**Table 1: moisture content for product coal and filter cake**

<table>
<thead>
<tr>
<th>Sample</th>
<th>Moisture content (%wb)</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Filter cake – HBF A</td>
<td>24.68</td>
<td>As received</td>
</tr>
<tr>
<td>Filter cake – HBF B</td>
<td>23.05</td>
<td>As received</td>
</tr>
<tr>
<td>Filter cake – HBF A &amp; B</td>
<td>23.92</td>
<td>As received, 50% HBF A/50% HBP B</td>
</tr>
<tr>
<td>Filter cake – HBF A &amp; B</td>
<td>28.96</td>
<td>Saturation moisture content, 50% HBF A/50% HBP B</td>
</tr>
<tr>
<td>Product coal</td>
<td>6.73</td>
<td>As received, bulk measurement</td>
</tr>
</tbody>
</table>

**CASE STUDY: TRANSFER CHUTE REDESIGN**

The project formed part of an upgrade to an existing coal-preparation plant, which required equipment and infrastructure improvements to accommodate increased production. Within this scope, Hatch was responsible for the transfer point to the final product conveyor, which loads the product to truck-loading bins (see figure 1).

**MATERIAL TESTING**

The first step of the EDEM BulkSim Solution involves material testing. Samples of the product coal and filter cake were collected from the product coal-processing system and two horizontal vacuum-belt filters (HBF). The material samples, including 120L of the product coal, were sent to the BMEA laboratory for analysis (see figure 2).

Services provided by BMEA include flow property testing and pneumatic conveying testing, and the company has access to the solids-handling facilities of the University of Wollongong.

The company tested the samples to characterise the materials, including measuring the moisture content (see table 1), size distributions and other properties. To understand how the materials behave...
under dynamic conditions, unique tests were conducted to study the dynamic flow of the two materials to aid in the calibration of the EDEM BulkSim simulations.

The variation in moisture content of the filter cake in samples HBF A and B was relatively minor, (table 1). The moisture content of the filter cake suggests the bulk solid was close to maximum strength conditions; i.e. 60-80% of saturation moisture.

Table 2 lists the measured solid and loose-poured bulk density of the materials that were used as guidance when selecting the solids density of the coal for use in the calibrated material model.

**DEM MODEL CALIBRATION**

The next step in the EDEM BulkSim Solution is to link the physical bulk material tests of the product coal and filter cake with material models in the DEM simulations. In this process, the simulation parameters were determined such that the physical test results are replicated in the DEM simulations of the BMEA tests.

The result of this step was two calibrated EDEM Material Models for the product coal and filter cake, respectively. Model calibration ensures the simulated material behaviour will reflect the real material bulk behaviour, providing confidence in the simulation.

Traditionally, the calibration of a material model is a time-consuming process that requires the user to manually input a wide range of material shapes and friction parameters, and perform an assessment on the simulation results.

To address these issues, DEM Solutions has implemented automated parameter sweeps and optimisation on a Microsoft Windows Azure cloud computing platform, making it possible to create a calibrated EDEM Material Model fast and efficiently while not affecting project timelines.

**SIMULATION SCENARIOS**

In the final step of the EDEM BulkSim Solution, a series of simulation scenarios were run to examine material flow behaviour in the existing and proposed designs. The process flow included:

- Importing CAD models of the existing and updated transfer chutes;
- Loading the calibrated EDEM Material Models, and
- Assigning the required mass flow rate of material to the transfer chute.

The first scenario simulated the conditions in the existing transfer chute design. The images taken from the simulation of the existing design (see figures 4 and 5) show the product coal coloured black and the filter cake gray. The velocity profile is also indicated. Simulation analysis of the existing transfer point operating at the design flow rate shows the same behaviour as observed in the field, such as the trajectory of the material and the clumping of the highly cohesive filter cake as it passes through the flop-gate.

Four additional simulation scenarios for the proposed new flop-gate design were then performed to troubleshoot and verify it. These scenarios included the updated equipment model running at design and maximum material flow rates. In addition, simulations were performed of the ‘worst-case scenarios’, including highly cohesive materials and surge in-flow rates (see figures 6-8).

These scenarios did show the potential of material flow separation and a small amount of spillage at the head roller region. For flow rates higher than those designed, separation was seen for the material leaving the head roller, causing the edges of the material flow to avoid the flop gate and load chute.

The simulation indicated that under certain conditions this could cause spillage, which prompted the team to review the design in the field.

Table 2: solid and bulk density for product coal and filter cake

<table>
<thead>
<tr>
<th></th>
<th>Product coal</th>
<th>Filter cake</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solid density (kg m$^{-3}$)</td>
<td>1,172-1,313</td>
<td>1,043-1,163</td>
</tr>
<tr>
<td>Loose-poured bulk density (kg m$^{-3}$)</td>
<td>681-804</td>
<td>791-833</td>
</tr>
</tbody>
</table>

**Fig 3: comparison of simulation and experiment for product coal**

**Fig 4: simulated material flow for the existing set-up, showing open and closed flop-gates**

The judgement of the team is that this minor flow separation was caused by a combination of slight differences in the CAD geometry versus the actual fabricated design, along with the team being very conservative on the nature of the most difficult material that the transfer point was likely to handle. The information provided from these cases allowed the robustness of the proposed design to be explored.

