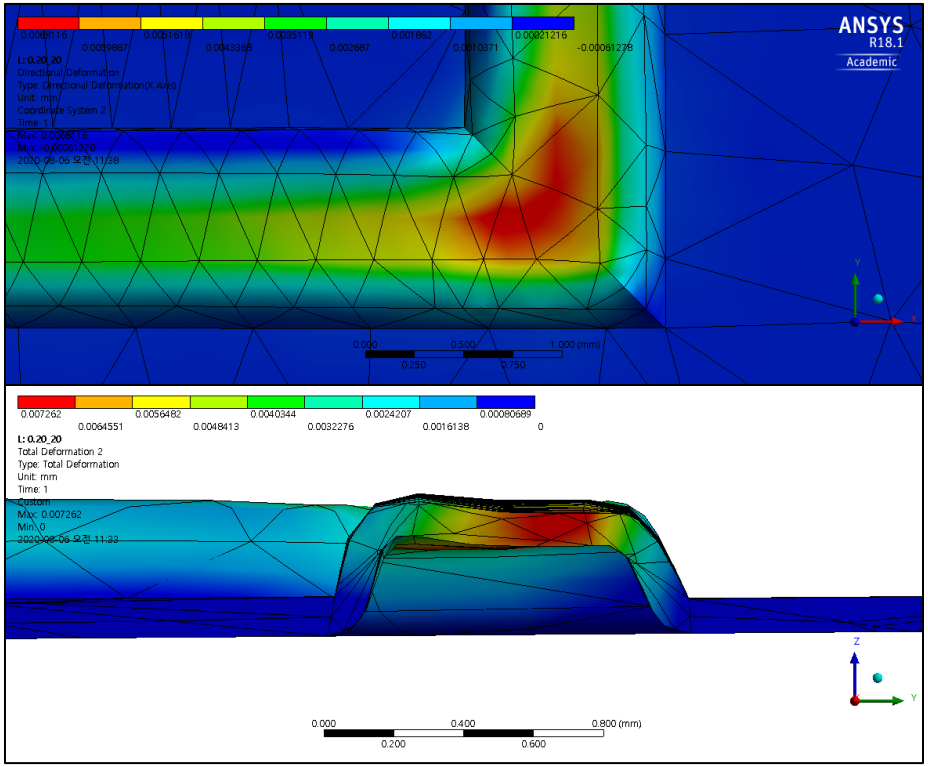
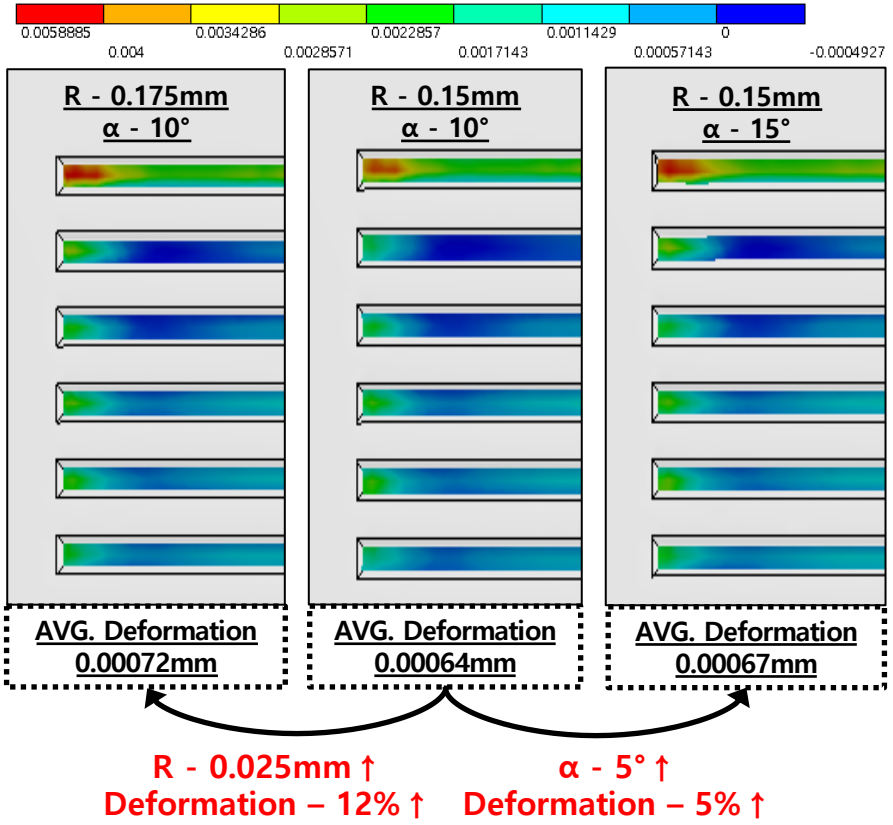


Fig. 2 Deformation of Bipolar plate on reference face



⇒ **Shape of the deformation is sinking shape**

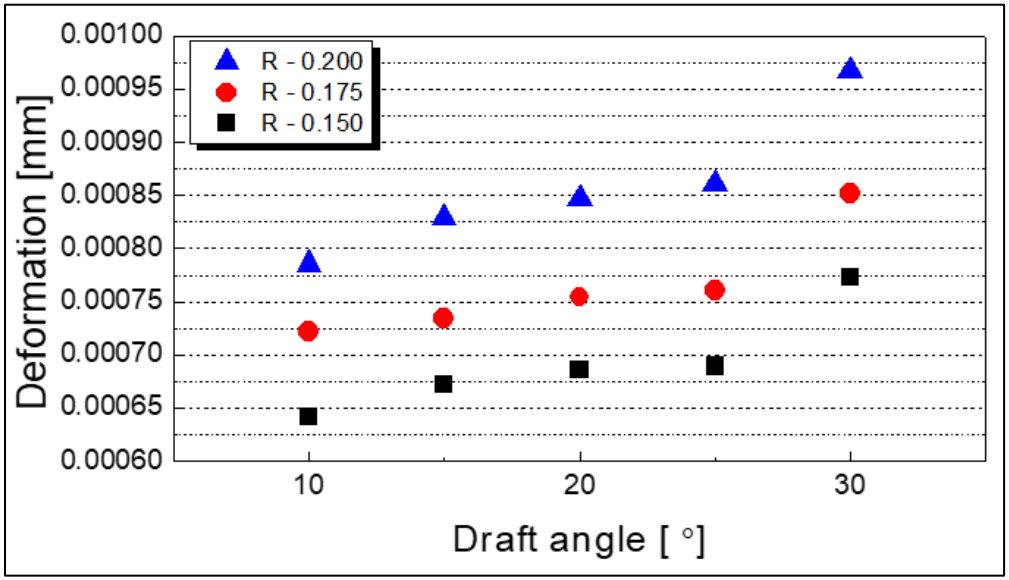
⇒ **Based on the deformation in the Z-direction of the face with reference to the Global coordinate system**

