CONVEYOR TRANSFER CHUTE ANALYSIS

Prepared for

ABC PORT OPERATIONS LTD

Coal Terminal Operations
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Ref - TBA

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CONVEYOR NUMBER CV102 TRANSFER CHUTE

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1 INTRODUCTION

A capacity upgrade of PORT OPERATIONS CV01.21 is planned. This conveyor is fed by the Train Unloading bin and has a head end transfer chute onto CV 103. The current operating capacity of the conveyor system is 6600tph and it is intended to upgrade the capacity to 8000tph of coal.

This chute has been observed on site to gradually block up when operating at 8000tph. The build-up is gradual, but it trips the blocked chute switch after about 30 minutes of operation.

Helix Technologies have undertaken to build a model of the existing transfer chute in the new Helix Chute Design program in order to correlate a theoretical Discrete Element Method (DEM) particle flow through the transfer chute with actual site observations.

The Helix Chute design DEM calculation program has recently been completed by Helix Technologies and this work has been undertaken in order to validate the theoretical results with real observations.

2 TRANSFER CHUTE GEOMETRY

2.1 Reference Drawings

The following drawings were used to build a model of the transfer chute.

- DWG1045/5
- DWG1046/7
- DWG8945/4
- P001-5063/4

The transfer consists of a rectangular top box fitted with a Tramp Iron Magnet. The magnet is mounted with a clear distance from the head pulley to the magnet face of 750mm. This close clearance is required to ensure tramp iron objects are picked up, however, it does make a restricted passage for the material to pass through. The middle section of the chute consists of four flat sides tapering inwards to a transition section and a lower boot section over the receiving belt. The bottom boot section is mounted over the skirts over the receiving conveyor belt.

2.2 Conveyed Material

The conveyed material is washed coal with a bulk density of 800kg/m3. The actual particle density has been estimated to be 1100 - 1250kg/m3.

Design capacity is 8000 tonnes per hour (tph).

2.3 Feed Belt CV 102 Capacity and basic description

The conveyor is a 3200mm wide belt running at 0.5 – 1.5m/s with an existing capacity of 6600tph. It has a declined approach of 0.77 degrees near the head pulley at the discharge end. The belt trough angle is 20 degrees flattening out to the discharge pulley over a transition length of 6.82m. The head pulley has diameter of 1274mm and face width of 3400mm.

2.4 Receiving Belt CV 103 Capacity and basic description

The conveyor is a 2000mm wide belt running at 5.6m/s with an existing capacity of 6600tph. The belt trough angle at the feed is 45 degree with 3 roll idlers. Transition distance is 5.735m flat at the Tail pulley to 45 degree trough.

2.5 Transfer Differential Angle and Drop Height

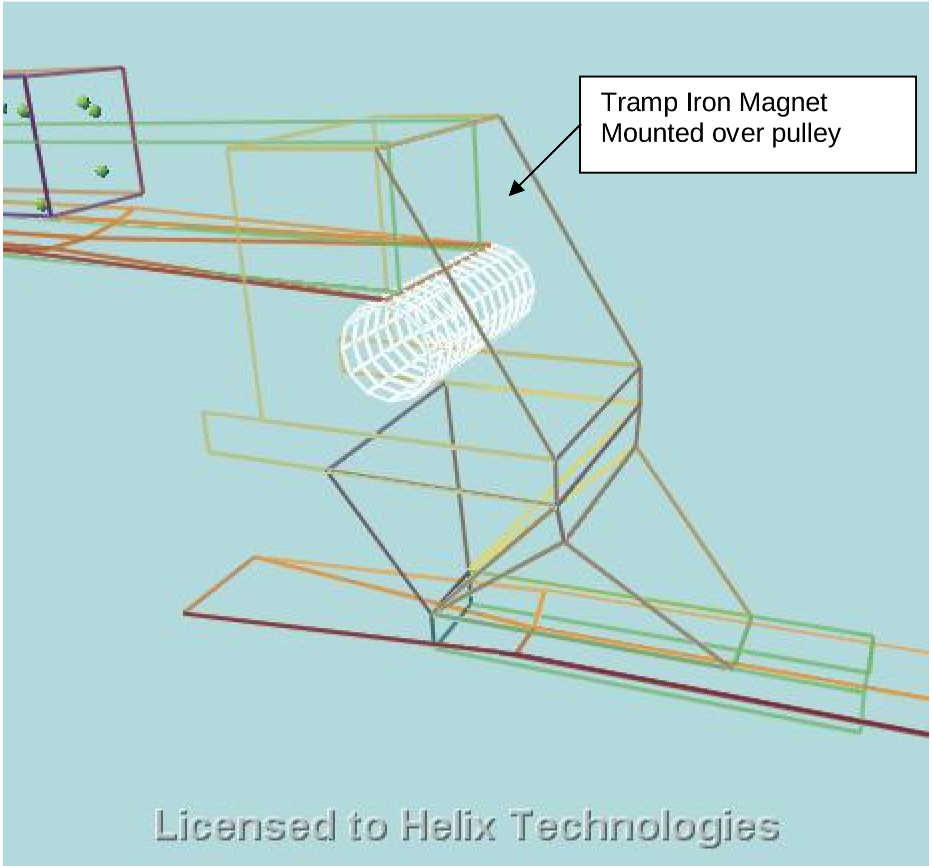
The transfer is straight in plan view. The discharge belt WP is at RL 0.243 and the Receiving belt is at RL -5.40 giving vertical drop of 5.643m.