The simulation results also show the predicted relative wear behaviour of the existing and updated designs, under normal operating conditions (see figures 9-10). In addition, the proposed design performed better than expected when
COAL HANDLING

Fig 5: simulated material flow for the existing set-up, showing velocity profile

Fig 6: simulated material flow for the new design running at surge in-flow rate (1,228t/h), showing velocity profile. Reliable flow is maintained

Fig 7: simulated material flow for the new design, running at design rate (1,200t/h) with extra-cohesive material, showing velocity profile. Reliable flow is maintained

Fig 8: close-up view of a ‘worst case’ scenario, showing clumping of highly cohesive material discharging to conveyor, running at design rate (1,200t/h). Even with clumping, steady flow is maintained

dealing with highly cohesive materials and at surge in-flow rates, with lower wear rates indicated.

The design flow and verification of process equipment involves an iterative process of preliminary, internal and client review sessions.

The availability of both 3D images and dynamic video streams as a part of the transfer chute design has proved to be an effective review element. Further, the ability to explore ‘what if’ scenarios allows worst-case situations to be investigated and operational robustness ensured.

The updated design improved the functionality of the transfer chute and reliability of material flow by optimising the geometry of the equipment.

Modifying the shape of the flop-gate and loading chute allowed the angles of incidence between the coal stream and equipment to be decreased in order to reduce the deceleration of the material upon impact and minimise material build-up and wear.

Troublesome issues such as spillage and material build-up in the conveyor load zone were also examined in the DEM simulations in order to reduce future maintenance costs and downtime.

Based on these results, Hatch was able to verify the performance of the new chute design and select the configuration for production of it.

The mining company client benefitted from Hatch’s understanding of the reliability improvement required for increasing conveyor performance.

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The EDEM BulkSim Solution provides the essential components needed to deploy DEM technology throughout an organisation.

With easy-to-use EDEM software, customised for the mining industry, outsourced materials-testing services and the highly-optimised material calibration provided by simulation experts, DEM Solutions and its partner, BMEA, provide an enterprise-wide, scalable engineering solution, which enables engineers to deliver superior designs.

Hatch can now test a higher percentage of designs virtually before installation, and disseminate simulation analysis and investigations throughout the organisation, thus offering simulation expertise to the majority of its clients around the globe. Additional benefits include:

• The security features of the Calibrated Material Model. Here, the material parameters cannot be modified, except by authorised users, reducing the design risk of unsubstantiated DEM simulations; and

• Designers engaged in 3D surface modelling of transfer points can deploy DEM simulation confidently, to deliver a robust design, by combining 3D CAD and EDEM BulkSim simulation and analysis within their design environment.

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technology into the design of new mines and redesign of problematic transfer chutes without the need to establish internal DEM simulation expertise across the organisation.

As seen in this case study, DEM Solutions and its partner, BMEA, provide the material testing and highly-optimised material calibration technology that is essential to ensuring high-quality DEM simulations that are fit for purpose.

The resulting high-quality simulations provide clients with a reliable operating envelope for each transfer point, including simulation scenarios that account for varying particle size and moisture content, tonnage and belt speeds.

The simulations also help clients to identify those areas experiencing the highest impact and abrasion forces, and to compare projected wear patterns between different designs or operational scenarios.

By integrating the EDEM BulkSim Solution into the design workflow, Hatch has moved beyond traditional empirical methods of conveyor design to offer the highest quality DEM simulation results possible and with the speed necessary to fit into tight mining project timelines.

As a result, mine operators will see maximised profitability of their bulk materials-handling equipment through increased uptime, lower operating costs, and extended equipment life – leading to increased mine productivity and performance.

Dr Brian Moore is lead engineer, bulk materials handling, South East Australian Hub, with more than 30 years’ experience, specialising in bulk materials-handling systems and equipment. James Fuata is a graduate engineer. His experience includes belt-conveyor analysis and transfer-chute design utilising EDEM. Dr Richard LaRoche is vice-president of engineering and US general manager of DEM Solutions. He has over 25 years’ experience as an expert consultant in engineering simulation, and the management of technical support and engineering consulting teams. Stephen Cole is a senior consulting engineer at DEM Solutions who focuses on DEM project management for the mining industry. Dr Andrew Grima is a principal design engineer at BMEA. He is an expert on the deployment of EDEM for the design and troubleshooting of equipment for handling ores in overland and in-plant conveying. Dr Peter Wypych is general manager of BMEA and an associate professor of mechanical, materials & mechatronic engineering at the University of Wollongong. For more information: www.dem-solutions.com; www.hatch.ca; www.uow.edu.au/eng/research/bmea