Optimizing the Drum Design of a Coal Shearer with **Adams-EDEM Integrated Simulation Approach**

By **Lijuan Zhao, Jiayi Fan, Minghao Li**
Liaoning Technical University, China

Figure 2. Spiral Drum of the Coal Shearer

Introduction

As the main working mechanism for coal cutting and coal loading, the spiral drum directly affects the working performance of the shearer. In recent years, a number of research projects have been conducted on the design and working performance of the shearer spiral drum. These results provided a reference for the high operational efficiency of the coal shearers.

When the spiral drum is operated under the condition of complicated coal seam, the impact load with nonlinearity and strong coupling will have a great influence on the reliability of the spiral drum itself and the key parts of the shearer. Therefore, based on the rigid-flexible coupling of the CAE model and EDEM discrete element simulation analysis software, our researchers leveraged the improved particle swarm optimization algorithm to enhance the overall performance of the spiral drum.

Figure 1. Coal Shearer in Operation

Modeling and Simulation for the Coal Shearer with Rigid-flexible Integration

When the shearer is working, the loads on the front drum are larger than the rear drum, so the front cross section is the main target of interest for this project. According to the coal-breaking theory from the former Soviet Union, and based on the "load simulation program" developed by the project team, the cut-off depth of the machine is 800 mm, the drum rotation speed is 58 r/min, and the traction speed is 10 m/min.

The research team used Pro/Engineer to establish a coal mining machine model and imported it into MSC Adams, the world's most trusted multibody dynamics software. The finite element software was then used to generate the flexible bodies for the spiral drum and the planet carrier, replacing the corresponding rigid parts in the Adams model. After adding the constraints, contacts and the driving forces of the virtual prototype, the Adams model of the shearer that contains both rigid parts and flexible parts is shown in Figure 3.

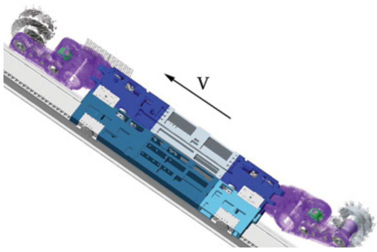

Figure 3. Virtual Prototype of the Coal Shearer in MSC Adams

As the next step, the initial loads from actual physical testing were properly imported into the Adams mode to make sure the boundary conditions for the simulation are realistic. Some of the simulation results can be found from Figure 4 to Figure 6, to capture the stress distribution on the front drum, the maximum stress curves and the stress diagram of the drum tooth. The stress diagram and the stress curves of the planet carrier are shown in Fig. 7 and 8.

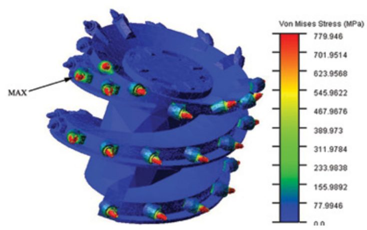

Figure 4. Stress Distribution on the Front Drum

It can be seen from Fig. 4-6 that the maximum stress value of the spiral drum is 779.946 MPa, and the calculated safety factor is 1.635. The maximum stress value node is located on the No. 24 tooth of the 12th section line. As illustrated in Figures 7 and 8, the maximum stress value of the carrier is 347.17 MPa, so the safety factor is 1.872, the maximum stress point appears at the hole of the planet shaft.

