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Relationship between Void Distribution Function of Soft Polyurethane Foam and Mechanical Property (Compression Force - Displacement Characteristic)

- (Second Report) Methodology Verifications, Validations and Improvements -

Minoru Inoue [1) 2) 3)] **Keisuke Suzuki** [2)] **Hiroyuki Ito** [4)]

1) Mazda Motor Corporation
3-1 Shinchi, Fuchu-cho, Aki-gun, Hiroshima, 730-8670, Japan (E-mail: inoue.min@mazda.co.jp)
2) Kagawa University
2217-20 Hayashimachi, Takamatsu, Kagawa 761-0396, Japan
3) Digital Monozukuri (Manufacturing) Education and Research Center, Hiroshima University
3-10-32 Kagamiyama, Higashi-Hiroshima, Hiroshima 739-0046, Japan
4) Toyo Seat Co., Ltd.
1-6-25 Kuninobu, Kaita-cho, Aki-gun, Hiroshima, 736-0002, Japan

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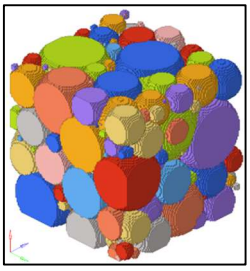
In the first report, CAE methodology to evaluate mechanical properties (compression force – displacement characteristics, hereafter F-S characteristics) of the soft urethane foams using void distribution function was presented. But CAE results showed 4 times higher F-S values than compression test results and so improvements in CAE predictions are required. In this second report, further studies and verifications are done to minimize the discrepancies between CAE models and real urethane foam tests. As these results, improvements in the CAE methodology are gained enough for studying F-S characteristics of the soft urethane foams for automotive seatings.

Possible causes of the discrepancies by 4 times higher in the values of F-S characteristics between CAE models and real compression tests are thought to be as follows.

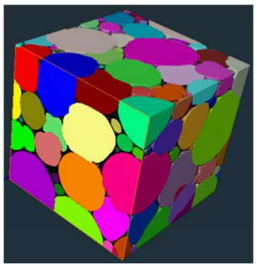
(1) Difference in Porosity between CAE model and real urethan foam.
(2) Material property used in CAE model is gained from the tensile test with the typical TPU plate sold in the roadside shop.
(3) Pressure effect inside voids when they are compressed. In the first report, pressure effect is not considered.

To clarify these major factors, new automotive seat polyurethane foam is gained, and several kinds of inspections, measurements are done such as X-ray CT measurement, Quasi-Static Mechanical Analyzer (QMA), Static Compression Tests, observation using electron microscopy and so. Then it was found that void radius identification using X-ray CT measurement data underestimate the void radius which resulted in the underestimate of porosity when generating the FEM model. And so, adding the scale factor to the radius when generating the voids in CAE model can get the exact structure model with the real urethane foam. Regarding the material properties of urethane foam structure, it was found that the current-temporary TPU material is rather good approximation and Young's modulus E has a great impact on compression F-S characteristics and S-S characteristics of material have fewer effects than Young's modulus E. Lastly pressure effects when void is compressed were clarified. It becomes greater according to the quadratic function of its radius.

Combining all these findings, F-S characteristic estimation by presented CAE methodology became closer to the real compression tests.



(a) Model



(b)Analyzed X-ray CT data

Fig.1 Porosity Matching

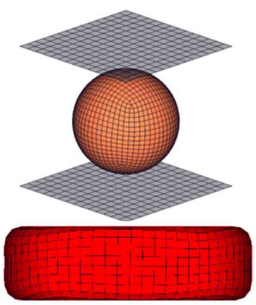


Fig2. Void Compression with Air Inside

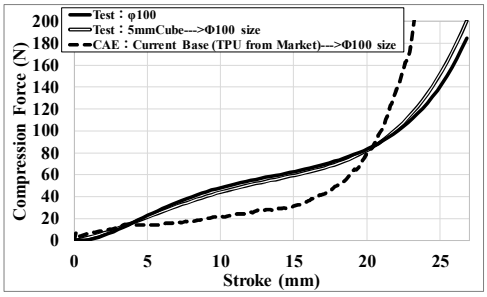


Fig.3 Improved Compression F-S Estimation