Engineering Next Generation Oilfield Equipment:

Driving Fast, Reliable and Collaborative Design Decisions

Designing oilfield equipment today is no easy task. There are serious technical and business trials. But modern technologies can help engineers rise to the challenge.

Published by:

LIFECYCLE INSIGHTS

Introduction

Being an engineer today is tough. You have to enable and foster a very democratic design process, where you're collecting feedback from organizations across the enterprise. You must collaborate with many experts in technical centers around the world. Errors that get downstream come back to your desk as emergencies, forcing you to reprioritize work constantly. There's no doubt: being an engineer today isn't for the faint of heart or weak willed.

Designing equipment for the oil and gas industry, however, presents some additional unique challenges. There is immense pressure to utilize new technologies to pinpoint reserves quickly and safely. Yet, due to the high daily expenses of exploration projects, failed equipment that stall operations undermine profitability, quickly drawing the ire of executives. Mistakes made under such dire business circumstances carry serious consequences for the organization and often for the individual.

Fortunately, the latest technologies offer new tools to empower engineers to be innovative while ensuring the reliability of their work. Emerging Computer Aided Design (CAD) applications have incorporated capabilities that make the exploration of alternatives faster and easier. New Computer Aided Engineering (CAE) software predicts performance more completely and accurately than ever before. Furthermore, enterprise information held in Product Lifecycle Management (PLM) systems are more closely integrated into both CAD and CAE technologies, providing greater visibility and participation in company wide processes. Such advances translate into the ability to evaluate more designs that run more reliably in the field.

In this eBook, you will find more details on how these advances affect engineers and the organizations that design oilfield equipment. It starts with an overview of today's business pressures for oil and gas companies; further delving into how those pressures translate into design challenges. It details new capabilities of CAD, CAE and PLM software and the advantages they represent to those designing oilfield equipment, closing with conclusions and a summary.

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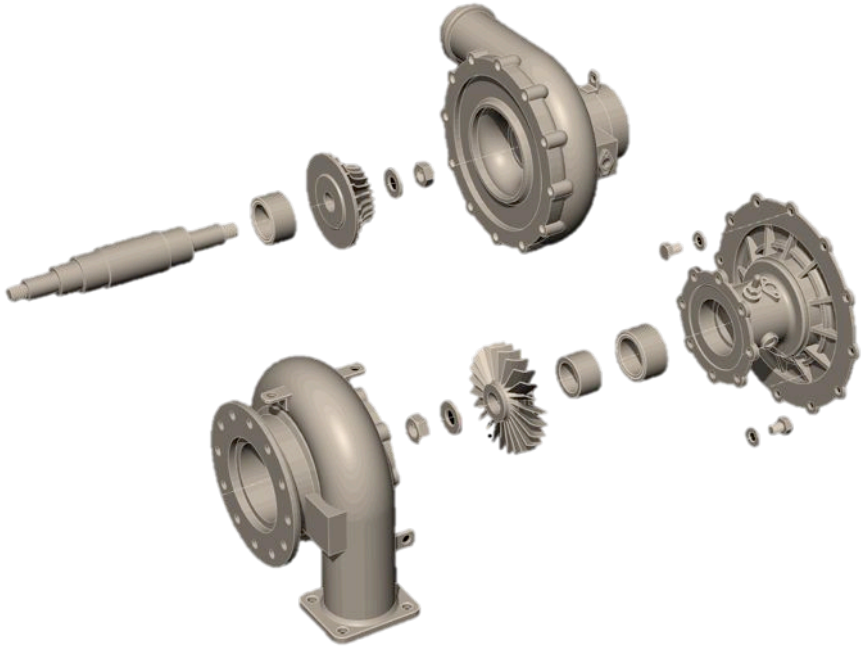


Translating Oilfield Business Pressures into Equipment Design Challenges

There is little doubt: project cost is a major concern for the oil and gas industry. Many have voiced doubts that the price of oil will continue its meteoric rise. Commodity markets, including oil, seem to have increased volatility, introducing concerns over continued top line growth in executives' minds. Many think that current approaches are simply not sustainable in terms of those costs. So, as expected, many companies seek to protect their profits by applying more scrutiny to the costs involved in the execution of these massive projects. Contract responsibilities are often complex. Site construction can be delayed because of failed equipment or changing requirements late in the development cycle, resulting in costly reengineering. All aspects of operations and internal processes are fair play for process improvement and cost control, including engineering.