2.6 CAD Drawing of Transfer

A three dimensional drawing of the transfer chute was made using AutoCAD and this drawing was imported into the Helix Chute design program. This step is not essential as the chute geometry can be entered directly into the Helix Chute Design program if a CAD drawing program is not available.

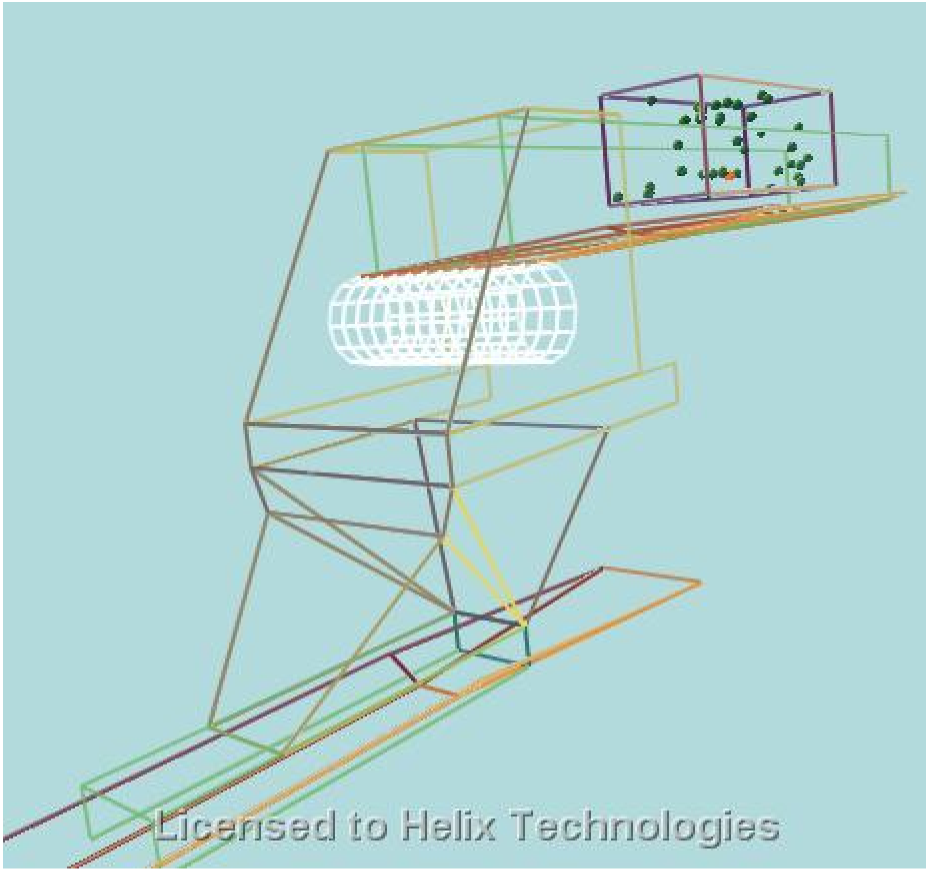
2.7 Wireframe model of transfer

The following is a 3D Wireframe outline model of the transfer as displayed in the Helix Chute Design program.