⇒ **R, α ∝ Deformation of Flow path**

Flow Path Analysis

◆ **Results**

Fig. 3 Case study results for average deformation of Bipolar plate

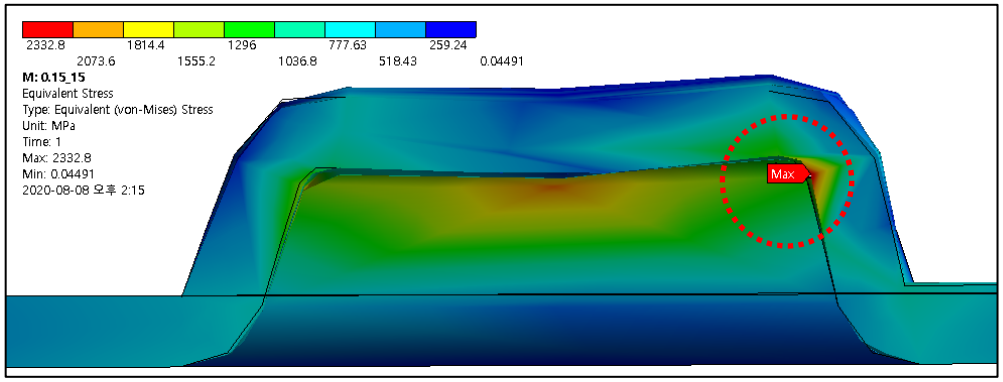


⇒ As the draft angle and fillet radius increase, the average deformation increases.

⇒ The least deformation occurs when the fillet radius and draft angle are minimized.

⇒ The gap between maximum and minimum deformation is about 0.0003mm (50% ↑)

Fig. 4 Von-Mises stress of Bipolar plate

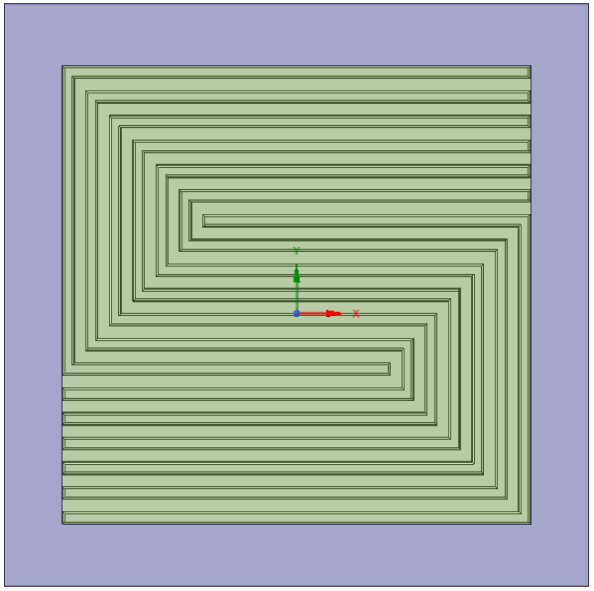


⇒ As the draft angle and fillet radius increase, the stress is concentrated in a specific region.

⇒ As a result, the flow path collapses due to the deformation of the region

Gasket Analysis _ Material

◆ Geometry



⇒ The model of Bipolar plate is R – 0.15mm, α – 10°

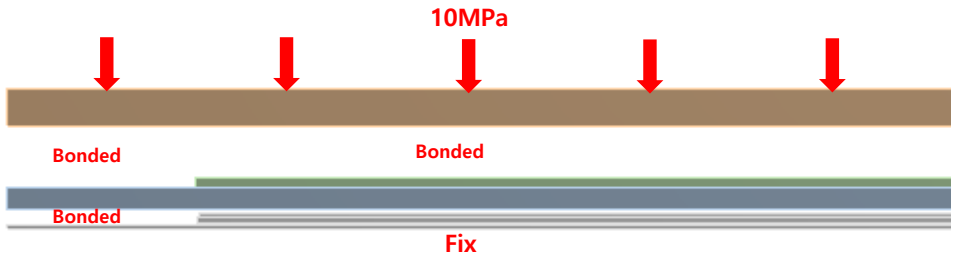
⇒ Properties of Gasket

Component	Gasket	
Material	Silicone adhesive	EPDM Rubber
Density $(kg \cdot m^{-3})$	1050	1430
Young's modulus E (MPa)	0.9	6.0
Poisson's ratio ν	0.49	0.49

⇒ Gasket Width : 5mm

◆ Conditions

(1) All bonded conditions
(2) 10MPa Pressure to Endplate
(3) Same contact surfaces on all cases