Design It Fast

Saying that the design effort behind oilfield equipment is hurried would be an understatement. Once given rights to move ahead with an exploration project, time to finding and producing hydrocarbons is critical. As a result, equipment meeting the specific requirements of the project needs to be developed and delivered quickly. Engineers are under the gun to design fast.

Design the Latest Technologies In

Innovation is the key to success and competitive advantage as technological, safety and environmental constraints force companies to find new ways to work. Engineers are looking to integrate innovative technologies into their equipment.

Design Reliability In

Quite simply, failures must be avoided. Equipment is critical to the success of exploration projects, where daily operating expenses are high, the environments can be extreme and safety a top concern. Failures can cause the entire project to come to a standstill, causing the company to lose money every hour it is delayed. Engineers must design reliability into the equipment and guarantee against failures.

Control Design-Driven Costs

Despite the time constraints and need for reliability, over-engineering the equipment is also an unpalatable choice. It could translate into higher material costs, transportation charges as well as other issues. Simply right sizing equipment for the task at hand translates into higher profitability.

Furthermore, reusing existing components reduces a variety of costs, ranging from testing to volume production discounts. Despite the need to meet requirements that vary widely from project to project, leveraging existing design efforts and physical components is a savings opportunity that is being pursued.

Be Ready for Change

Unfortunately, the scope and requirements for the equipment can change on a day-to-day basis. Engineering teams must be agile in accommodating change across their entire design cycle, ranging from exploring new designs, validating their performance or keeping up with changing specifications.

The Takeaways

It's clear that engineers who design oilfield equipment are under multiple competing constraints. Here are the key competencies that engineering organizations need to develop to be successful.

- Oilfield equipment engineers must be able to make well-informed and sound design decisions quickly. They must be able to design reliability into equipment by assessing and validating performance throughout the design phase, not just as a final verification step.
- Furthermore, they need to be able to explore and iterate on many design alternatives and options, such as investigating the equipment's design space or operating environment. This is critical to finding the innovative capabilities needed to be successful in the oilfield. But it is critical to execute these activities easily and quickly.
- Last, but not least, experts in particular fields are often spread across the globe, both inside and outside of the engineer's company. They need to be able to collaborate with all of them, gaining feedback and correcting the trajectory of their designs along the way.

In all, incorporating all of these competencies into an engineering organization is a tall task. New technologies, however, can help enable such changes.

Progressive Design Tools

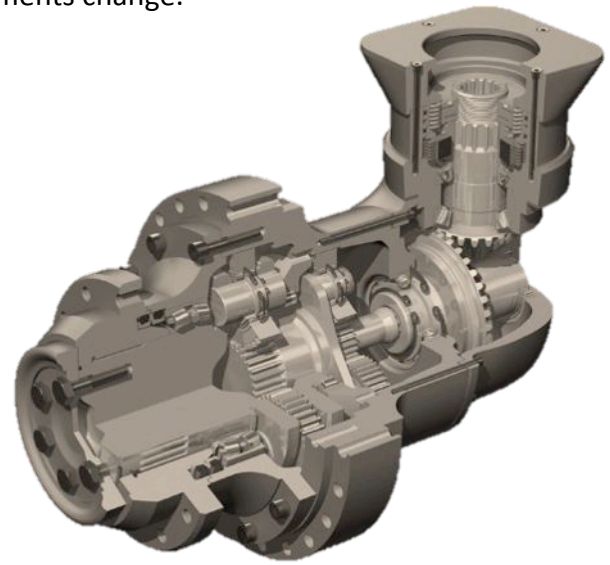
Bringing about improvement to design and engineering activities can be driven by organization change, process modifications and adoption of technology. In the past few years, there have been marked improvements in the tools at the disposal of designers and engineers. In this section, we'll take a deeper look at three of those kinds of technologies and detail how their capabilities are relevant to engineers designing oilfield equipment.