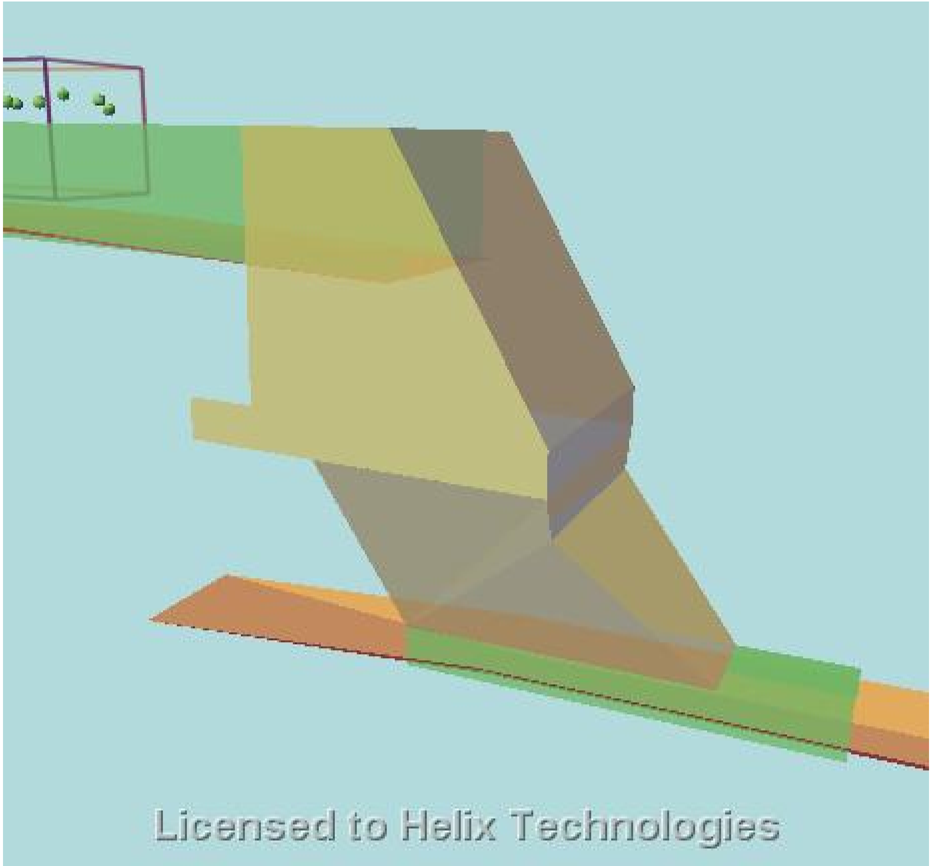
Note the X,Y,Z origin is the centre of the discharge pulley. The position of chute elements can be adjusted at the click of a few buttons; this is a user defined choice of origin.

The inclined front face of the chute is the Tramp Iron Magnet. It has a clearance distance of 750mm from the head pulley.


Licensed to Helix Technologies

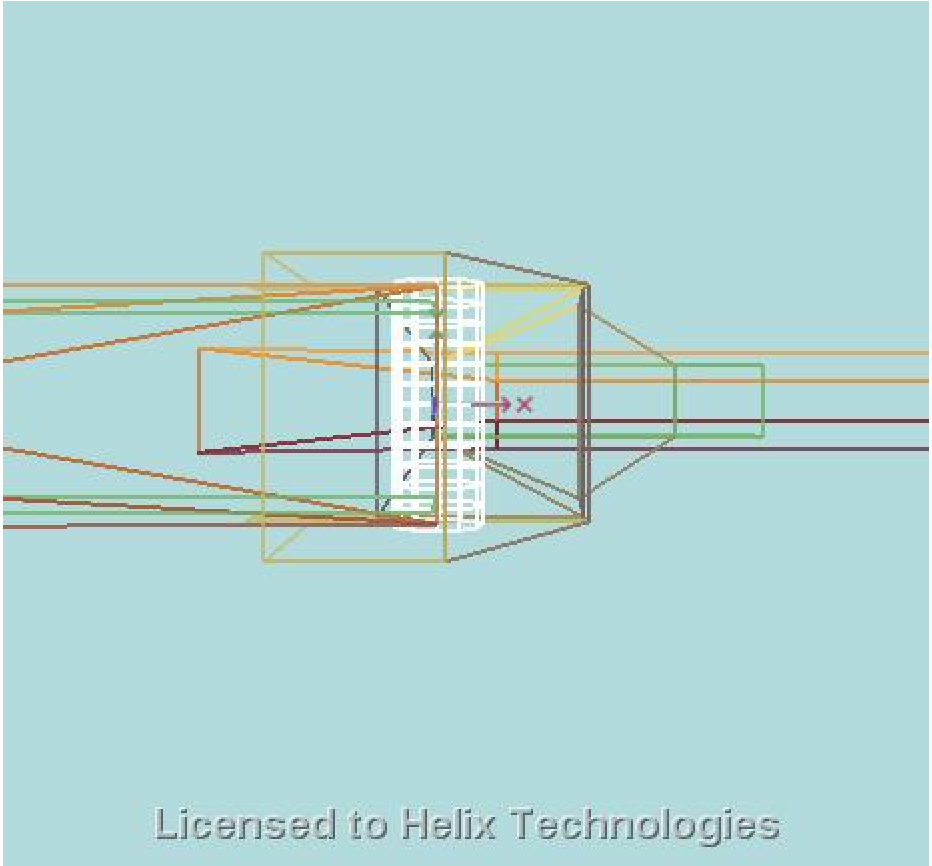
2.8 Solid model of transfer

The following is a Solid wall model of the transfer as displayed in the Helix Chute Design program.



