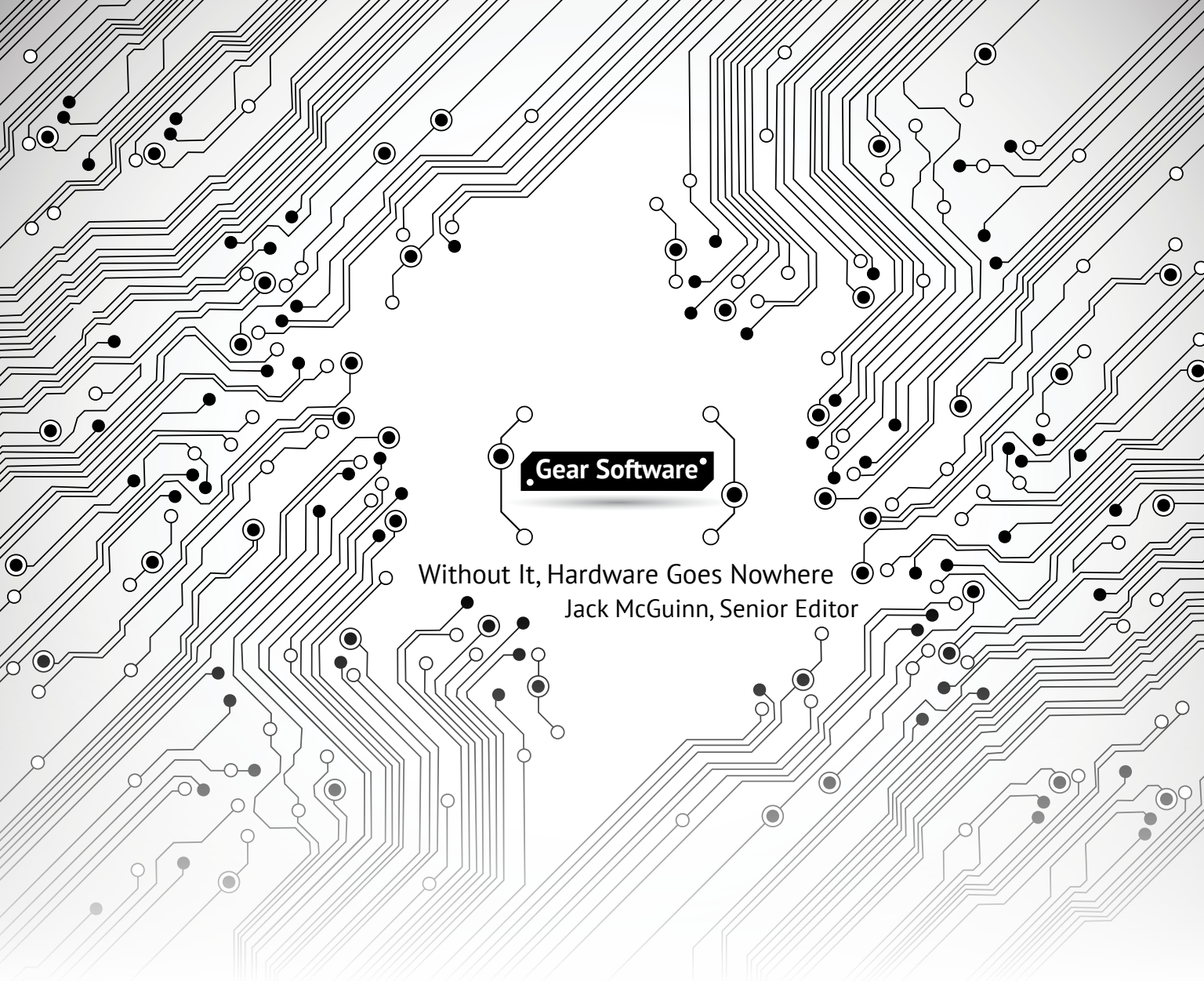

Without It, Hardware Goes Nowhere

Jack McGuinn, Senior Editor

It's a brave, new hardware-software world out there.

Players in the worldwide gear industry who don't have plenty of both run the risk of becoming irrelevant—sooner than later.