New Modeling Tools Boost Design Exploration

For many years, CAD applications were considered staid because of the slow rate of impactful change and their middling effect on organizational performance. However, the past five years have interjected numerous innovative advancements, specifically in the sphere of design exploration, not engineering documentation. Here are the most important advancements and why they are relevant to oilfield companies.

- **The Integration of Direct and Feature-based Modeling:** Direct modeling allows users to push, pull and drag geometry without regard to how 3D geometry was originally created. Feature-based parametric modeling allows users to capture their design intent, powering automated and intelligent change. Individually, both provide value to design efforts. Though, in combination, these tools allow engineers to make quick and easy modifications to 3D models, enabling them to explore new design iterations and alternatives.
- **The Emergence of Direct Sketching:** Not all design is done with 3D modeling. In fact, early work on designs often starts in 2D, where there is minimal commitment and planning required. A new means of designing in 2D, called direct sketching, provides capabilities to make fast but intelligent change to lines, curves, arcs and more. This stands in stark contrast to sketching tools, which can constrain the modification of 2D entities despite efforts to iterate, as well as drafting tools, which offer few options for broad and intelligent change.

Both of these advancements, the integration of direct and feature-based modeling as well as direct sketching, enable the same thing: faster iteration and exploration of design alternatives. For oilfield equipment engineers, it supports the need for design agility, both in finding new designs and when requirements change.

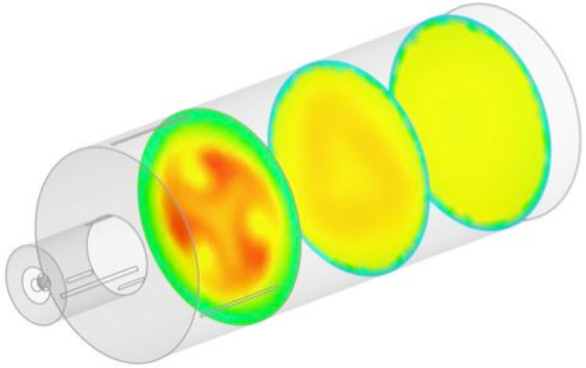


Driving Design Decisions Based on Simulation

Simulation driven design is not a new concept. The idea has always been to use simulations as criteria for design decisions long before a last pass simulation. Organizations have been pursuing it for many years with varying degrees of success. The difference, more recently, has been the emergence of new functionality that eases the transition from 3D detailed design models to simulations as well as taking broader physics into account. Here are more details on those capabilities.

- **Converging Design and Simulation Models:** Building CAD models and CAE models have traditionally been separate activities. Engineers have relied on different tools from the CAD designer, requiring an import of the CAD model geometry into the CAE software application, an error prone task. In recent years, some software providers have integrated CAE and CAD capabilities. The end result is a more seamless environment where designers and engineers can set up and conduct simulations more easily and far quicker. That is a critical improvement that empowers engineers to check performance during the design cycle.
- **Application of Direct Modeling to CAE Preparation:** Detailed design 3D models are rarely ready for simulation without preparation. They often require some abstraction and simplification, efforts that have been painful in the past. Direct modeling tools, which have been integrated with CAE capabilities, enable engineers to perform such modifications much faster and with a smaller chance of errors. Importantly, CAE engineers can perform this task themselves and not have to rely on CAD experts to make the changes.
- **Multi-Physics Increases Simulation Accuracy:** Another area of advancement has been the broadened scope to cover a wider range of physics. For oilfield equipment, this includes structural simulation of downhole tools, vibration and acoustic analysis of electronic sensors, motion analysis of actuator mechanisms and thermal and flow analysis. Software applications that support these multiple simulations are more efficient because a lot of the modeling work can be re-used across these disciplines. But furthermore, this range of physics can be coupled together to account for their combined effects. That means the simulations are more accurately representing the physical phenomena the equipment will encounter in the field.

