Retention Force And Its Frictional Contribution Influence On The Plug-socket Connection Stability

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Abstract

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The plug-socket connection in a hearing aid provides sufficient retention force to securely hold the receiver-in-canal (RIC) module in place and maintain a reliable electrical connection to the behind-the-ear (BTE) module, which houses the rest of the electronics. The retention force refers to the amount of force needed to disconnect the modules. However, the connection must remain loose enough to avoid causing mechanical damage to the plug, socket, or electrical contacts. This requirement is critical in miniaturized systems, which are more prone to breakage due to their small size.
COMSOL Multiphysics® provides valuable insights into the components of the retention force, which include both contact force and frictional effects. This allows the designer to better understand the physical behavior of the mechanical interface, predict the expected retention force, assess whether the connection will be subjected to excessive stress, and identify the locations of maximum stress and strain.
In this investigation we present a COMSOL Multiphysics® model that incorporates a Contact Pair simulation of the plug-socket connector, typical of a Sonion RIC device. Figure 1 shows the retention forces at the socket bump location as the connection is gradually separated by a prescribed displacement of 1 mm in z-direction. To validate the measured retention force of 12 N in z-direction, simulations were run using frictional coefficients of 0.07, 0.08, and 0.09 applied to the plug-socket interface. The simulation outputs include the total contact force and frictional components, as well as the corresponding stress and strain distribution within the plug and socket for each friction value. The peak force in Figure 1 indicates the expected maximum retention force at the socket bumps, while the area of highest stress reveals the potential weak point in the connection. The results show that a friction coefficient of 0.08 yields a maximum retention force of 12 N, which aligns with the measured value.
Based on our simulation results, the calculation and optimization of the retention force were sensitive to the applied frictional coefficient and geometric parameters, including the size, shape, and location of the plug, socket, and bump features. The Contact Pair simulation feature in COMSOL Multiphysics® effectively captures the retention force in socket-plug systems and aids in identifying the optimal frictional coefficient to ensure the required stability and durability of the connection system.

Figures used in the abstract

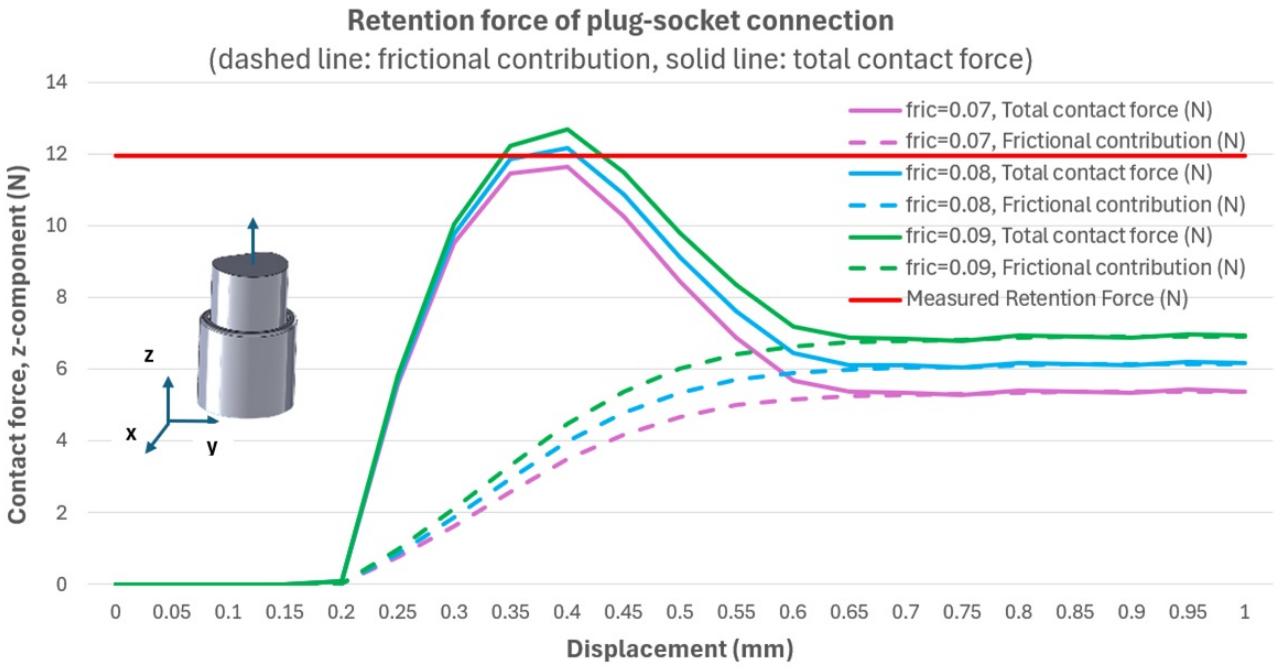

Figure 1 : Figure 1. Contact force in z-direction of the plug–socket connection calculated during gradual separation under a prescribed displacement of 1 mm.

Figure 2 : Thumbnail image. Sonion CS9X RIC plug.