Windsor Industrial Development Laboratory, inc.

WIDL Écho

Your partner in design through simulation

Volume 16, Number Two

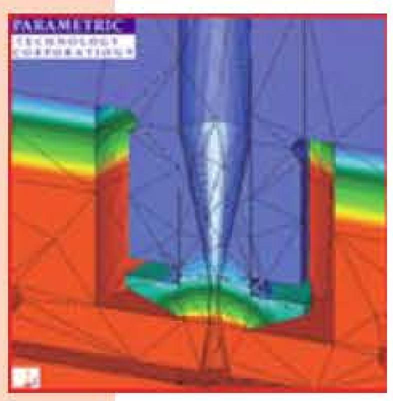
About Us

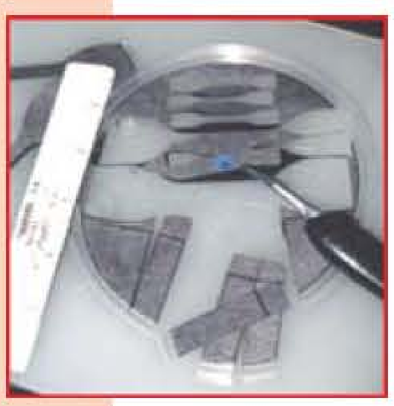
Success in today's business climate demands a comprehensive and diverse approach to product development. The goal: Higher quality and lower cost goods before your competition. For years, WIDL has pioneered methods, processes, and software technologies for speeding, yet optimizing the way companies design, engineer, and manufacture products.

Indeed, WIDL's corporate culture blends a global product development consulting brainpower with well established testing tools and computer software, to provide customers with industry proven experience and the latest in technological advancements. From design development through production setup, WIDL's capabilities, experience, and technology are for sure timely and cost effective.

In fact, WIDL continues to position itself as an R&D/Engineering firm that merges internal skills to customers' solution processes. We pride ourselves on introducing new technologies to improve product and process automation, visualization, and modeling.

In testimony, our newsletter WIDL *Écho* bi-monthly reflects our dedication to product and process optimization. Within the newsletter's articles you will particularly find products, services, news, and information that will help you stay abreast of significant changes in the materials, design, development, and testing arenas.





Total Product Optimization

Many companies still have a segregated approach to designing new products, or to make major upgrades to existing ones. Technical disciplines tend to be grouped into "silos": Groups of engineers perform portions of the product design, with relatively little interfacing with other groups. While there are plenty of meetings and phone calls, the actual design work is done with processes and tools that become unique to their discipline.

Fortunately, some companies like NASA and other advanced technical organizations are beginning to take a first major step toward "Integrated Product Teams" or IPTs. These teams, work together in a common area, report to a common boss, charge to a common budget, and have one common focus.

Still, after an IPT concept has been implemented in some way, shape, or form, the next logical step is to produce a complete model of the product, such that the entire design can be developed and optimized as a total entity. This Total Product Optimization (TPO) concept can yield huge advantages, in particular when cost, time-to-market, and other competitive considerations are important.

Still, the effort to create an integrated model of a product, especially when it is a large system like an automobile, airplane, missile, assembly line or refinery, can be truly awesome. It is seldom practical to just drop existing discipline models and start over with a new complete model. An incremental phase-in of a TPO environment is usually necessary. The early selection of a capable total simulation tool, in-house or through contract, is required. Such tool must have all key features to ultimately become the central simulator. Because of the need for the incremental phase-in, it must interface directly or indirectly with common discipline-specific models already in existence. Some of these models may later be incorporated into the central tool, while others, due to their uniqueness, may remain separate but integrated from control and data passing points of view. Other very important central tool characteristics are:

- A friendly and flexible user interface, and dialog capabilities;
- The ability to generate multidiscipline models (mechanical, electrical, thermal, chemical, etc.);
- Predefined, or easily adapted interfaces to existing models;
- The ability to perform trade studies and what-ifs, to quickly show product performance for varying conditions;
- The flexibility to insert simulated failures, and to show system's performance under adverse scenarios;
- The ability to accumulate "design knowledge" about the product, to apply to testing, product operation, field maintenance, or later improvement;
- The capability to become a real-time operation and diagnosis tool, and
- A highly developed and proven hardware interface

Once such a tool is selected – or a link to it, through a development house, found-, and users have become accustomed to it, organizations can begin to reap the benefits of optimized products and shorter development cycles.

