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The engineering design process

All the disciplines of engineering can be subdivided into two basic categories: *design* and *research*. Research, in turn, can be divided into *pure* and *applied*, with applied research in fact oriented toward the solution of a design problem. Thus, the vast majority of engineering professionals or practitioners are engaged directly or indirectly in the design process.

The process of developing a design is an interesting one, whether the design be of a component, a subsystem, or a total system or product. The first observation is that there are two basic approaches to the philosophy of design of engineered systems. One is to start with an inventory of the known available products, define the parameters of the anticipated system, and then set about the task of accomplishing the resolution of the parameters with the products of the inventory to achieve the system. The second approach is to concentrate on the specific definition of all possible parameters for the system, subsystems, and components and from these develop an idealized design, then temper the final design by reducing the ideal to that which can be accomplished with the available products.

Designer's knowledge important

In the first approach, the design is limited by the designer's initial knowledge of the available components; whereas in the second approach, the ultimate design is limited only by the designer's ingenuity in defining the parameters, with the *total* available components simply defining the limits. In the second case, not only does the lack of knowledge of the available component products not restrict the

results, but, because the designer achieves a preliminary result *prior* to inventorying the component products available, he has considerably better knowledge of what he is looking for when he does conduct the inventory. Furthermore, the designer who follows the second approach has historically been the catalyst of progressive inventions of new products.

Another similar observation that carries the *available product* foundation of the design process one step further is the *handbook* approach. This approach to design is to consult reference materials and publications to determine how past designers have developed previous similar designs, and then to use their concepts as though they were an available product.

Other ways of expressing this difference in design philosophy are:

- *Continuity of methods* versus *creativity*. This is the approach wherein the designer develops his new design utilizing the same fundamental parameters he employed in the past, rather than continually updating his definition of parameters and forcing them into a specific project.

- *Product orientation* versus *systems orientation*. In this case, the difference must be recognized between a final system product and a component product. As an example, the designer of an electrical resistor or transistor has completed the design (and subsequent manufacture) of a component product. It is the system designer who utilizes this product as a component of a television set, calculator, or whatever. Similarly, the designer of a

window air conditioner or a centrifugal water chiller has provided a component for a building environmental system. The component products are *not* the completed system until they are integrated into the systems in some planned or unplanned array of other devices. Lack of recognition of the difference between the product and the system inevitably leads to inferior ultimate performance.

When one observes the myriad of engineered products and systems over the years, it is evident that the vast majority were designed on the basis of the *available component product* or *prior experience* philosophy, rather than the *system* philosophy.

The design of the ultimate system or consumer product, when based on the first of the philosophies discussed, tends to fix the state of the art; whereas, when based on the second philosophy, it tends to advance the art. As one observes specifically the HVAC industry over the past three and one-half decades, the most striking example of the overabundant application of the product-oriented philosophy is the evidence of fads, such as radiant heat, dual duct high velocity, perimeter induction, absorption cooling, total energy, all electric, variable air volume, and so on. These fads varied more with calendar time than with any

other recognizable parameter. Yet calendar time has little to do with the specific parameters relating to a specific building project.

System design requires talent

Admittedly, the second or conceptual approach to systems design may require more engineering talent and time. Talent being in short supply and time being an economic fact of life likely justifies having to use the first approach. However, we are at a stage in both the national and international economic cycles where we can no longer afford the luxury of waste caused by a static state of the art. The day of being successful in the automotive industry by making last year's product with different trim is past. The day of building the new glass-skinned skyscraper with a dual duct high velocity system has also passed.

Unlike the consumer product business of optics, electronics, and automobiles, the building industry is not motivated by foreign competition. However, as our economy becomes ever more sensitive to capital shortages, reduced growth of productivity, increased operating and maintenance costs, and energy shortages resulting in increased costs, the need for recognition of the value of the conceptual approach to designing engineered systems will inevitably surface.