Closures Deformation Optimization Considering Kinetic system

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MOTOR GROUP

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Closure Deformation

By Opening Equipment

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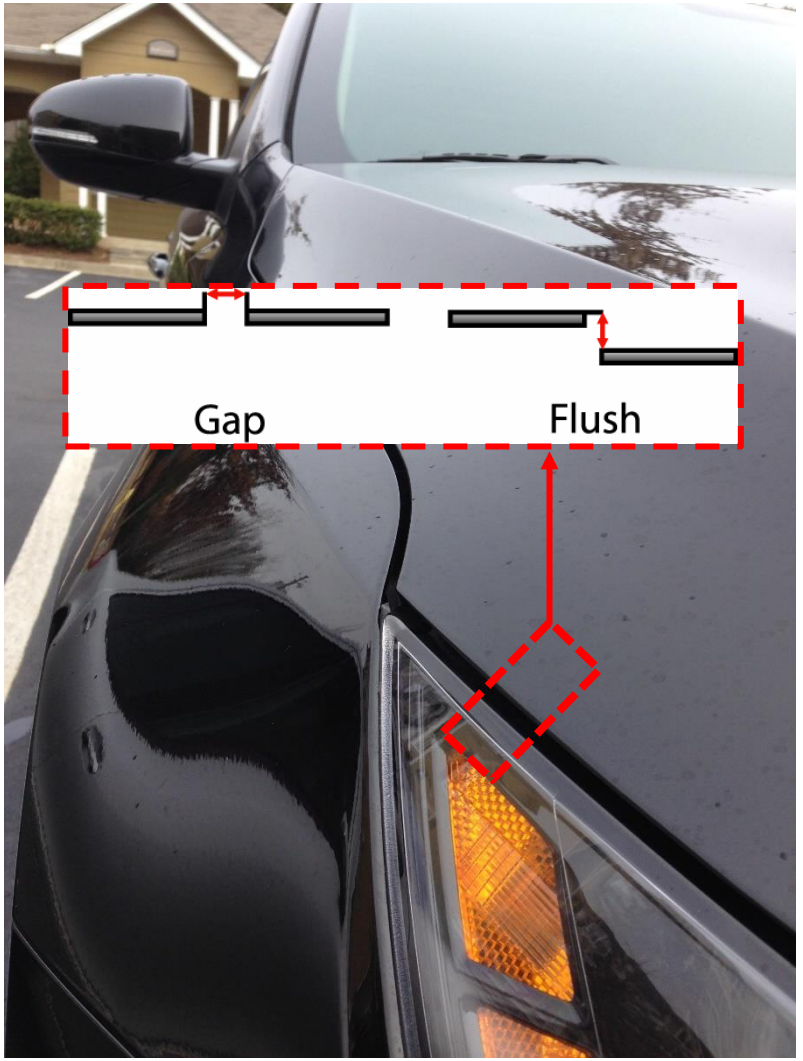


1. Overview of Technology Development

❑ Purpose

- Development of a technique that minimize deformation while satisfying the opening/closing force of the closures through kinetic system optimization

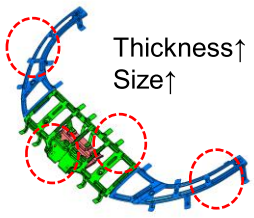
❑ Content

AS - IS

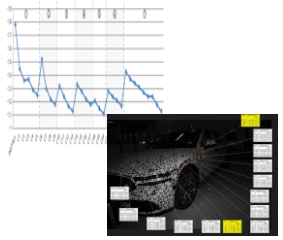
☐ Using inefficient improvement plans

- Increased part thickness and size → Cost&Weigt increase
- Excessive M/H due to repetitive work
- Opening/Closing force is hard to compute

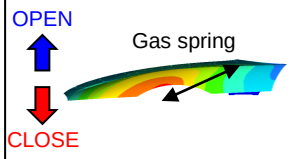
→ Adjust Gas spring position is difficult



Cost/Weight Increase



Exessive M/H

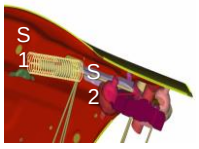


Can't analyze Open/close force

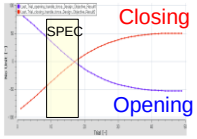
TO - BE

☐ Improvement through Kinetic System Optimization

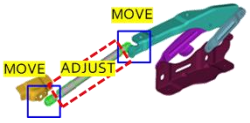
[Kinetic system simulation]