WIDL *Écho is a bi-monthly e-publication*

Do you know?

that demanding applications in industries such as the aerospace, automotive, pluming, and healthcare have traditionally relied on metals like titanium, aluminum, and steel, as well as, on alloys made of zinc, copper, and magnesium. Today's high-performance plastics though offer lower-cost alternative to these metals, and improve products performances. Compared to metals, injection-molded plastics can reduce cost in at least four ways:

Part consolidation – One of the biggest advantages of injection molding over other manufacturing techniques is the ability to produce extremely complex shapes. Two or more parts can be molded as a single component having the same function and features as a multi-component system. By eliminating assembly operations, production costs can be significantly reduced.

Lower cost per part – As with stamped, cast, or forged parts, there are tooling expenditures associated with injection molding plastics components. However, once initial tooling costs have been recovered, the cost to produce each injection-molded component is typically less than that to produce a metal counterpart. This is because injection molding has faster cycle times, so more parts can be manufactured per machine hour. Besides, tooling for plastics can last considerably longer than die-cast tooling, because of the more aggressive processing conditions required for metals. Complex geometries can be precision-molded to tight tolerances, unlike the die-casting of metals that require post-machining operations.

Assembly simplification – Plastics components use a variety of assembly techniques to improve efficiencies. Ultrasonic staking and welding are commonly used to join plastics components, thereby eliminating the needs and expenses of fasteners. Injection-molded components can also be designed with snap-fit features for quick assembly, a common technique with plastics because of materials' inherent flexibility.

Elimination of secondary operations – Cost can be further reduced by "getting rid" of expensive, time-consuming secondary operations. Plastics don't rust or corrode like metals – eliminating the need for protective coatings. Because plastics can be injection-molded to tight tolerances with exceptional reproducibility, no additional machining is required. Moreover, plastics can be pigmented before molding, thereby eliminating the need for secondary painting operations.

Product performance improvement – Although cost reduction is often the driving force behind a metal-to-plastic conversion, there are often added benefits that improve overall product performance. These include reduced weight, increased product life, greater design options, better appearance, and noise reduction.

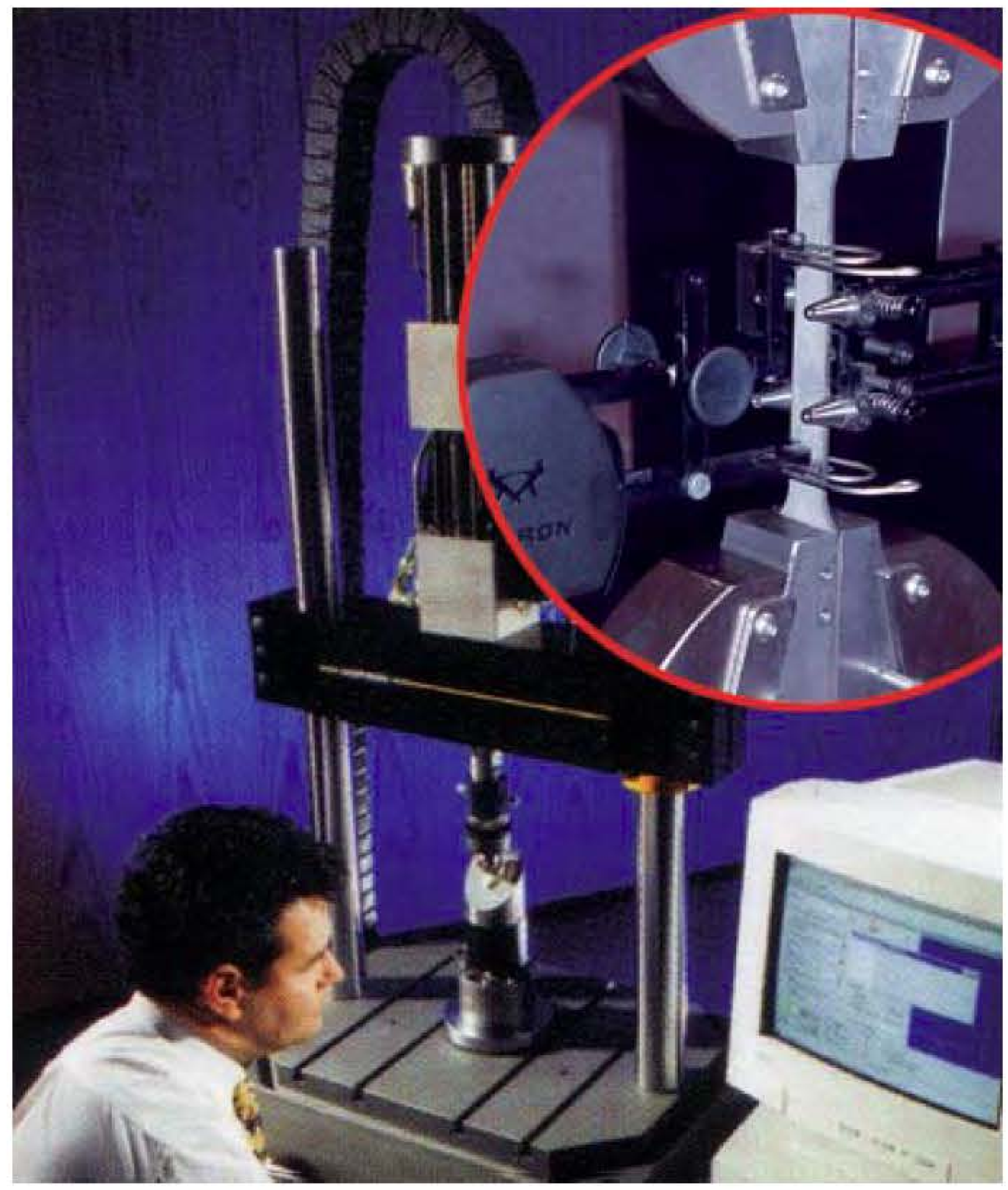
An example? Sterilization cases and trays made of polyphenylsulfone are virtually unaffected by 000s of autoclave cycles. These durable, lightweight trays are easy to handle and can further be customized (than stainless steel) by choice of color, silk screening, and permanent laser etching.

