Estimation of misaligned position in drop test of IP-2 type metallic container

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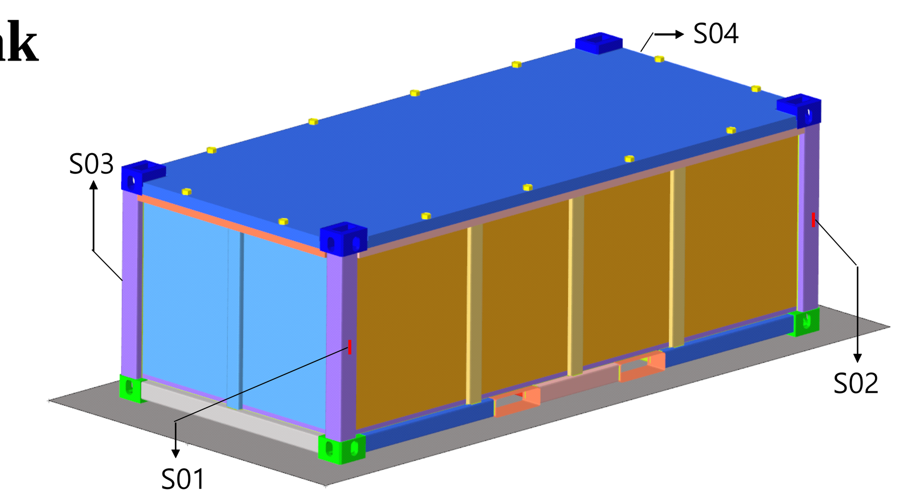
Ⅰ Introduction

- In this study, a misaligned position of an industrial packages Type 2 (IP-2) metal rectangular container in a drop test is estimated
- In order to estimate the misalignment of the drop position, an optimization technique with a response surface model is proposed
- To construct the response surface model, a computational drop analysis to simulate the drop test is performed

Ⅱ Drop Test of the IP-2 metal rectangular container

- Drop test of the IP-2 metal container with of the concrete waste foam as a content to be loaded in the container is performed
- Because of the symmetry of the attached strain gauges, the strains of each gauge have to be same in the bottom drop. However, the results show the considerable differences in the strain and the time to reach a peak
- These differences are caused by the misalignment of the drop position



▲ IP-2 Metal rectangular container

Ⅲ. Estimation of the misaligned position in the bottom drop test

- In order to estimate the misaligned position of the test model in the bottom drop test, the optimization technique is proposed.
- The proposed formulation to find the misaligned drop angle

Find θ_x, θ_y

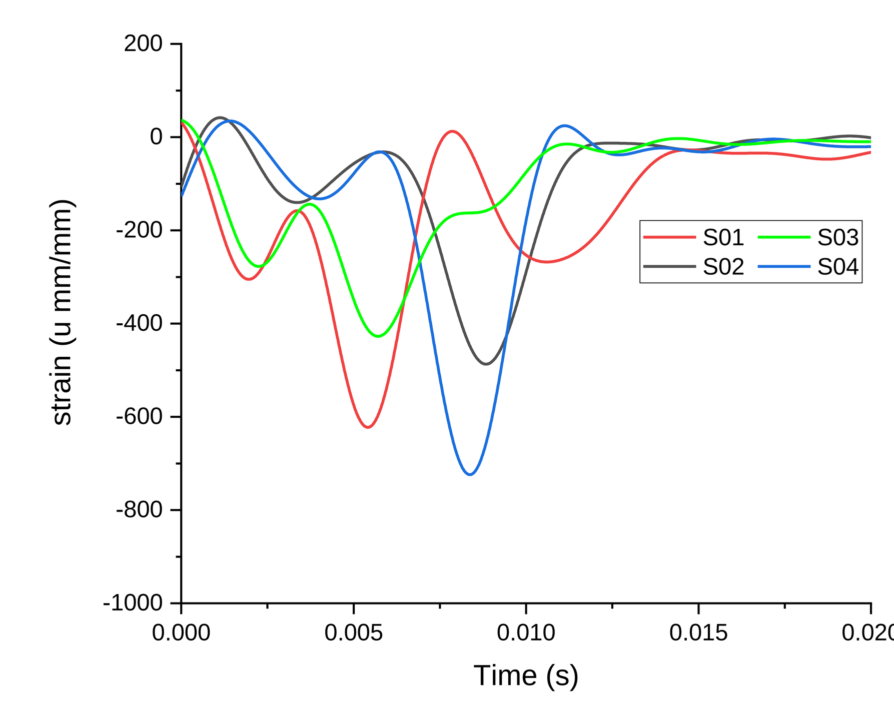
Minimize $\sqrt{(T_{T1}-T_1)^2+(T_{T2}-T_2)^2}$

Subject to $0.05° \le \theta_x \le 0.3°, 0.2° \le \theta_y \le 0.4°$

$T_{T1} = 0.3 \text{ ms}, \; T_{T2} = 2.96 \text{ ms}$

$$T_1 = T_{S03}^{max} - T_{S01}^{max}, \quad T_2 = T_{S02}^{max} - T_{S01}^{max}$$

where, T_{S0N}^{max} means the time to reach the maximum strain of S0N. T_{Ti} is obtained from the test results, and T_i is obtained from the drop analysis. θ_x and θ_y means the drop angle caused by the misaligned position of the test model.



