NEWS RELEASE

THE YOKOHAMA RUBBER CO., LTD.
36-11, Shimbashi 5-chome, Minato-ku,
Tokyo 105-8685, Japan

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Contact:
Corporate Communications Dept.
Phone: 81-3-5400-4531
Fax: 81-3-5400-4570

Yokohama Rubber Develops Simulation Technology for Multi-Objective Design Exploration Enabling Innovative Rubber Material Design

Tokyo – The Yokohama Rubber Co., Ltd. announced today that it has developed a simulation technology for multi-objective design exploration of rubber materials in this October. The new technology was developed to support innovative thinking about rubber material design. Through such innovative thinking, Yokohama Rubber aims to create tires that meet the highest standards in areas that normally are at odds with each other, such as low fuel consumption and safety or ultralight weight and high rigidity. The new technology is the latest in a series of innovative technologies developed by Yokohama Rubber. For example, Yokohama Rubber's proprietary aerodynamic simulation and aero-acoustic noise simulation technologies have led to the discovery of tire designs featuring dimples or fins that better control the airflow around the tire, thereby contributing to greater fuel efficiency.

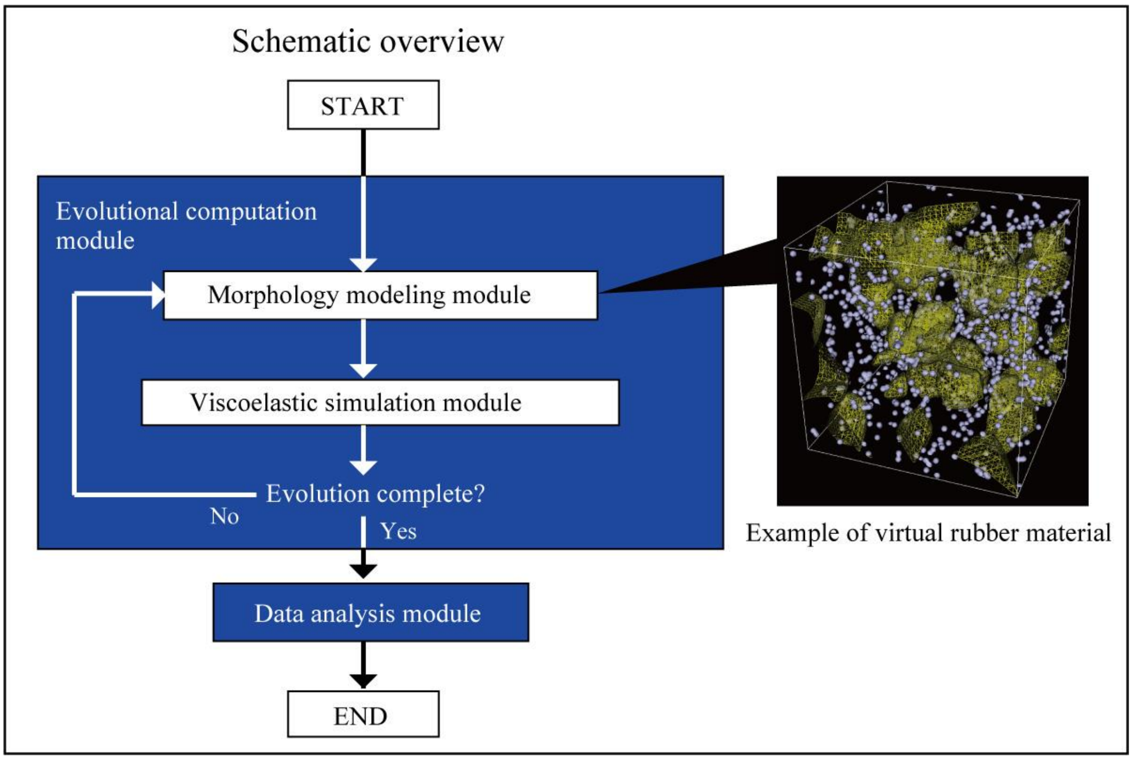
Tire performance is greatly affected by the complex morphology in the rubber material, i.e., the dispersion and quantity of polymer (rubber) and filler (carbon black and silica, etc.). The new multi-objective design exploration simulation technology differs from the previous simulation methods that assumed the use of actual rubber materials. Instead, the new simulation technology creates rubber material models based on virtual morphologies, thus enabling simulations of various morphologies. By changing the morphological parameters (variables), the new simulation technology enables us to create huge-scale simulation models consisting of about one billion elements having various morphologies. A performance evaluation run on the TSUBAME2.5 supercomputer in the Tokyo Institute of Technology, confirmed that the new simulation technology can complete huge-scale computations consisting of one billion elements in just 75 minutes, a feat previously unheard of when using the finite element method.