Gear industry-related software—both design- and manufacture-oriented—is essential to any number of steps inherent in gear design, inspection, metrology and manufacture. Those include: prototyping, preliminary design and calculation; standards compliance; geometry factors; measurement; enabling closed-loop gear manufacture; time- and downtime-savings; tooth contact analysis; gage certification; mesh; reverse engineering; material and hardness analysis and so on. Many of these elements serve to determine the optimal machine settings for, say, cutting machines, a modern means of practicing the tried-but-true practice of "measure twice, cut once."

Bottom line, all of the above serve to make according-to-spec gears that customers demand. Absent software today—no NASA, no moonwalks, no CGI (Holy Holigraphs Batman!)—no MRIs and certainly no high-ratio hypoid gears (*which you can read about in this issue's Ask the Expert column on page 43*),

How to Choose Right Software Vendor/Package

"An engineer looking to purchase software has to consider a number of important factors," says Robert Forrest, SMT (Smart Manufacturing Technology) product support and marketing manager, "some of which include knowing whether the software is reliable and gives accurate results to the latest standards; (whether) the vendor provides timely technical support; whether the software meets their current and future needs: and if there is a clear vision for future software development."

For Excel Gear Inc. president N.K. "Chinn" Chinnusamy, "This is highly variable; some do an Internet search and look for a familiar name and/or read the ads. A recommendation from the machinery supplier carries a lot of weight. A consultant's recommendation can sometimes be decisive."

"Different software packages are applicable in different situations," says Mike Fish, co-founder of Dontyne Systems Limited. "In each case, a cost/time/function evaluation must be performed—preferably on several options in the market. There is no one package applicable to every situation; some companies are of the opinion that due to budget restrictions they must opt to develop existing, in-house methods themselves. I think that if engineers, though in many cases technically capable, considered the time to develop and maintain a calculation tool with continued support, documentation and transferability, it would not be cost-effective."

And from S. M. "Jack" Marathe of UTS (Universal Technical Systems, Inc.), "The key criteria by priority are capability of the software as it pertains to the needs of the user; ease of use; ease of learning; credibility; i.e., who else is using it, how long has the product been on the market and how long has the software developer been in business; quality of support available; and price."

"The most important aspect is that the software vendor has a proven history of validated usage across a range of industries across the globe," says Dr. Jamie Pears, product manager, Romax Technology. "You also need to choose a software vendor that has a highly qualified and knowledgeable team covering software development, mechanical engineering and commercial activities. A vendor who actively invests in R&D shows that they are in it for the long haul and will continue to support customers in the future."

Once you've chosen a vendor the next task is identifying the best software package or packages for your business.

Forrest says that "Two important features that differentiate software packages from one another are ease of use and expandability, and a clear vision for the future. The highly modular nature of *MASTA* means that engineers can select the functionality that is important to them in the knowledge that additional functionality can be easily added to meet their changing needs."

Why Not Just Use the Machinery Vendor's Software?

Not surprisingly, "A machinery vendor has a major advantage," says Chinn. "Someone buying a machine is likely to try the vendor's software if he has it. A reason not to use a vendor's software is if it works only with the vendor's machine and the buyer has different machines. Using one software program instead of many is a major advantage."

"I don't think this would be common practice unless the software was specific to the function of that particular machine, which may be the case in high volume production and patented gear manufacturing methods," says Fish. "Conversely, we have several machine manufacturers as customers who have opted to utilize certain sections of our code integrated to their machines. This is particularly the case when a manufacturer wants to offer solutions for specialist applications without the cost of reinventing it themselves."

"It depends on the type of software being considered," says Marathe. "Typically a machinery vendor does not provide gear design and analysis software. Their main business is to sell machinery and not software. In some cases if the software is very closely aligned to the use of the machinery, then it may be practical for the machinery vendor to provide such software and for the customer to consider buying it from the machinery vendor.

"For example, if it is a gear checking/inspection machine, then it may be logical to get certain software that does further analysis of the results of the gear inspection from the machine vendor. Also it may be appropriate to buy the change gear software or CNC part programming software from the machinery vendor."

"We are seeing that customers normally require a solution that is seen as independent from the machinery vendor," says Pears**.** "This means that they can avoid being tied to one particular vendor and enable the same software to be used across a range of machinery; it 'future-proofs' them to a certain extent.