Convert to Kinetic Model

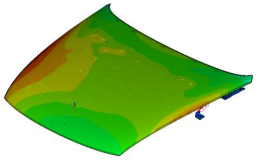


Analyze Opening/Closing Force



Optimize

[Connecting to Deformation]



Simulation with optimized values

Improvement plan		
Force	S1	S2
-26	-2.0	-1.7

Make improvement plan

❑ Effects

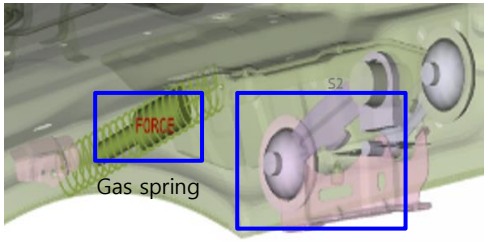
- To derive an improvement plan that minimize cost and weight increase
- Reduce car development time without the need for data transfer between design/simulation part

2. Development Process

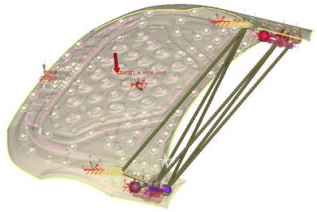
1. Process

Kinetic Model Conversion

- **Model conversion for Kinetic simulation**



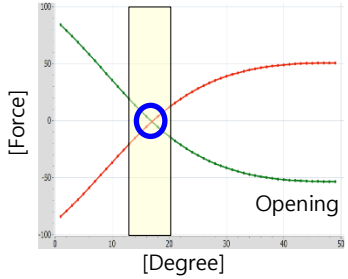
- **Kinetic model generation of Acting hinge structures (Gas spring + Link of Hinge)**



Opening/Closing Simulation

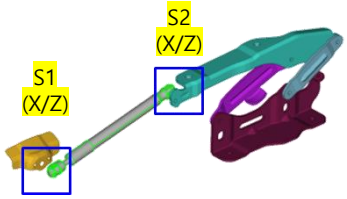
- **Closure Opening/Closing simulation**

- **Analyze Opening/Closing Force**



Optimization

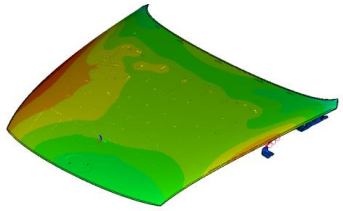
- **Generate DOE Model**



Id	FI	S1_X	S1_Z	S2_X	S2_Z
DOE_Run_002					
1	299.310345	207.060000	556.206897	-24.931034	508.275862
2	353.103448	206.630000	551.379310	-24.448276	504.137931
3	276.896552	205.160000	558.965517	-23.482759	506.551724
4	308.275862	204.320000	556.551724	-28.068966	504.827586
5	281.379310	203.900000	553.793103	-29.275862	507.586207
6	357.586207	209.160000	550.689655	-29.034483	501.724138
7	371.034483	208.530000	554.827586	-28.310345	507.931034
8	294.827586	204.740000	556.896552	-26.620690	502.758621
9	303.793103	209.790000	551.034483	-24.206897	505.517241
10	339.655172	208.740000	553.103448	-24.689655	502.068966

- **Optimizing & Verification**

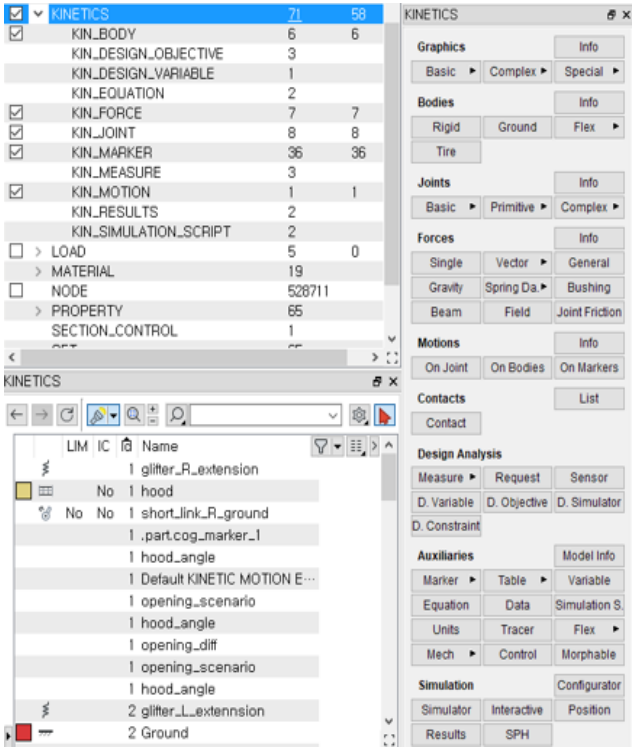
Force	S1_X	S1_Z	S2_X	S2_Z
368	141	587	-95	513