Metals Elastic-plastic Modeling

In recent years, metal forming simulation (e.g., stamping, forging, extrusion, etc.) using Finite Element Analysis received a great deal of attention. As a predictive mathematical tool, FEA has the potential to reduce lead times and minimize scrap rates by removing "black art" elements from manufacturing methods. Despite recorded breakthroughs, research is still needed before full confidence can be placed in these methods. One such area is the material model to use.

Example: There is a large number of proven constitutive equations built into finite element codes such as ABAQUS™ (cf: http://www.hks.com) for general purpose non-linear analysis, or PAM-Stamp™ (cf: http://www.esi.fr), specialized in sheet metal stamping. Metal models provided in ABAQUS™ for example consist of general elastic, elastic-plastic, and visco-plastic behaviors. Both isotropic and anisotropic responses can be modeled. However, more complicated materials require a subroutine interface; UMAT.F in ABAQUS™ can in particular code sophisticated materials models, such as visco-plasticity, coupled plastic visco-plasticity, crystallography, creep, and brittle and ductile damage.

A simple formulation to model plasticity is von Mises, associated to an isotropic flow rule based on Prandtl-Reuss equations. Such a model requires true stress-strain measurements. The elasticity modulus, E, defined by curve fitting a line



Tension Testing Metal Samples for True Stress-Strains at WIDL

to test data prior to yield is needed. A technique known as the "0.2% offset" on strain is described in ASTM Standard E111. Poisson's ratios (or transverse to longitudinal strains) complete the definition of elastic régime for metals-like materials (cf: ASTM E132). Strain hardening is based on pairs of true stress and logarithm plastic strain. The latter is defined as: $\varepsilon_p = \varepsilon - \varepsilon_e = \varepsilon - \sigma/E$ where σ and ε are true stress-strain data; ε_e is the elastic strain recovered if samples were to unload, once yielded.

Still, the difficulty in modeling metal forming is prediction of failure. Many analysts associate failure to the yield stress. Better approaches use J2Flow, Gurson, and Taylor Crystalline failure criteria for metals. Such models are calibrated to laboratory tests, using Limit Dome Height and necking, in particular.

WIDL Écho *welcomes your opinions, critics, article proposals and any suggestion for further readings*

Windsor Industrial Development Laboratory, inc.

MAILING ADDRESS: 3310 Longfellow Avenue
Windsor, Ontario, Canada N9E 2L6

TEL: (519) 966-4479
FAX: (519) 966-7133

INTERNET: http://www.widl.ca

PLEASE CIRCULATE THIS NEWSLETTER. THANK YOU!