The challenges to establishing this simulation technology were the modeling technology that enables complete control of the morphology and the large-scale viscoelastic simulation technology needed to calculate the mechanical properties of rubber material. These problems were solved thanks to the efforts of a joint research project with Professor Dominique Jeulin of MINES ParisTech / Centre de Morphologie Mathematique (CMM) in France. This joint research developed a modeling technology, the random morphological model and a new computational scheme for large-scale viscoelastic simulations. The establishment and combination of these two key technologies provided the finishing touches to Yokohama Rubber's simulation technology for multi-objective design exploration of rubber materials.

Multi-objective design exploration is a technique for deducing knowledge useful to the design process. It focuses on organisms' evolutionary processes and uses a multi-objective genetic algorithm to search for more optimal solutions. Yokohama Rubber's past use of multi-objective design exploration to determine the optimal structural design for its tires has produced some useful results, including the development of YOKOHAMA's flagship low fuel consumption tire, the "BluEarth-1 EF20,"which has been assigned a AAA rating for rolling resistance and an "a" rating for wet grip performance, the highest ratings assigned by Japan's tire labeling system for each of those tire performance categories.

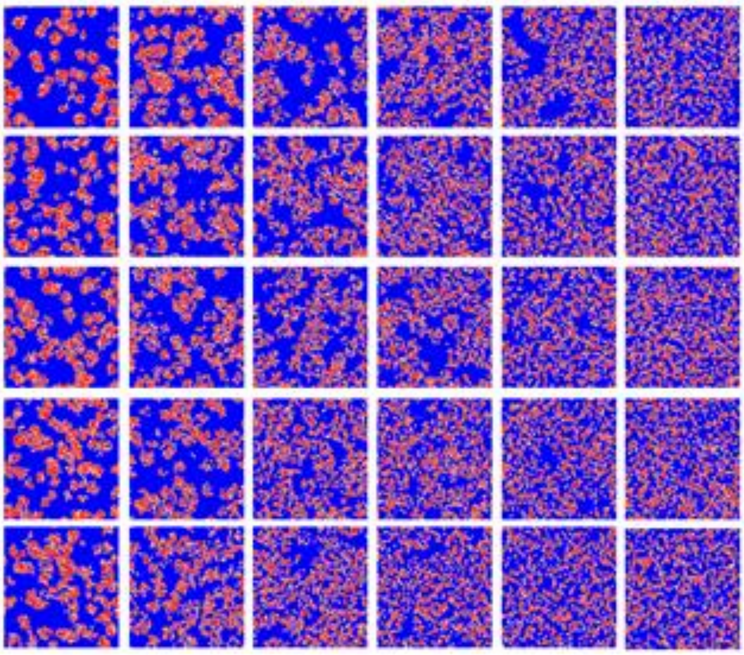
Schematic overview of simulation technology for multi-objective design exploration of rubber materials and an example of a virtual rubber material model

The new simulation technology for multi-objective design exploration of rubber materials comprises four modules: (1) morphology modeling that controls the morphology of the rubber material, (2) a viscoelastic simulation to calculate the mechanical properties of the virtual rubber material, (3) an evolutional computation to improve the mechanical properties, and (4) analysis of the big data generated by the evolutional computation to extract information useful to material development (data mining).



Example of rubber material model created by morphology modeling module

Changing the morphological parameter results in virtual rubber material models with various morphologies



Sectional view of 30 of models with varying morphologies