

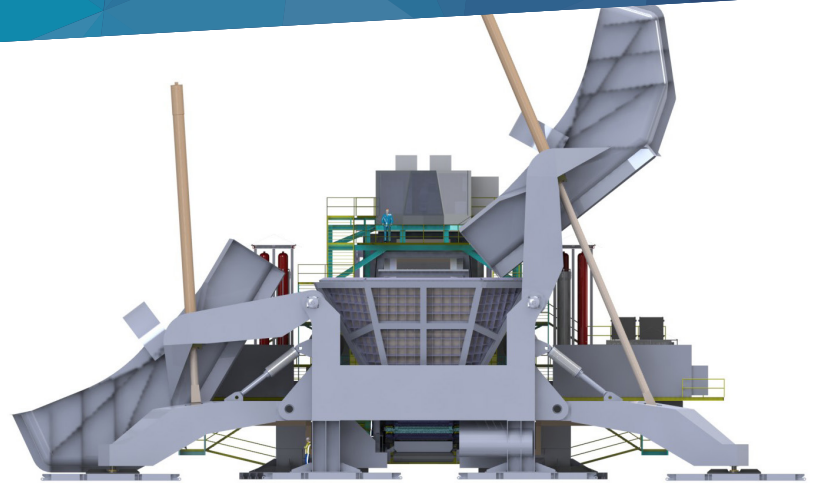
Maplesoft Engineering Solutions team helps FLSmidth develop revolutionary mining equipment

In the mining industry, processing plants are generally constructed on the site of extraction. Mined ore gets transported by super-heavy duty trucks to the plant, where it gets crushed into smaller sizes before being stockpiled, or transported offsite for further processing. Besides the ore, the mine typically has to move four times as much overburden as ore. Big mines typically have to move 700,000 tonne of material per day. As the mine gets larger, the trucks have to travel longer distances to deposit their load, resulting in significant increases in the cost of fuel and vehicle maintenance.

To address this problem, FLSmidth engaged the services of Maplesoft's Engineering Solutions team to develop design and analysis tools that would help them design a Dual Truck Mobile Sizer (DTMS) - an innovative machine that can be relocated throughout a project, as the haul distances increase.

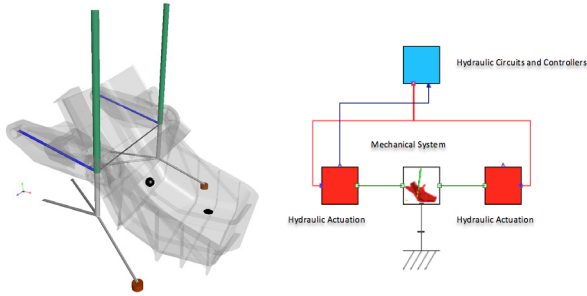
The DTMS increases in-pit crushing efficiency due to its dual-skip configuration. A truck backs into one skip until it reaches a restraining curb in the floor. After dumping its load on the skip floor, it then slowly pulls ahead, lowers its bed, and pulls away. Once the truck clears the end of the skip, the skip can be raised. As the skip is elevated, it pours material from the discharge of the skip and deposits the material into the apron feeder hopper. As material is introduced onto the apron feeder, it conveys the material to the sizer where it is crushed to the appropriate size. After being crushed, the material is deposited onto the discharge conveyor where it is taken to the bench conveyor. This process is performed while another haul truck is depositing material into the twin skip, thereby increasing the number of truck cycles.

- Complex projects involve multiple design groups working on different subsystems which are later integrated together
- System-level modeling provides early identification and correction of integration issues before they become expensive problems



- MapleSim is tightly integrated via API commands to Maple, enabling complex multidomain models to be analyzed and optimized
- Multidomain system-level studies of the DTMS provided early insight into its overall dynamic behaviour, leading to the implementation of significant improvements in its structure and dynamic response
- MapleSim and Maple were invaluable tools for early system design and analysis

To create tools that would help FLSmidth to design this innovative piece of equipment, the Maplesoft team first had to develop a deep understanding of the dynamics of the skip system. They began by using MapleSim, the advanced modeling and simulation platform, to develop a fully parameterized model of the skip. Taking advantage of MapleSim's multidomain modeling capabilities, they were able to create a high-fidelity model that incorporated all the key components of the skip - from its geometric structure and mechanical operation, to the hydraulic circuits and controllers. "The DTMS is a very large and complex machine," says Willem Fourie, Global Product Line Manager - Mobile Sizer Stations, FLSmidth. "The ability to model all aspects of its operation during the design phase using MapleSim gave us confidence that the product we would ultimately build would function correctly the first time. We cannot even begin to put a value on what this means to us."