Gasket Analysis _ Material

◆ **Results**

Fig. 5 Pressure at the contact surface of the gasket and BP

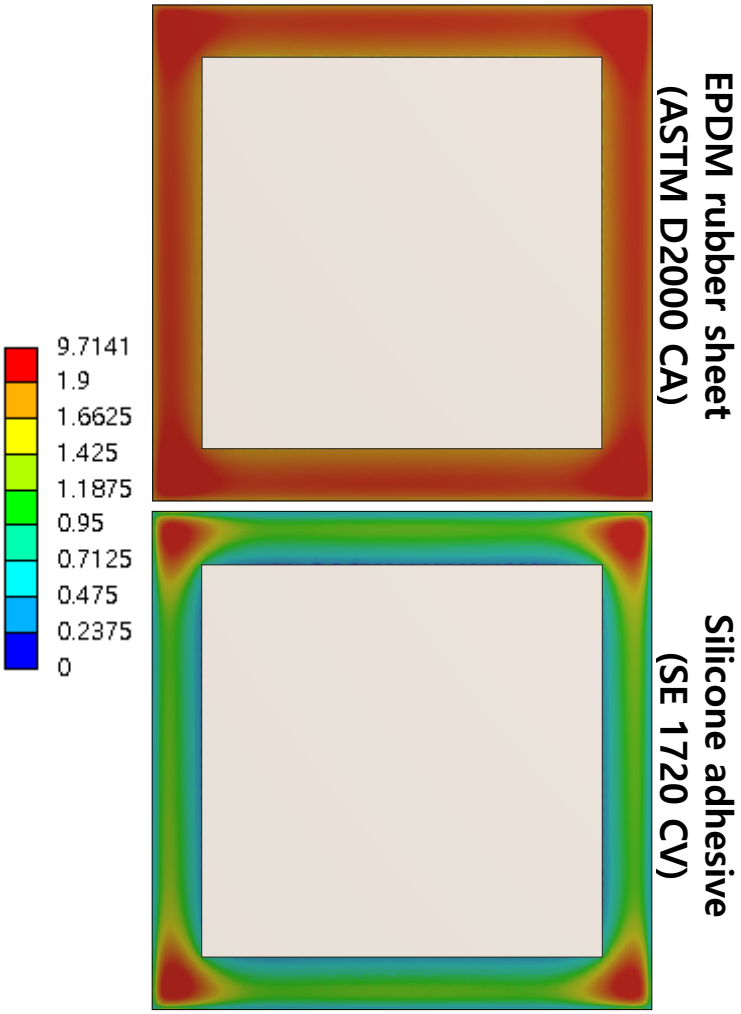
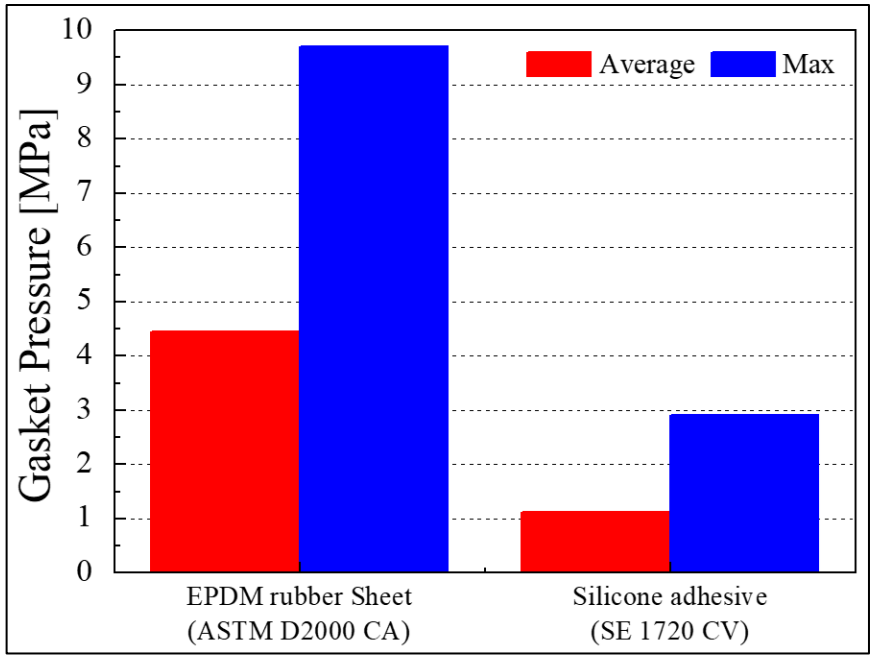


Fig. 6 Pressure at the contact surface of the gasket and BP



⇒ According to the preceded research, pressure applied to the contact surface must be more than 1.9MPa to prevent the leakage of hydrogen and oxygen compressed into 0.3MPa

⇒ The average pressure applied to the EPDM rubber sheet is 4.4MPa and silicone adhesive is 1.1MPa

Gasket Analysis _ Material

◆ **Results**

Fig. 7 Deformation of flow path

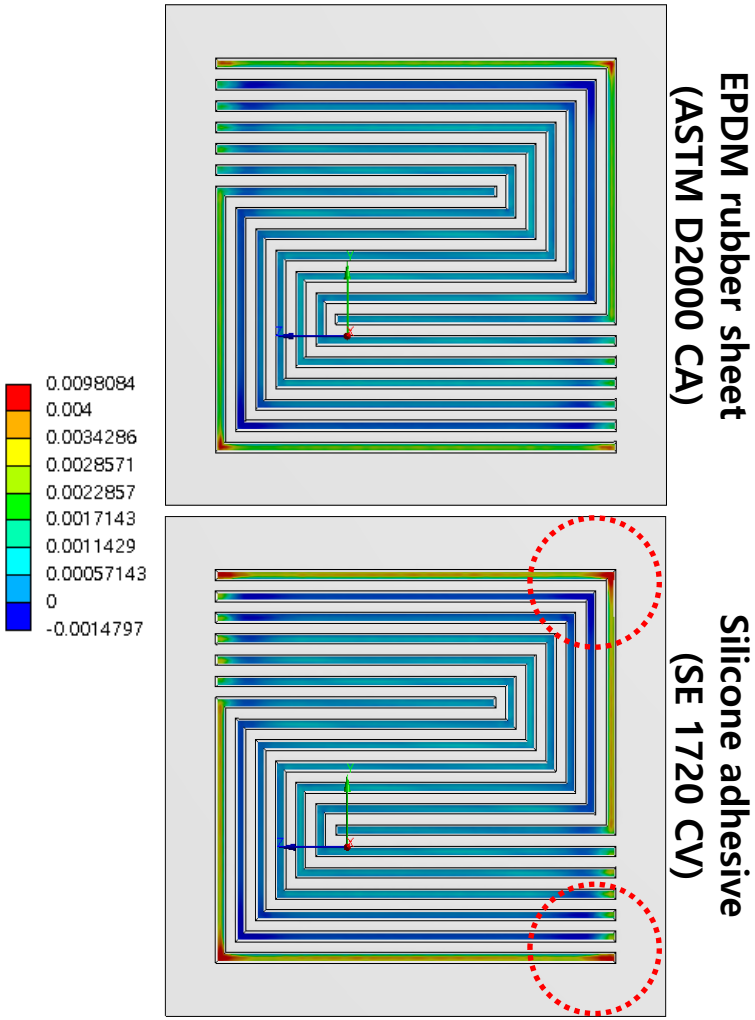
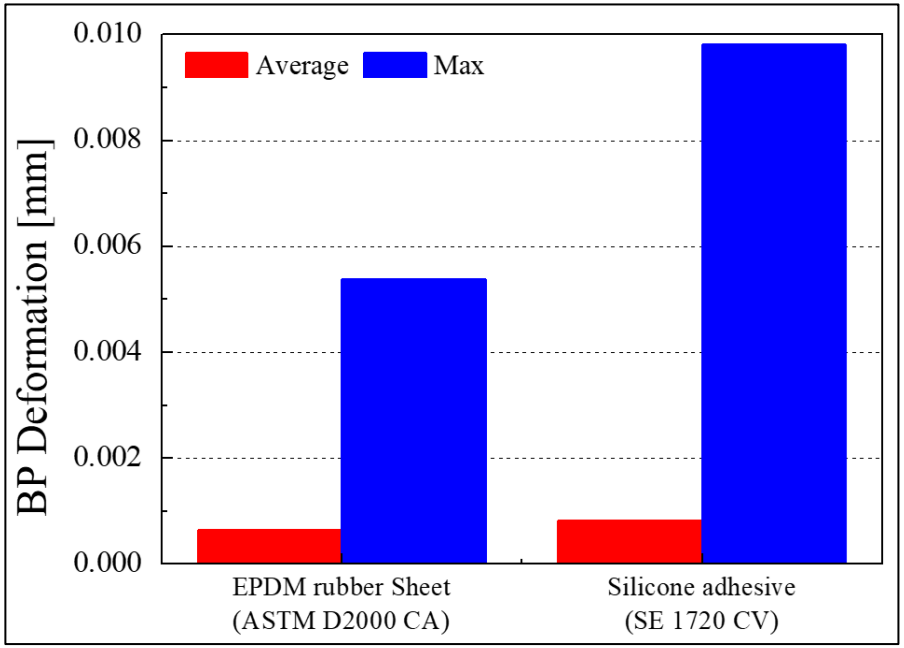