In all, these advances aid equipment engineers in numerous ways. They can make well-informed decisions, taking performance into account. Additionally, they can design reliability into the equipment without over-engineering them, addressing some of their competing constraints.



PLM Platforms Enable Collaboration and Control

Most discussions about Product Lifecycle Management (PLM) systems focus on the enterprise, not on engineering. However, an engineer has just as much to gain from PLM, if not more, than the rest of the company. Here are the capabilities of PLM systems that are most relevant, and valuable, to the cadre of engineers designing and manufacturing equipment for oilfield services.

- **A Platform for Global Collaboration:** PLM systems frequently include Product Data Management (PDM) functionality. These sets of capabilities understand how to manage CAD designs, CAE models, specifications and other engineering deliverables in a structured format. These systems can also expose and visually share the information in each of these specialized formats without the need of their original CAD and CAE software applications. Additionally, PLM systems allow engineering organizations to share important design data and information to selected suppliers in an intellectual property friendly manner. For oilfield engineers, this assists in their efforts to work with a global network of experts quickly and easily.
- **Overlaying Enterprise Information on 3D Models:** Engineers work with product development information on a daily basis. They also need to access other information, such as inventory, failure rates, supplier costs and more from other enterprise systems, such as Enterprise Resource and Planning (ERP), Procurement Systems and Manufacturing Execution Systems (MES). New solutions offer the ability to overlay such information on top of 3D models with CAD software applications. This enables engineers to make well-informed decisions with information found in other enterprise systems without ever leaving their design environment.
- **Automating and Enforcing Processes:** Design constraints come in many forms. For some organizations, a Failure Modes and Effects Analysis (FMEA) might be required before testing can start. For others, deploying of equipment in a certain country might require certain material limitations. Either way, PLM systems can route tasks and activities around an organization, automating processes, as well as run checks against key information, reminding or even enforcing specific checks during the design cycle. Engineers, as a result, gain automated assistance to adhere to corporate standards giving them more time to focus on design.

For engineers, PLM systems can provide value in a variety of ways. They provide a platform for enterprise process standardization and help to share your wealth of product development data and information across a global network of experts. They offer access to enterprise information on top of design models. They automate and enforce enterprise processes, even if they are obscure.

Implications of Progressive Design Tools

New CAD capabilities enable more design iterations and, overall, more agility to make changes. New CAE capabilities allow engineers to more completely predict performance, avoiding failures in testing and the field. PLM systems enable global collaboration, enable well-informed decisions and automate processes.

The key question here is: how do these advantages help the company? It's simple. Organizations can pursue and adopt these new technologies, but ultimately they must manifest in some tangible benefit. This section answers that question.

Implications for the Organization

Adoption of these technologies provides benefits that come in a number of forms.

