Overview

Nippon Valqua Industries is a leading manufacturer of industrial packing and gaskets that produces rubber, fiber products, high-performance resins and metal packing. One such product, the “welded metal bellows,” consists of an accordion-folded frame formed with elaborate metal disks cut out of corrugated plates, of which the inner and outer edges are alternately welded. The welded bellows have elastic and airtight features and are applied for seal application, such as ultra-high vacuum valves for the semiconductor industry, wafer processing equipment and single-crystal grower, as well as gyroscopes, accumulator and dampers used for aerospace vehicles.

Purpose of and Challenges to Bellows Structural Analysis

In this case, Nippon Valqua faced the challenge of extending the service life of weld bellows. To this end, it is critical to optimize the shape of corrugated plates comprising welded parts. For the design of welded bellows that receive concentrated reaction force on/around welded parts, it was critical to create a corrugated plate best suited to disperse such concentrated reaction force.

Analysis Process

Nippon Valqua created a model of corrugated plate having three crests from the entire bellows model as an axial-symmetric model to be analyzed. To this analysis, it applied the optimization method using parameter design. At this stage, Nippon Valqua parameterized circular arcs and other factors that specify the corrugation shape of corrugated plates. Subsequently it performed analyses using ANSYS software. For this analysis, a series of processes — from changing model shapes using parameters to storing analyzed results — were automated using ANSYS Parametric Design Language (APDL).

Cause of Breakage

Considering the fact that most breakage of bellows occurs on/around welded portions, Nippon Valqua explored possible causes of the increase in the Von Mises stress based on obtained results of analyses.

As a result, it could find a parameter exerting significant effects upon the increase in stress from among those causes.

Benefits

As shown in the figures above, the Von Mises stress was successfully decreased by changing the shape of bellows, compared to the existing shape. When comparing the fixed optimized shape (as shown above) to competitors’ bellows or straight (non-corrugated)-type bellows, it is obvious that the amount of deformation and other factors have been improved. Durability also has been enhanced, obtaining far better test results (exceeding 1 million operations) than those of the existing models. Thus, the adoption of analyses using ANSYS software and optimization method has made a great contribution to product durability and consequent quality improvement.