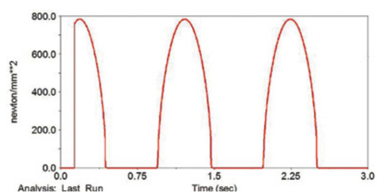

Figure 5. Maximum Stress Curve of the Spiral Drum

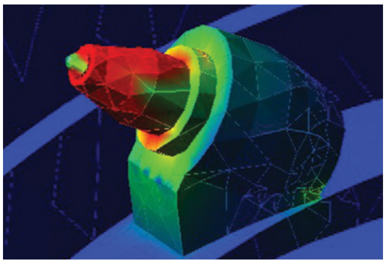

Figure 6. Stress Distribution on the Drum Tooth

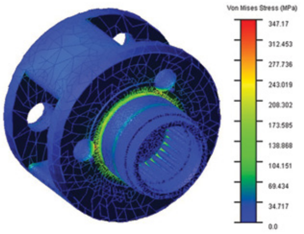

Figure 7. Stress Distribution on the Planet Carrier

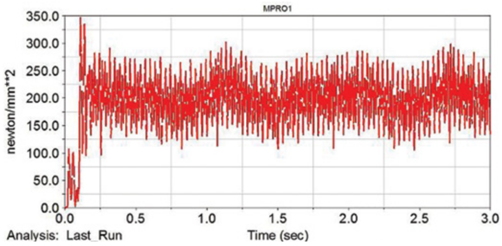

Figure 8. Stress History Curve of the Planet Carrier

Predicting Coal-Carrying Performance of the Shearer with EDEM Software

According to the coal mining theory, the Hertz-M contact model is selected for the simulation. The material parameters of the drum are set up in the EDEM software, as well as the contact parameters between the drum and the coal wall. According to the mining conditions of the drum prototype and the drum model, the coal particle plant is shown in Figure 9.

After importing the CAD model of the coal shearer in IGES format into EDEM, the simulation model is shown in Figure 10.

As illustrated in Figure 11, under normal operational condition, the number of coal particles that were successfully loaded was 9,476, and the number of unfilled coal particles was 5,964. The success rate for loading was 61.37%. From the physical testing results of the actual MG400/951-WD shearer, the coal loading rate is over 60%. Based on the discrete element method, the coal mining performance simulation results provide clear data support for the reliability design of shearer spiral drum.

Improving the Robust Design for the Spiral Drum

The structural parameters of the spiral drum have an impact on its working performance. Therefore, in order to improve the performance of the drum, it is necessary to optimize the robust design of the spiral drum.

After the optimized design, the updated modal neutral file for the spiral drum was generated and imported into MSC Adams, in order to perform the FEA-MBD coupled simulation analysis. It can be seen from Figure 12 that the maximum stress of the optimized spiral drum is 735.841 MPa, which is 5.65% lower than that of the previous design. The maximum stress value of the carrier is 332.117 MPa, 4.34% lower than before. The change in the spiral drum design variables reduced the cutting resistance, and thus reducing the loads on the key components.

Summary

The results of this simulation-based design show that the negative impact of the structural parameters on the reliability of the spiral drum is reduced, and the comprehensive performance of the spiral drum is improved. The optimized spiral drum meets the design requirements. Since June 2015, this type of improved coal shearer has been manufactured and officially put into operation at the Ordos Coal Mine of YanZhou Coal Mine. The annual output of the single machine has reached 1.2 million tons. The shearer is stable and reliable.

Reference

1. ZHAO Lijuan, FAN Jiayi, LI Minghao. Gradient reliability design of shearer's drum in complicated seam [J]. Journal of China Coal Society.

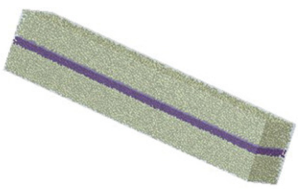

Figure 9. Coal Particle Plant Model in EDEM

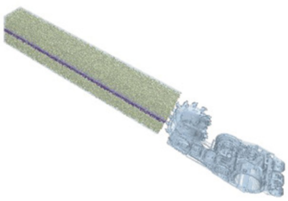

Figure 10. EDEM Model Which Includes Both the Mining Machine and the Coal Bulk Material

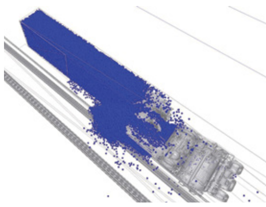

Figure 11. Loading Effect Simulation in EDEM

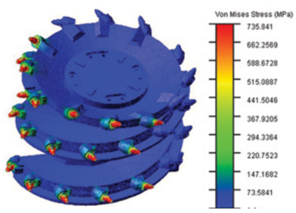

Figure 12. The Stress Distribution of the Spiral Drum after Optimization