3D skip model, and corresponding 2D model with hydraulics

MapleSim’s modeling approach not only addresses the basic requirements of dynamic multidomain simulation, but through seamless access to the underlying symbolic equations, enables the user to rapidly create targeted design tools using Maple’s high-performance symbolic computation engine.

The creation of the skip model was complemented with the development of multiple design tools to aid in adjusting the model to achieve the desired behavior. One such design tool is the Geometric Design Evaluation tool, which provides the ability to evaluate changes in the dimensions of the skip design and their effect on the dynamics of the system. The tool uses Maple -Maplesoft’s symbolic computation tool - to perform a parameter sweep, by simultaneously running simulations using the different parameter values provided. Maple then presents the results overlaid on a single plot window for easy comparison and evaluation. Other tools developed include tools for sizing the hydraulics and components, designing the motion profile, investigating the dynamic loading on the bearings, and estimating the material flow load.

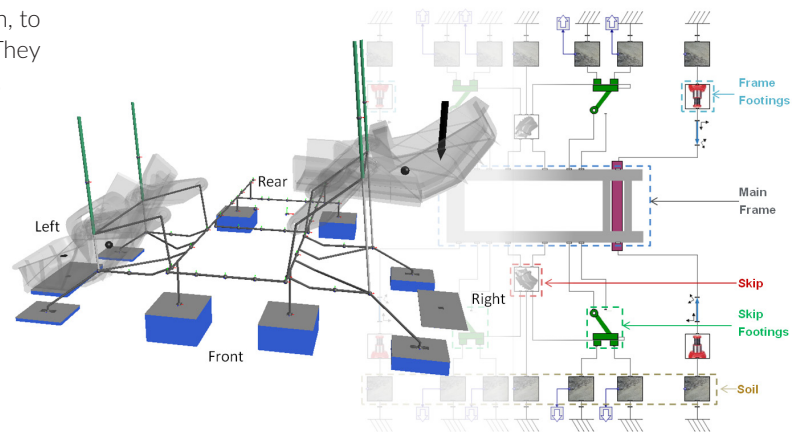
As part of developing and testing the skip model, Maplesoft’s technical team also evaluated the design, to identify the sources of vibrations and their effects. They developed an approach to perform stability analysis, which was made possible by the fact that the skip

model provided easy access to key geometric features and dynamic properties of the design. The stability analysis approach was demonstrated using a case study in which the location of the feedback sensor was varied. The analysis identified a potential issue very early in the design phase, enabling engineers at FLSmidth to develop a more robust design.

“The stability analysis performed by the Maplesoft team was very insightful,” said Fourie. “Knowing about a potential issue early on enabled us to design with it in mind, rather than having to go back and rework our design at a later stage. This contributed to keeping our project on track, and saved us millions of dollars down the line.” The stability analysis design approach and all the other analysis tools developed by Maplesoft were delivered to FLSmidth, enabling them to apply them to future projects.

Once the modeling and testing of the skip system was completed, during the following phases of the project, Maplesoft staff went on to develop the chassis model, and finally the full DTMS. Many more design tools were created, providing the ability to evaluate joint flexibility, center of mass variations as the skip was raised and lowered, and even soil modeling to investigate the vertical displacement of the system on different types of soil.

“From start to finish, Maplesoft provided truly knowledgeable and professional service,” concludes Fourie. “Their team worked tirelessly to accommodate our schedule, and the power of the Maplesoft toolset is second to none. The level of design detail and the amount of insight we gained have enabled us to revolutionize onsite crushing through the development of the DTMS. We could not have achieved this without the services of Maplesoft’s Engineering Solutions team.”



Full DTMS model, including footings and soil interactions