Fig. 8 Deformation of flow path



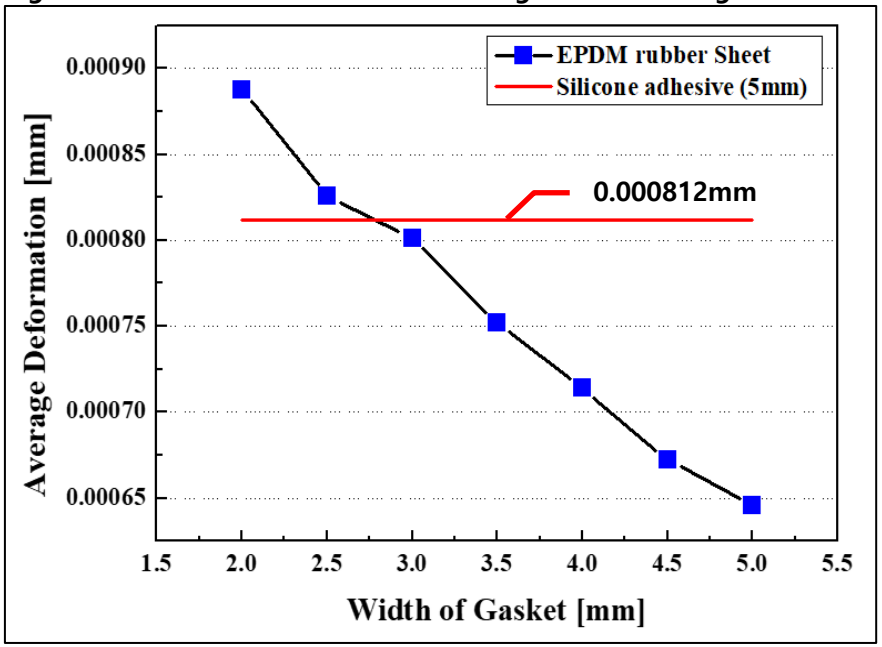
⇒ The average deformation of bipolar plate is similar for both gaskets

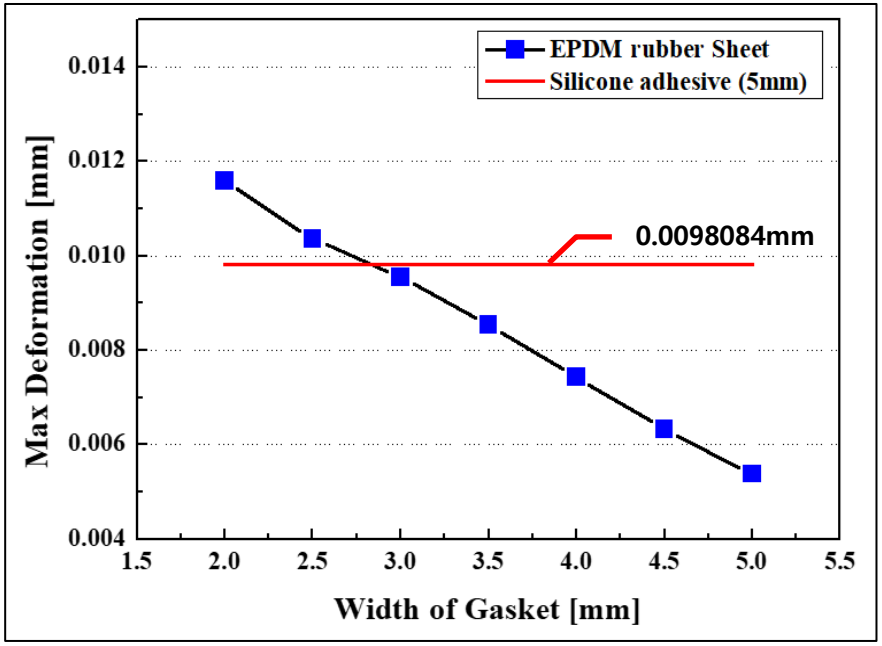
⇒ In the case of silicone adhesive, stability is low due to the maximum deformation at the edges