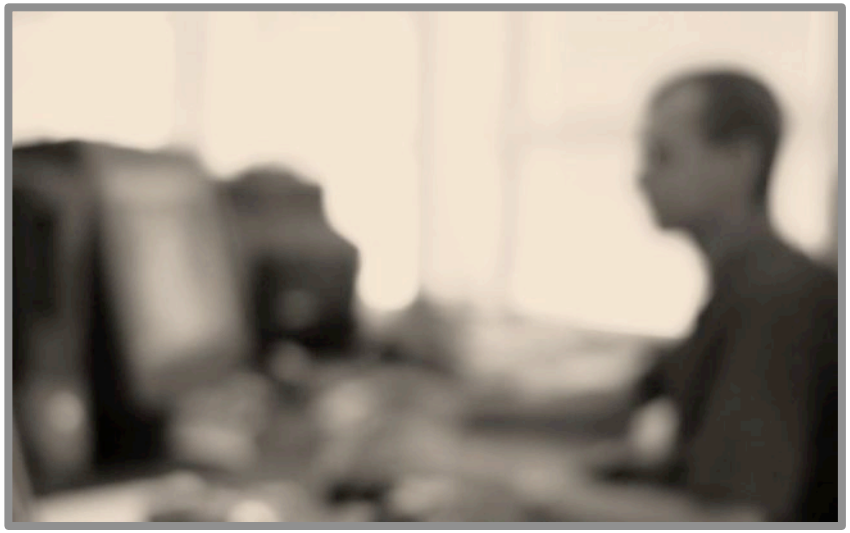
- Increased design exploration results in more innovative and functional equipment creation. Project objectives can be achieved more readily for future use.
- Predicting performance more accurately yields greater reliability in equipment. Yet, it also lowers the cost of equipment sold as over-engineering can be avoided.
- Access to enterprise information results in better design decisions, which in turn results in more effective equipment. More easily enabled collaboration results in better equipment design and can lower the engineers' effort required to conduct that collaboration.

Implications for Individual Engineers

When considering the adoption of new technologies, the emphasis is often on what it means to the organization. But for oilfield equipment engineers, there is a lot at stake as well.

When equipment fails in testing or in the field, engineers have to scramble to fix the problem, frequently deprioritizing current work in favor of the emergency. Unfortunately, deadlines for design release often don't move out, forcing engineers to work nights and weekends to catch up on current product development projects.

Increasing design exploration capabilities, more completely predicting performance and automating processes reduce the chance that design failures get downstream. That, in turn, lowers the chance that an emergency comes back to the engineer's desk as a disruption. Nights and weekends are preserved.



Summary and Conclusion

Being an engineer today is tough. They have to enable and foster a very democratic design process, squash errors before they get downstream and champion collaboration amongst technical centers around the world. Designing equipment for the oil and gas industry, however, presents some additional unique challenges.

Business Pressures and Design Challenges

As concerns over the price of oil increase, time, innovation, reliability, and cost are all hard competing requirements for oilfield equipment. All of these business pressures translate into specific drivers for design activities.

Engineers must be able to make well-informed design decisions quickly and be able to design reliability into equipment by assessing and validating performance throughout the design phase, not just as a final verification step.

They need to be able to explore and iterate on many design alternatives and options. Such investigation of the equipment's design space is critical to finding the innovative capabilities needed to be successful in deploying new oilfield technologies.

Collaboration is key and being able to collaborate with experts in particular fields that are often times spread across the globe is imperative to engineering success in the oil and gas field.

Progressive Design Tools and Their Implications

Improvements in CAD, CAE and PLM software address the design challenges today's equipment engineers are facing.

The introduction of direct modeling and direct sketching allows engineers to quickly explore more design alternatives. The result is more innovative and functional equipment that achieves project objectives more readily.

The integration of design and simulation environments as well as improved multi-physics simulation allows engineers to predict equipment performance more readily and completely. As a result, engineers can design reliability in and cost out.

Greater collaboration as well as automated and enforced corporate processes ease the burdens on engineers while maintaining high quality equipment design.

Being an oilfield equipment engineer today is difficult. But new technologies provide powerful tools to make their work easier, more reliable and innovative.

For more information on design practices and tools for engineers of oilfield equipment, visit Siemens PLM's site. Underwritten in part by Siemens PLM, all concepts and ideas developed independently,

Chad Jackson, the Principal Analyst of Lifecycle Insights, is a recognized authority on technologies that enable engineering, including CAD, simulation, PDM and PLM.

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