2. Development Process

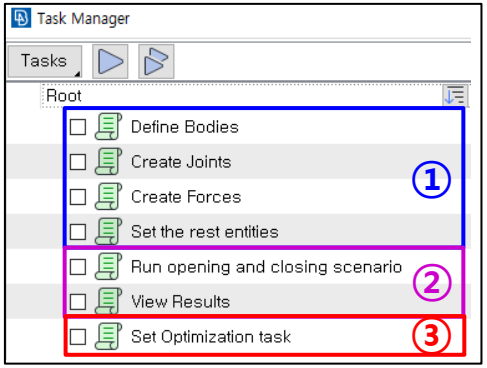
1. Process

Development Kinetic System Analysis Automation Tool (S/W : ANSA)

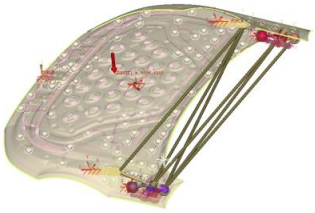


User manually configure kinetic system and input every value in system

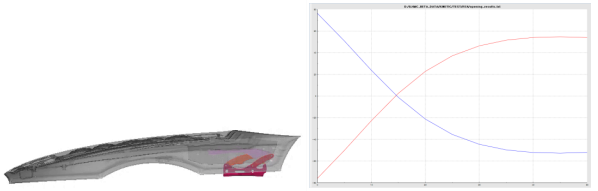
→ Overtime & Complex



Automate the entire process using task manager

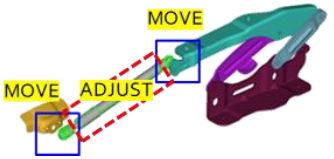


① Kinetic Model Conversion



② Opening/Closing simulation

Experiment	force	angle
30	2.5662	15.4445
29	6.9527	20.4046
28	2.9736	14.545
27	0.819451	16.1605
26	4.5678	15.4261
25	7.2358	18.344
24	0.226505	15.8173
23	5.9192	13.4407
22	1.2452	15.1931
21	4.7973	20.692
20	3.9483	20.4683