Gasket Analysis _ Material

◆ **Results**

Fig. 9 Deformation of the rubber sheet gasket according to the width





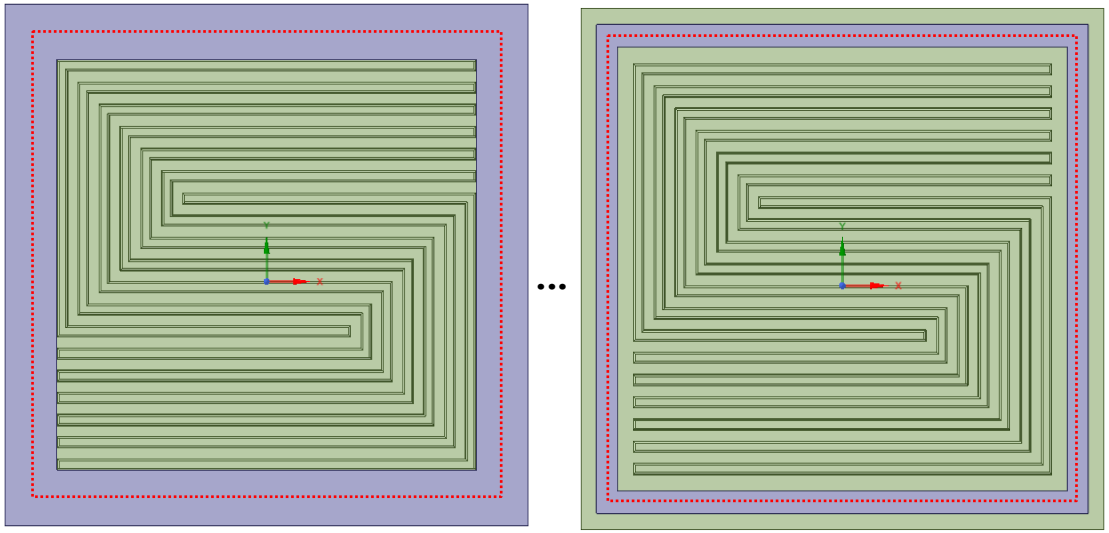
⇒ **Analyze by changing the width of the rubber sheet (the thickness is fixed)**

⇒ **Considering the average and maximum deformation of the flow path, if a 3mm rubber sheet is used, performance similar to a 5mm silicone adhesive can be achieved**

⇒ **By reducing the width of the gasket, the active area can be increased.**

Gasket Analysis _ Internal Pressure

◆ **Geometry**



<5mm> ... <2mm>

⇒ The model of Bipolar plate is R – 0.15mm, α – 10°

⇒ The width of the gasket is 2 to 5 mm, total 7cases.

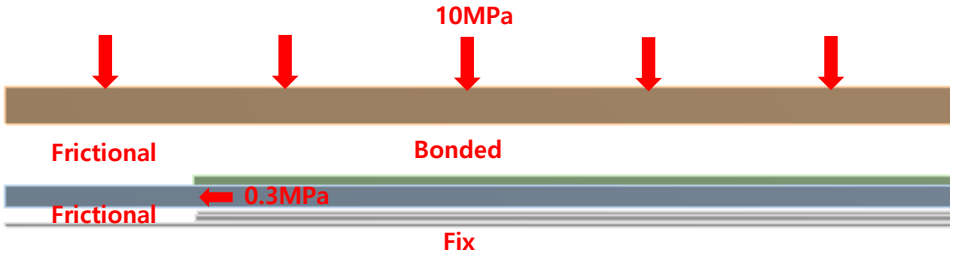
⇒ The position of the gasket was centered.

⇒ The structure to prevent the gasket from coming off was not applied

⇒ EPDM rubber sheet is used

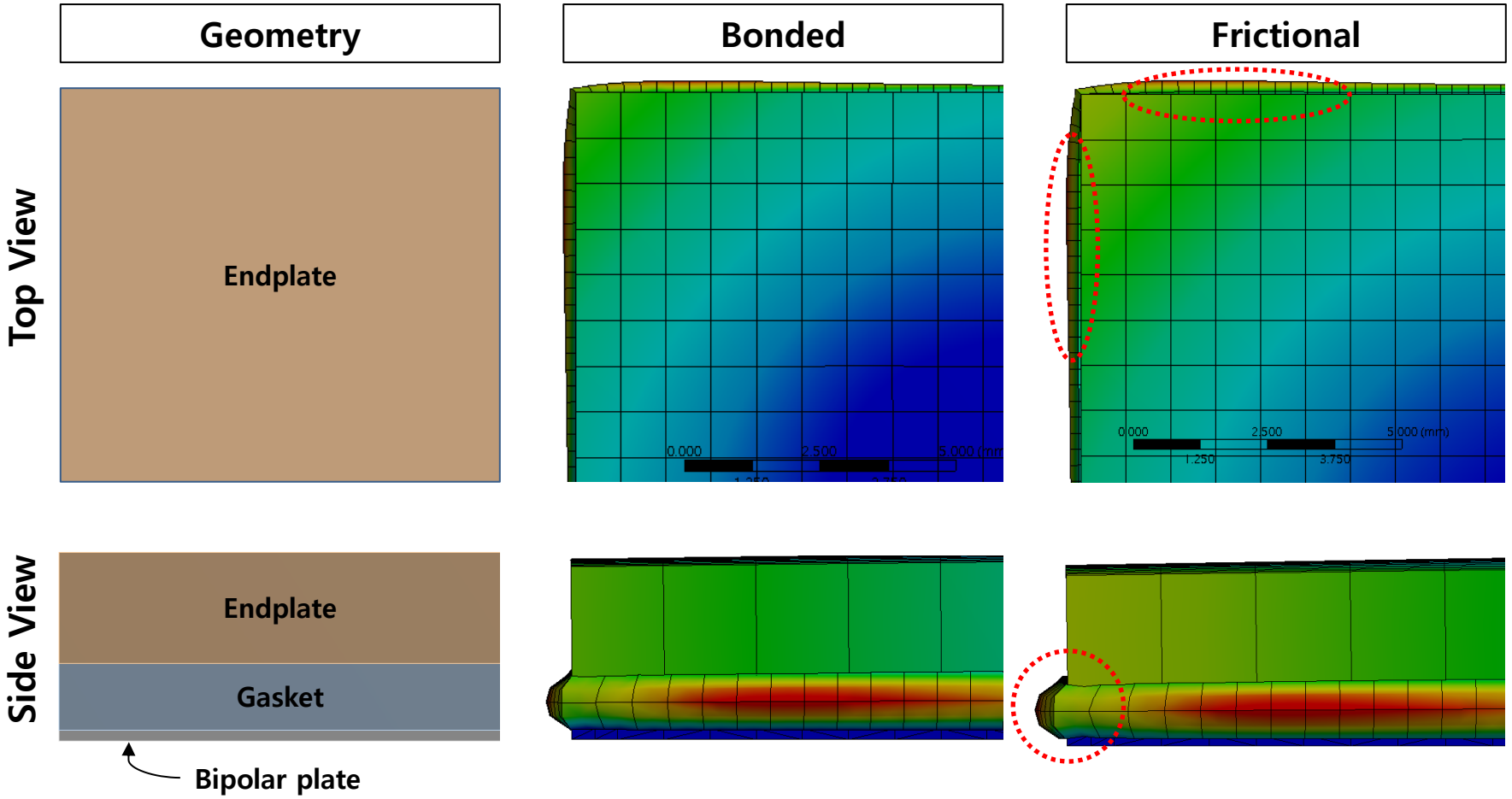
◆ **Conditions**

(1) Frictional conditions :
Bipolar plate - Gasket, Endplate – Gasket
(Coefficient of friction: 0.64)
(2) 10MPa pressure to Endplate
(3) 0.3MPa internal pressure to Gasket
(4) Same contact surfaces on all cases