"However, sometimes the machinery vendor has unique knowledge and understanding of the manufacturing machine, especially for bevel and hypoid gears. In these cases, we see that customers want to use the specialized machinery vendor software, but often want to combine this with an independent system level gearbox analysis tool. This was one of the drivers for the successful partnership between Romax Technology and Klingelnberg GmbH, where we have linked *RomaxDesigner* with *KIMOS*. This enables customers to use the sophisticated *RomaxDesigner* gearbox system level analysis to predict the misalignment of the bevel or hypoid gears, and then use *KIMOS* to perform a detailed loaded gear contact analysis, considering the predicted mesh misalignment and the manufactured gear profile."

What Drives Gear Software Development Today?

"Good software follows machine technology to the extent that the software should not allow something to be designed that cannot be made," says Forrest. "However, good soft-

ware should allow the user to push the boundaries of the machine technology to get the best design possible."

"Gear software usually follows technology," says Chinn. "However, a major step forward in technology may require simultaneous release of software in order for the technology to be used properly."

Pears adds that "The driver for new software is mainly a requirement to design and analyze gears in a process that is quicker and easier to use; we are seeing that users of our *RomaxDesigner* software have less gear-specific experience and are required to be multi-skilled across a range of engineering areas."

What About Price?

"As modules are priced individually and can be added at any stage, the user retains the flexibility of seamlessly adding more functionality at a later date to meet their requirements," says Forrest. "The price for software from different companies varies considerably but the old saying, 'You get what you pay for,' applies here; and sometimes what you pay for is not what you want."

"There are differing packages available which have differing prices," says Fish. "It is important for a company looking to buy software not to look purely at the outlay, but to consider the benefit to the improved production. Once it is established that there is a technical benefit, it can be more easily justified financially. Says Marathe, "It all depends on the capability and the underlying complexity of the software and the type of investment that is required to develop such software." There is a huge difference between being able to make drawings that show gear tooth profiles versus making the gear calculations that are the heart of a good gear design."

Expertise Required

"A range of disciplines are required when creating and developing gear system design and analysis," says Forrest. "These include gear design engineers; bearing engineers; gearbox system designers; analysts for NVH and dynamics; software specialists; and manufacturing engineers. SMT employs engineers in all these disciplines who collectively have decades of practical experience in gear and transmission design and between them have delivered numerous successful transmission designs for the automotive, wind turbine, industrial machinery, aerospace and marine sectors."

"Good 'user-friendly' gear software requires gear design knowledge and experience," says Chinn. "Programmers do not require much industry experience if an experienced design/manufacturing engineer leads them. The best program results from a team headed by an experienced engineer, some good programmers and some feedback from a few users."

"The experience is crucial," Fish believes. "A trained software engineer can rapidly develop an interface and even implement standards from documentation to produce a calculation procedure, but would have no feel for the accuracy or application of this tool. We

have also experienced many gear engineers who developed their own calculations on various platforms. These are fine for internal use but generally only reflect one approach to design."

"Knowledge of the gear industry (where and how the gears are to be used and real-life problems being addressed) is very important," says Marathe. "Equally important is the knowledge of the gear mathematics and expertise in developing and maintaining the software. Gear design engineers may or may not have such breadth of background that is crucial."

Pears believes that "Gear industry experience is definitely required to ensure that the technical details are correct and the work processes are properly captured in the software; another important aspect is that the software is user-friendly and intuitive."

Customized Solutions

"All users want a solution that fits their specific application needs and good software should accommodate this as far as possible," says Forrest. "For example, in *MASTA*, as well as industry-standard materials and a comprehensive catalogue of commercially available bearings, the designer can define (and store) customer-specified materials, bearings and gear tooling parameters."

"This used to be common," says Chinn. "Software was written in-house or by a consultant. It probably is still done for high-value or high-volume work. Since no one knows everything, some special applications require special, specific-type programs that become too complex for common use."

"Some customers may have specific requirements," says Fish, "but all such systems should at least have the capability to work to a recognized standard system for a traceable reference."

"It is common if the software we are talking about is very closely aligned with the operation of the machine," says Marathe. "Also, customer-specific software may be the most practical way to get software developed that meets the targeted needs of a customer for whom the software that meets the needs of a broader customer base may not be as beneficial."