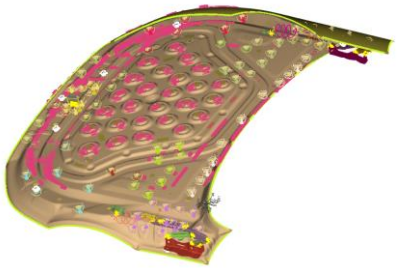


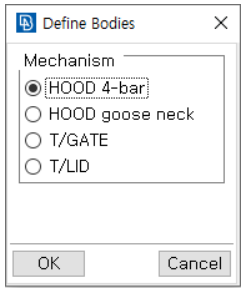
③ Optimization

2. Development Process

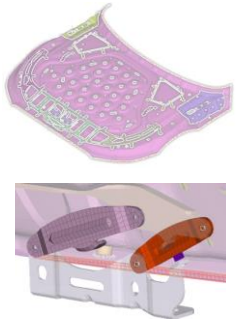
2-1. Kinetic Model Conversion

Deformation Model → **Conversion Tool** → **Kinetic Model**



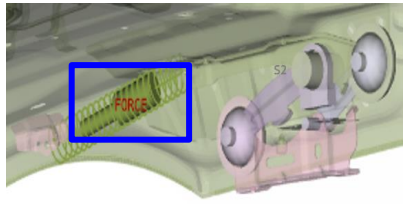


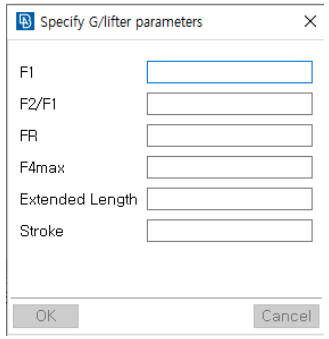
1. Select Part type



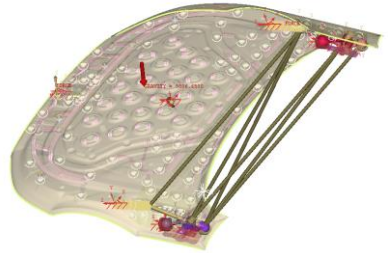
2. Set Body/Ground/Link

3. Set Joint





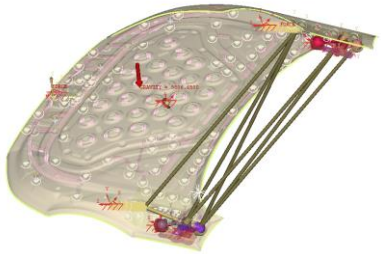
4. Input Gas spring Position & Force information

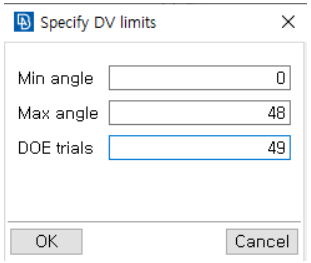


2. Development Process

2-2. Opening/Closing Force Analysis

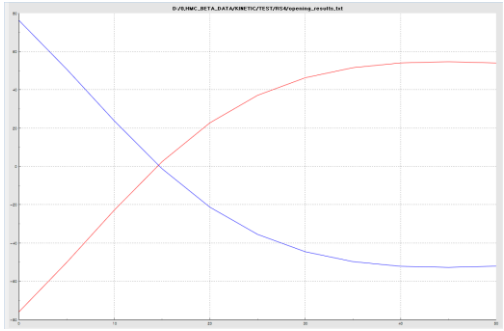
Kinetic Model → **Opening/Closing Simulation** → **Analyze Opening/Closing Force**



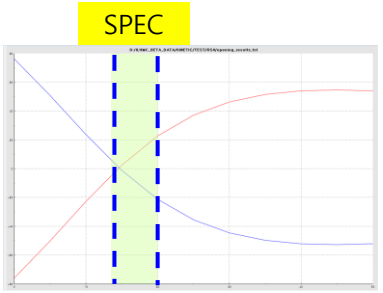


1. Opening/Closing Simulation

Degree	Open Force	Close Force
0	76.17	-75.94
5	50.72	-50.15
10	23.67	-22.78
15	-1.28	2.46
20	-21.3	22.71
25	-35.52	37.09
30	-44.58	46.27
35	-49.76	51.52
40	-52.19	54.01
45	-52.76	54.6
50	-52.1	53.97



3. Caclulate Opening/Closing Force

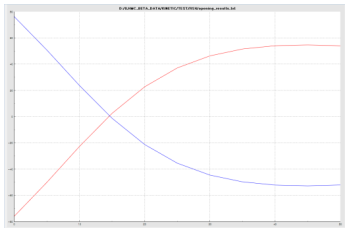


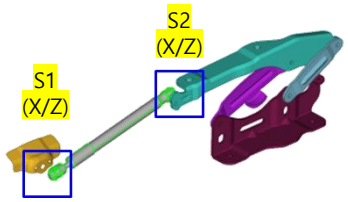
Check whether Opening/Closing force Is satisfied

2. Development Process

2-3. Optimization

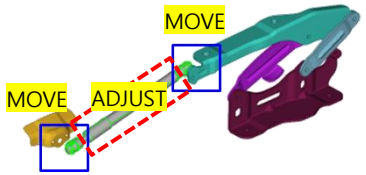
Analysis Result → **Generate DOE Model**





	S1(mm)	S2(mm)
X	**± 3**	**± 2**
Z	**± 5**	**± 5**

1. Set the S1/S2 point within design allwances



Id	F1	S1_X	S1_Z	S2_X	S2_Z
DOE_Run_002					
1	299.310345	207.060000	556.206897	-24.931034	508.275862
2	353.103448	206.630000	551.379310	-24.448276	504.137931
3	276.896552	205.160000	558.965517	-23.482759	506.551724
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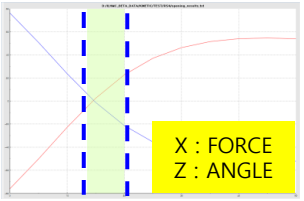
8	294.827586	204.740000	556.896552	-26.620690	502.758621
9	303.793103	209.790000	551.034483	-24.206897	505.517241
10	339.655172	208.740000	553.103448	-24.689655	502.068966