Gasket Analysis _ Internal Pressure

◆ **Results**



Gasket Analysis _ Internal Pressure

◆ **Results**

Fig. 10 Sliding distance and Deformation of flow path

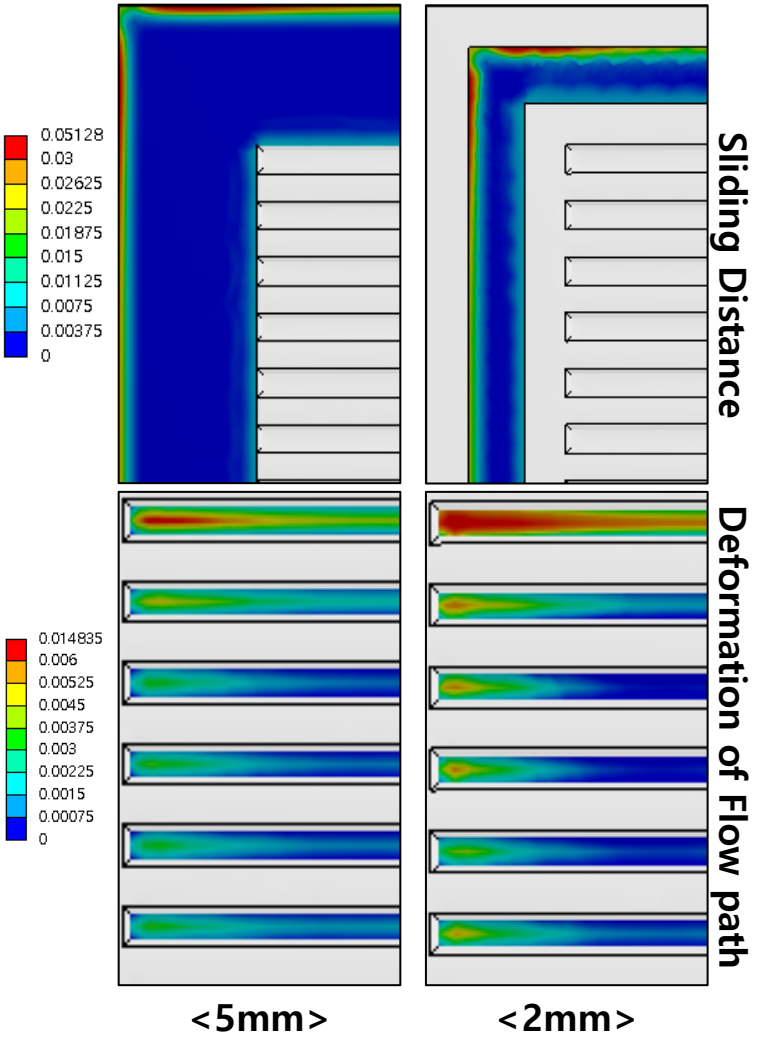
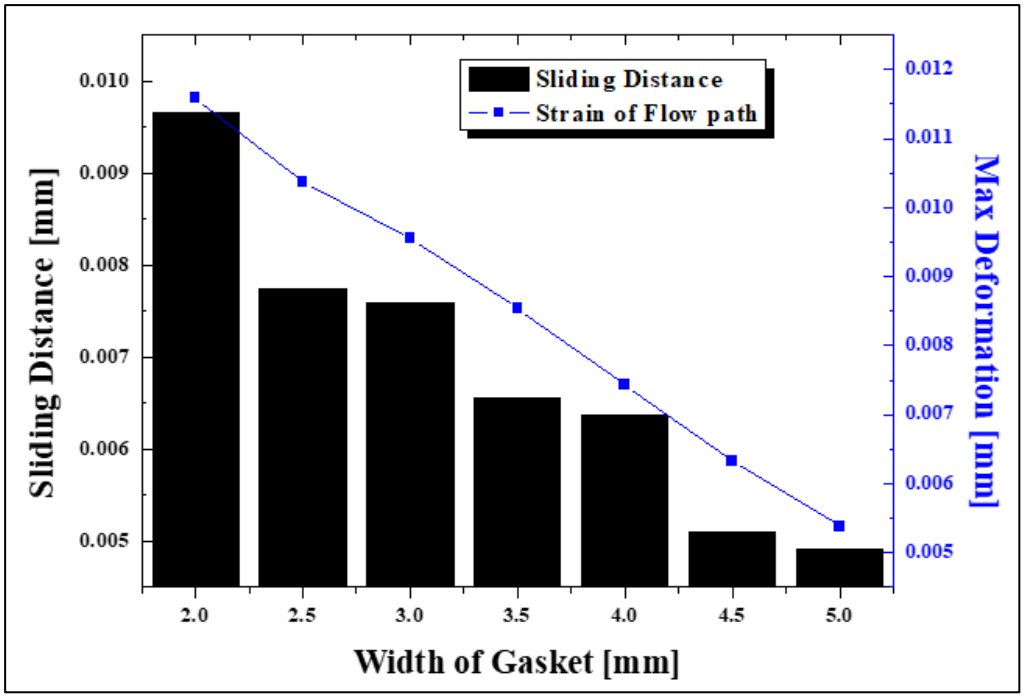


Fig. 11 Sliding distance and deformation of flow path



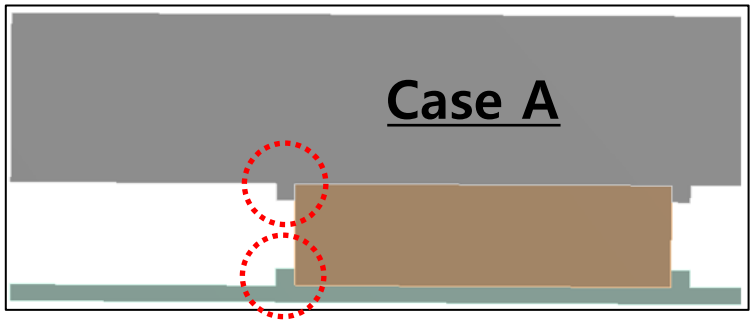
⇒ **The smaller the gasket width, the larger the sliding distance**