▲ Stain results of drop test in the bottom drop

- In order to evaluate an objective function in the formulation, the computational drop analysis is required . Since each optimization step requires the evaluation of objective function and its gradient, the significant number of analyses is required to reach the optimum
- For this reason, a response surface model is utilized. The computational drop test is performed at only sampling points which are required to construct the response surface model. After constructing the response surface model, an additional analysis is not required during finding the optimum

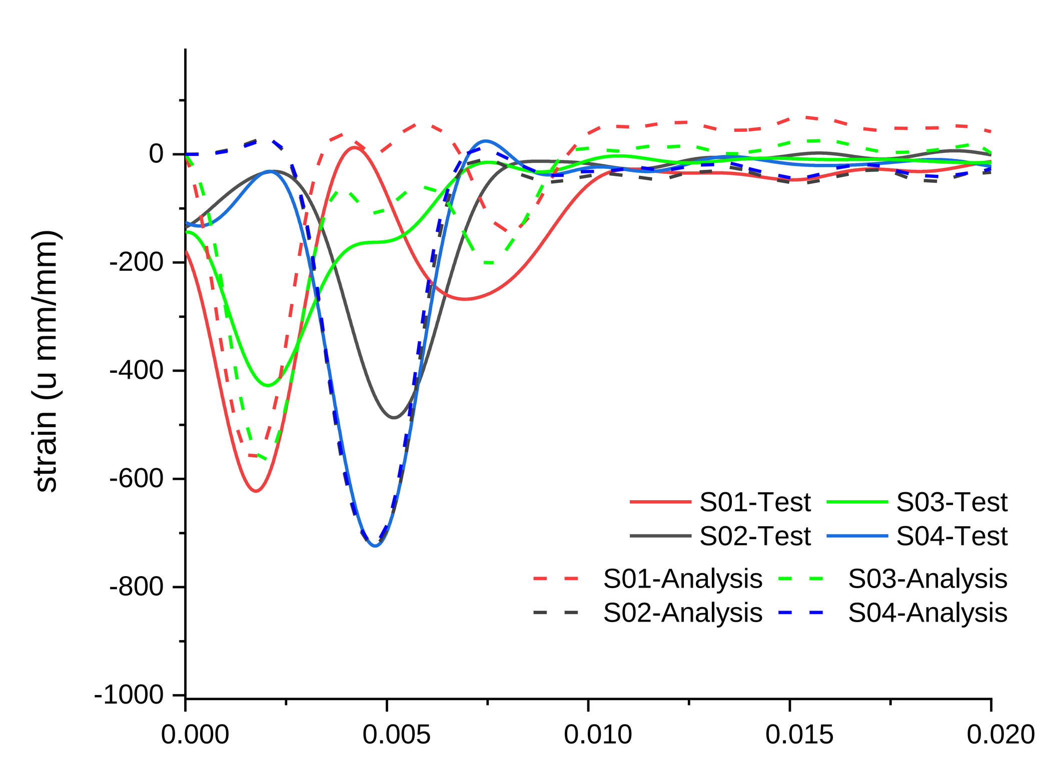
$$T_i = c_{i1} + c_{i2}\theta_x + c_{i3}\theta_y + c_{i4}\theta_x\theta_y$$

▲ Response surface model

- To construct the response surface model, the coefficient of each polynomials is determined using sampling points. In order to obtain the time differences at the sampling points, a computational drop analysis is performed
- The sampling points and results of the analysis at the sampling points is shown as below. Using the sampling points in Table, the coefficient of the response surface model can be determined. Using the formulation for the optimization and response surface model, the misaligned drop angle is obtained

	θ_x (°)	θ_y (°)	T_1 (ms)	T_2 (ms)
Sample Points	0.05	0.2	0.27	2.17
	0.05	0.4	0.24	3.55
	0.3	0.2	2.49	2.74
	0.3	0.4	1.87	4.05
Calculated Angle	0.111	0.203	0.27	2.98

▲ The misaligned drop angle calculated by the proposed method



▲ Strain results of the drop test and analysis with the misaligned position

Ⅳ Conclusion

- The drop analysis with the misalignment obtained using the proposed method agree reasonably well with the test data with respect to the time difference between the first and third impact
- Effectiveness of the proposed method is validated by performing the verification and comparison between the test and the analysis applied with the drop angle error