2. Generate DOE model using S1/S2 & Gas spring Force

Experiment	F1	S1_X	S1_Z	S2_X	S2_Z	force	angle
30	321.7241	205.58	554.4827	-27.8275	506.2068	2.5662	15.4445
29	250.	204.11	555.1724	-25.8965	509.3103	6.9527	20.4046
28	335.1724	208.11	558.6206	-23.	508.6206	2.9736	14.545
27	317.241379	209.37	557.241379	-26.862069	507.241379	0.819451	16.1605
26	348.6206	208.95	550.3448	-30.	510.	4.5678	15.4261
25	267.9310	204.53	558.2758	-25.1724	501.3793	7.2358	18.344
24	326.206897	209.58	552.758621	-23.724138	509.655172	0.226505	15.8173
23	344.1379	204.95	554.1379	-23.9655	500.3448	5.9192	13.4407
22	330.6896	208.32	550.	-25.4137	501.0344	1.2452	15.1931
21	254.4827	207.9	559.6551	-26.3793	504.4827	4.7973	20.692
20	258.9655	206.84	552.0689	-29.5172	505.8620	3.9483	20.4683

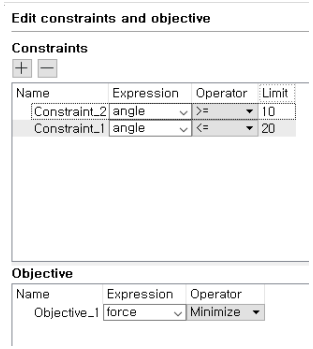


3. Get Force & Angle value by
Simulate all DOE models

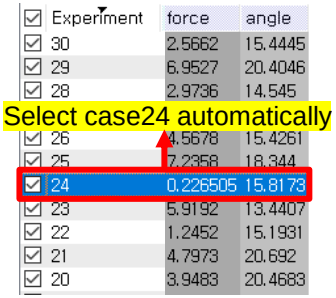
2. Development Process

2-3. Optimization

Optimizing



1. Set the Constraints , Objective

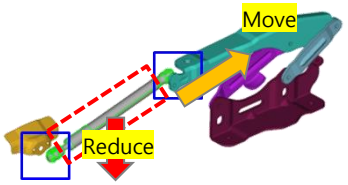


2. Select the doe model closest to the spec automatically.

	Design Variables					Responses	
Experiment	FI	S1_X	S1_Z	S2_X	S2_Z	force	angle
112	368.964471	141.901678	587.46854	-95.60947	513.654641	0.0220899	17.275
111	368.9797	141.9162	587.4491	-95.6081	513.6400	0.0099	17.2775
103	369.0323	141.9368	587.5005	-95.6021	513.6368	0.0132	17.2722
81	369.0796	141.8855	587.3862	-95.5738	513.5855	0.0286	17.2636
96	369.1309	141.8520	587.4126	-95.6235	513.6249	0.0341	17.2578
98	369.1376	141.8710	587.5184	-95.6403	513.5880	0.0547	17.251
75	369.1379	141.9067	587.4785	-95.5798	513.5886	0.0386	17.2559
101	369.1906	141.9739	587.4549	-95.6069	513.6502	0.0307	17.2728
93	369.2332	141.8320	587.4082	-95.6137	513.6531	0.0410	17.2474
106	369.2512	141.9809	587.4700	-95.6018	513.6720	0.0345	17.269
58	369.2690	141.8349	587.4341	-95.6244	513.6135	0.0499	17.2418
99	369.2879	141.9238	587.5409	-95.6262	513.7637	0.0025	17.2563
94	369.2919	141.9859	587.4711	-95.5985	513.6380	0.0311	17.2647

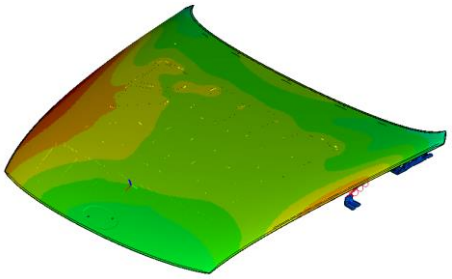
3. Get Optimizing Result
→ Derive the variables with smallest Gas spring force While satisfying the Opening/Closing Spec