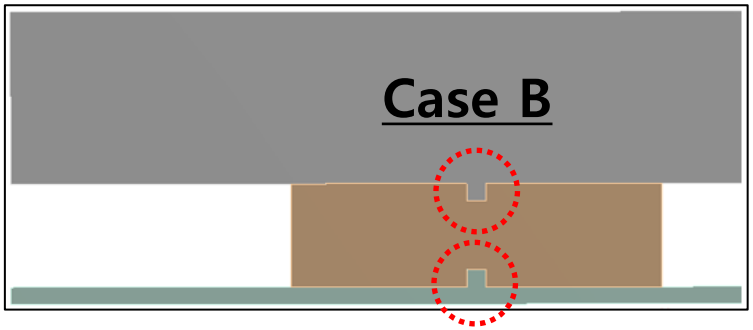
⇒ **The larger the sliding distance, the larger the deformation of the flow path**

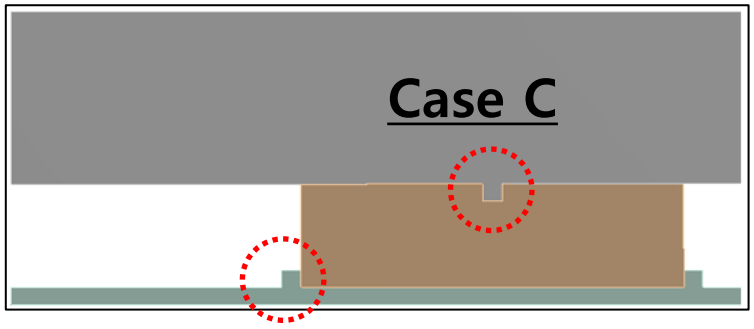
⇒ **By sliding, the deformation of edge increases**

Gasket Analysis _ Internal Pressure

◆ Geometry

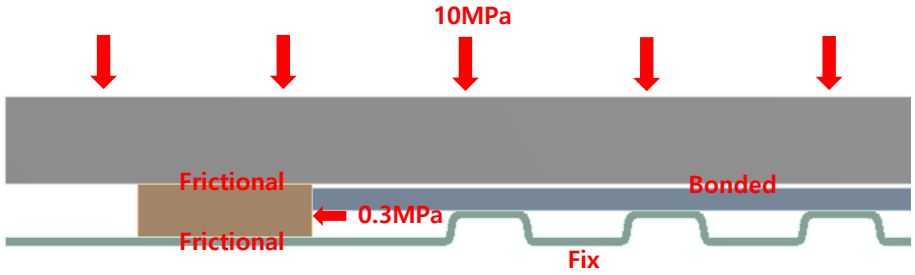






◆ Conditions

(1) 2D Analysis
(2) Frictional conditions :
Bipolar plate - Gasket, Endplate – Gasket
(Coefficient of friction: 0.64)
(3) 10MPa pressure to Endplate
(4) 0.3MPa internal pressure to Gasket
(5) Same contact surfaces on all cases



Gasket Analysis _ Internal Pressure

◆ **Results**

Fig. 12 Deformation of single cell

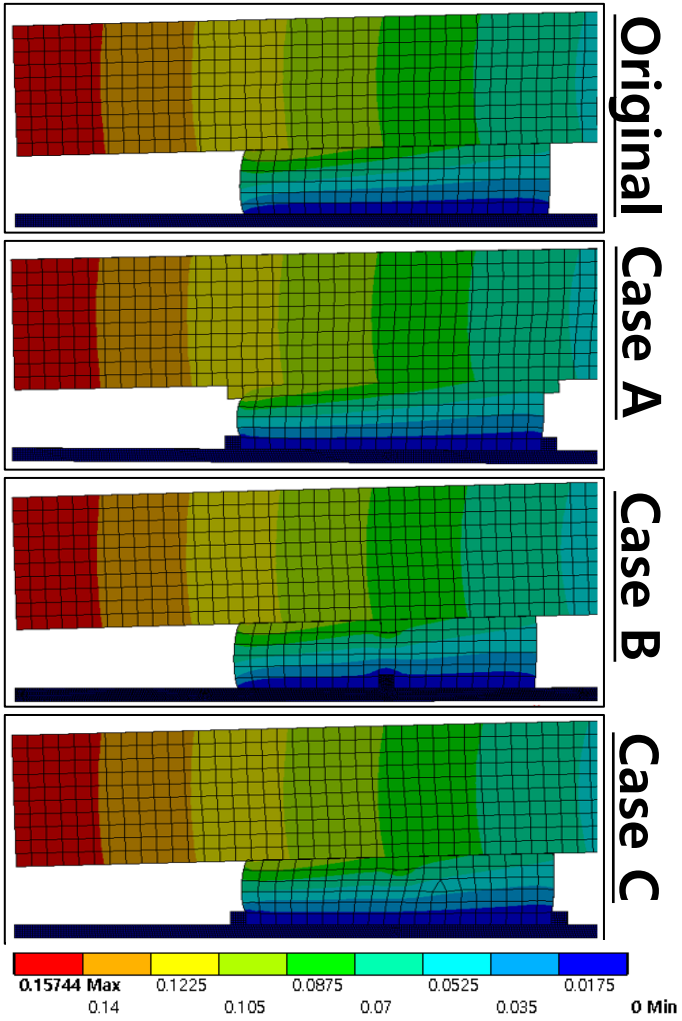
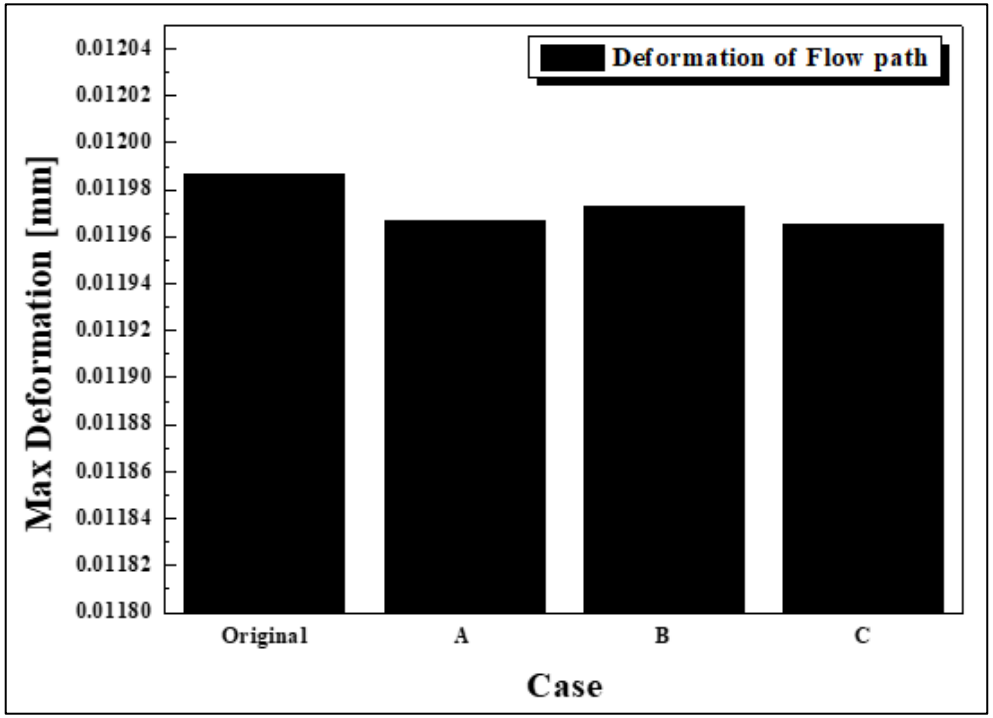