"Romax often performs customer-specific developments, says Pears. "On *RomaxDesigner*, for example, a customer may have their own gear contact analysis algorithm that has been proven over the years in their particular application. (At some point) they may come to (us to) integrate their code into *RomaxDesigner*, which we then supply back to them on an exclusive basis; we handle the time-consuming and risky maintenance and updates of the software to Romax."

"First and foremost, it must be fit for purpose," says Fish. "Apart from the list of available functions appropriate to their production, the speed to perform a specific task should be considered. Customers may also have a preference in the layout of the GUI, technical support and response to dealing with any issues or questions that arise."

And from Pears: "A technical lead in software can only be established by actually doing the same work as your clients. Romax has done more than 65 NVH projects in the last 10 years, designed automotive transmissions that are made in volumes of over 1 million-

per-annum and has completed dozens of wind turbine gearbox designs—up to 5 MW."

It's Not *ALL* about the Software

"Software is a tool," says Forrest. "And like any tool it can be misused by inexperienced people. Design engineers need to understand the application (i.e., where and how the gearbox will be used) in order to design both for robustness and functionality.

"In addition, the designer needs to have knowledge of how the product will be manufactured. All designs are a compromise; the use of good software tools allows the impact of decisions made to facilitate manufacture to be explored before metal is cut."

"Almost any software can be misunderstood/misused," says Chinn "An experienced engineer should always review critical applications. This is especially true of design and analysis software. Inspection software is less likely to be misused."

Fish contends that "There is an increasing element in the inquiries that ask for some kind of solver or optimizer to present a solution based on the input data; it is important to resist this. In our experience good software simply facilitates the ease with which a competent gear engineer completes their task, providing observations and suggesting areas in the design, manufacturing or measurement to which it relates could be improved. It will never replace the role of a competent engineer."

"Younger engineers have a tendency to feel that 'If the results came (from) software, then it must be the perfect answer,'" says Marathe. "However, they do not understand that good engineering judgment is a must. That comes from real-life experiences of having to live with what you have designed. Otherwise, it is a case of 'garbage in–garbage out.'"

Hot Industries for Software

"In general, gear products that have demanding requirements in terms of power density and safety, such as aerospace or high-value products such as wind turbines, large marine or industrial transmissions, benefit more from utilizing gear system analysis software tools like *MASTA*," Forrest says. "This is because many different design scenarios can be explored before finalizing the design direction. The automotive sector is increasingly using these system tools to predict potential NVH issues in vehicle drivelines."

"Support is a huge issue to all sectors," says Fish. "Quite often now, gear production is a global operation with the design in one country, manufacture in another, and sales in another. All sectors will require—and should expect to have—timely access to customer support (in line with) their operations."

"In all sectors that involve reliability and need to have optimized designs (in terms of performance, minimum size and weight, minimum cost, reliability, etc.) having good software to work with is a *must*, says Marathe. "Aerospace and wind turbines are certainly the kinds of applications that do need good software but frankly speaking as do most applications these days."

Keeping it Lean

"*MASTA* was developed to enable a designer to build a 3-D model of the gearbox, run the model through a virtual development program before creating the CAD models for production," says Forrest. "The *MASTA* models can be exported to CAD for packaging studies and adjustments made, again before creating the final CAD models. This can significantly reduce product design and development time. The biggest hurdle to 'leaning out' the product development cycle is that most companies follow the traditional route of laying out the gearbox, analyzing, adjusting the design, re-analyzing, building prototypes, testing, adjusting the design, etc."

"Machine manufacturers will perform a degree of performance evaluation trials for testing and marketing," says Fish. "Statistical evaluation methods will be employed by the manufacturers. This is certainly present in some inspection equipment; the data can be used to improve production accuracy and efficiency, as well as change the performance characteristics of products."

"Lean manufacturing requires integrated software that links all aspects of a business," says Marathe. "But in addition to lean manufacturing (i.e., optimum), design is also a need of the hour."

(*Author's Note: When reporting on gearing software, one could write a suite's worth of stories on the subject—each one on a different code capability and application. With that said, we'd love to hear from you regarding the finer points and capabilities of manufacture and design software. Inspection, cutting—whatever—if you have something you think your fellow readers should know about, please send your suggestions, technical papers, white papers at jmcguinn@geartechnology.com.*)

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