Deformation Simulation & Make improvement plan



G/Spring Force	S1_X	S1_Z	S2_X	S2_Z
368.96	141.90	587.47	-95.61	513.65

1. Create a simulation model that reflects the result of Optimization.



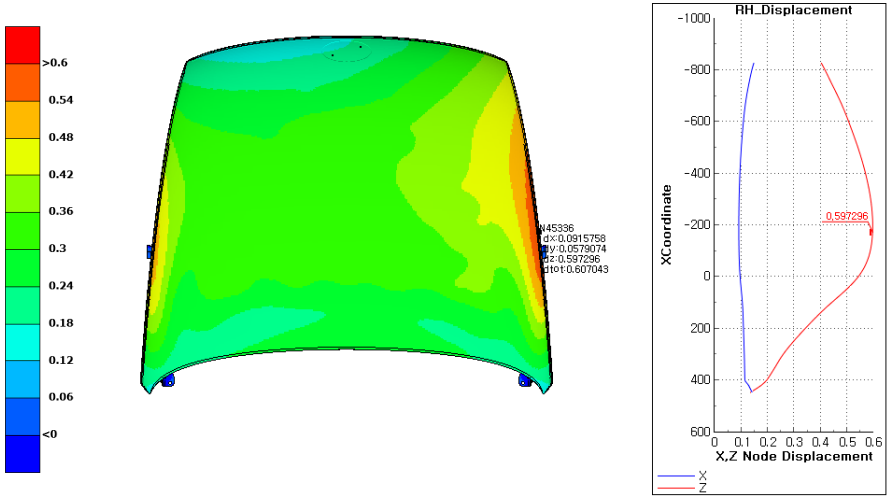
BASE	Improved Model
0.597	**0.509 (-15%)**

2. Verification of improvement through deformation simulation & suggestion of improvement plan

2. Development Process

2-4. Applicable Case

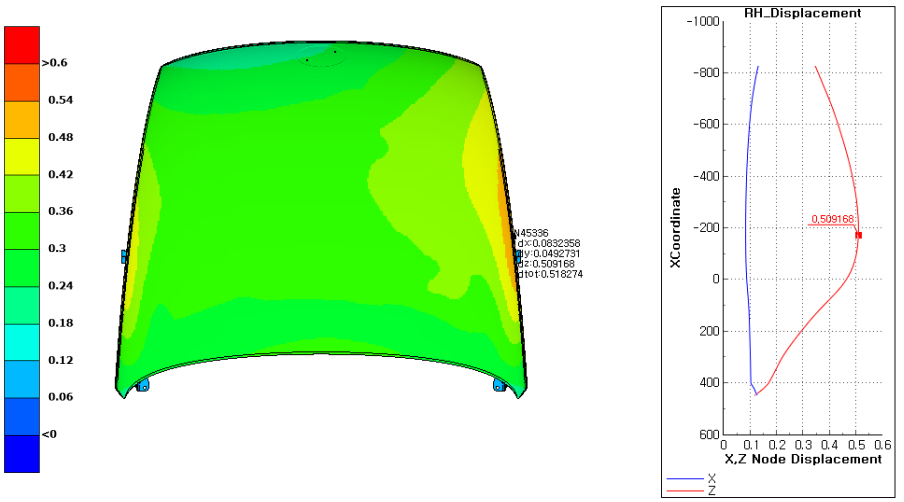
Base Model



Deformation max : 0.597mm

Kinetic Optimization Model

Changed Amount Compared to the Base Model				
G/spring (N)	S1_X (mm)	S1_Z (mm)	S2_X (mm)	S2_Z (mm)
-26	-2.0	-2.6	-1.7	-3.8



Deformation max : 0.509mm

Improved Deformation by 14.9%(0.598mm → 0.509mm)

→ Kinetic Optimization can improve deformation without increasing parts thickness & size

3. Conclusion & Future Plan

1. Conclusion

- **Develop closure deformation optimizing considering kinetic system**
  - Position and Force of Gas spring that satisfies Opening/Closing force and minimize Deformation can be derived
    → Suggest optimal improvement plan
  - **Cost and Weight reduction by minimizing part size and thickness increase**
    → Improve vehicle performance and profitability

2. Future Plan

- **Improved Optimization**
  - Since it is difficult to predict the amount of deformation in model before the deformation simulation
    → current optimized target : Gas spring Force.
  - Composition of **deformation prediction logic according to position and force of Gas spring using machine learning**
    → Upgrade Optimizing tool using the **amount of deformation as a target value**.

▣ How to contact me

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