Axiomatic Design Trounces Traditional Methods of Reducing Friction and Wear

The Axiomatic Design Process

- Improves the quality of designs
- Facilitates the creative process
- Requirements driven
- Captures design intent and traceability
- Provides early phase risk assessment
- Gives objective metrics for design evaluation
- Reduces the Design-Build-Test-Design Cycle
- Scalable from small projects to very large

Context

Circuits in electronic components and devices must be joined to other devices and components using connectors. As technology has advanced, electric/electronic circuits and components have become increasingly smaller and more powerful, but their necessary counterparts—connectors—have not similarly evolved. Most connectors are still comparatively large to accommodate more lines of interconnections as well as to prevent cross-talk between the interconnects.

Problem

The goal was to create connectors that would have an increased number of interconnections per unit, produce good electric contacts at all times, reduce the manufacturing cost, and increase reliability. In the past, to reduce wear and friction in connector surfaces, such surfaces have been designed by trial-and-error resulting in coupled designs. MIT designers recognized that these coupled designs could not be improved by simply arbitrarily changing a few material properties or the geometry of the devices. It was necessary to design the connectors satisfying the Independence Axiom of axiomatic design from the outset, rather than try to correct the problems generated by coupled designs.

Solution

Using axiomatic design principles, designers started off with Functional Requirements such as: FR2 = Provide electric contacts with contact resistance of less than 20 mΩ at each connection; FR3 = Maintain the contact pressure between the electric contacts at all times under all operating conditions (when they are mechanically connected).

(continued)

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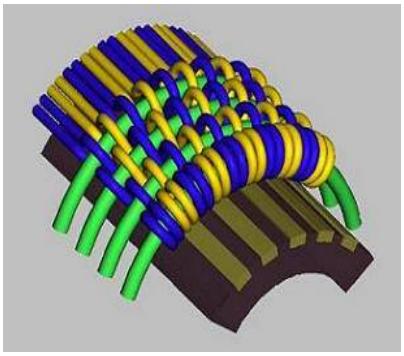
Reducing Friction and Wear (cont'd)

The result was the following decoupled design:

$$\begin{Bmatrix} FR1 \\ FR4 \\ FR3 \\ FR2 \end{Bmatrix} = \begin{bmatrix} X000 \\ 0X00 \\ X0X0 \\ X0XX \end{bmatrix} \begin{Bmatrix} DP1 \\ DP4 \\ DP3 \\ DP4 \end{Bmatrix}$$

The decomposition of several first-level FRs (FR1, FR2, and FR3) yielded an uncoupled design. One example of a connector the designers created used a combination of woven contacts arrayed with an appropriately shaped mating surface to produce multiple-redundant, controlled contact points. The resulting contact interface could be modified for very high current density or for very high density discrete data paths. The normal force required between the mating surfaces to obtain good electrical contact would be reduced by an order of magnitude compared to traditional fork and blade connectors.



The electrical connector had increased surface contact across the separable interface, greatly reduced normal force with significant impact on insertion force and plating life, with highly redundant and load-balanced contacts for very low milliohm resistance. This and others in the new class of connectors was patented and is now available to a range of industries, including military, aerospace, medicine, information technology, automobile, electronics, and appliances. The design results not only in more interconnections in a smaller space and a controllable insertion force, but also a longer connector life, lower cost, and easier manufacturing. The design was the basis for a new company, Tribotek, Inc. (www.tribotek-inc.com).

Axiomatic Design Solutions is a business and technology consultancy that delivers measurable results and value through the application and support of axiomatic design methods as a basis for quality-driven design processes.

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