Fig. 13 Maximum deformation of the flow path according to the structure that prevents the gasket from separating.



⇒ **Deformation of the flow path is reduced by applying a structure that prevents the gasket from separating.**

⇒ **At this time, the difference in deformation was not large, less than about 0.2%. The width of the gasket has a greater influence on the flow path deformation.**

Conclusions

⇒ For weight reduction, volume reduction, and stability, PEFC uses metal separators.

⇒ Since the metal separator is thin, there is a problem of deformation when the pressure exceeds a certain level.

⇒ As the fillet radius and drafts angle increase, the area where stress is concentrated occurs, so when the design variable is decreased, deformation is decreased.

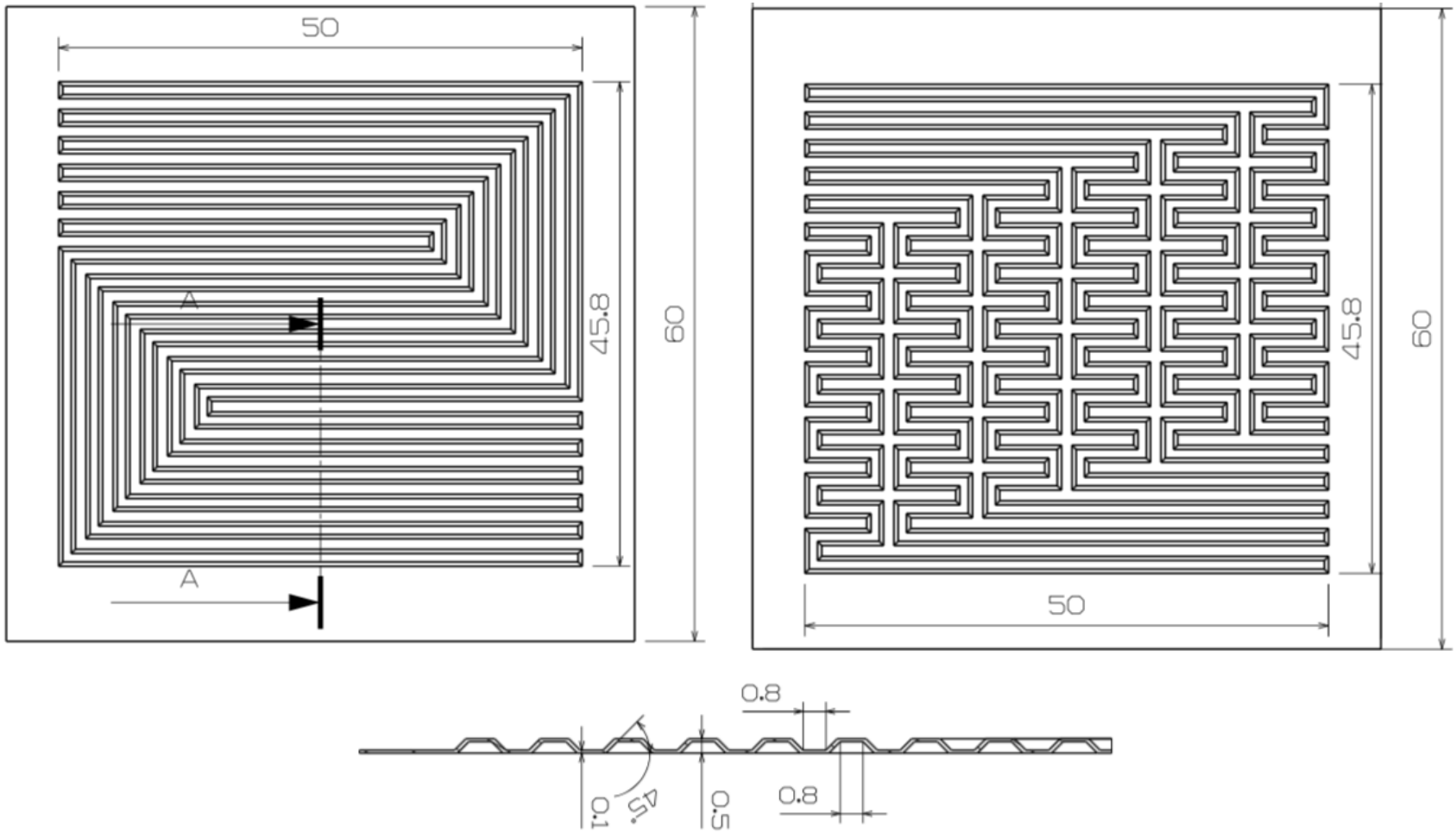
⇒ The pressure applied to the contact surface of the EPDM rubber sheet is 4.4MPa and the pressure on the silicone adhesive is 1.1MPa, so the rubber sheet is more appropriate in same thickness and width.

⇒ At the same thickness, 3mm EPDM rubber sheet and 5mm silicone adhesive have similar performance in terms of flow path deformation.

⇒ Considering the compressed hydrogen and oxygen inside, the width of the gasket affects the deformation of the flow path and the sliding distance.

⇒ The width of the gasket has a greater influence on the deformation than the sliding of the gasket.

Plans



⇒ **Experimental verification of analysis results**

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Thank you