3d View

The transparency and colours of each face can be adjusted by the user, as can the position and intensity of scene lighting etc.



Plan View of chute – line drawing

3 PARTICLE FLOW - DEM CALCULATIONS 6600TPH

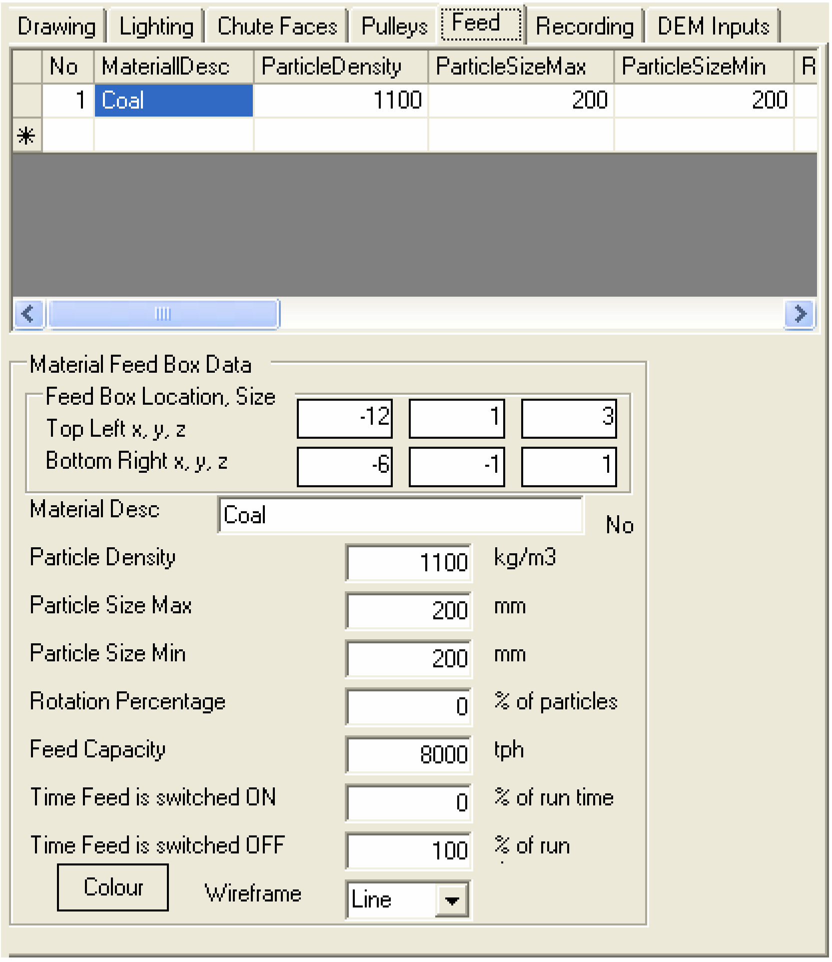
3.1 Material Density, Particle Size and Capacity

Particle Density - 1100kg/m3

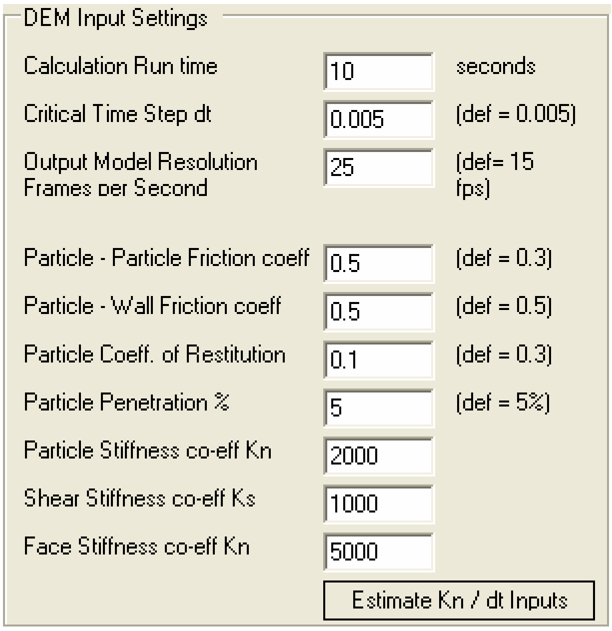
Particle Size Range for DEM Calculations - 200mm max 100mm minimum

In order to speed up the DEM Calculations, the particle size used was random spheres sized between 200mm and 150mm. These particles are larger than actual product size but use of spherical particles ensures that the void ratio remains very close to actual material void ratio.

Other DEM settings used were as follows:



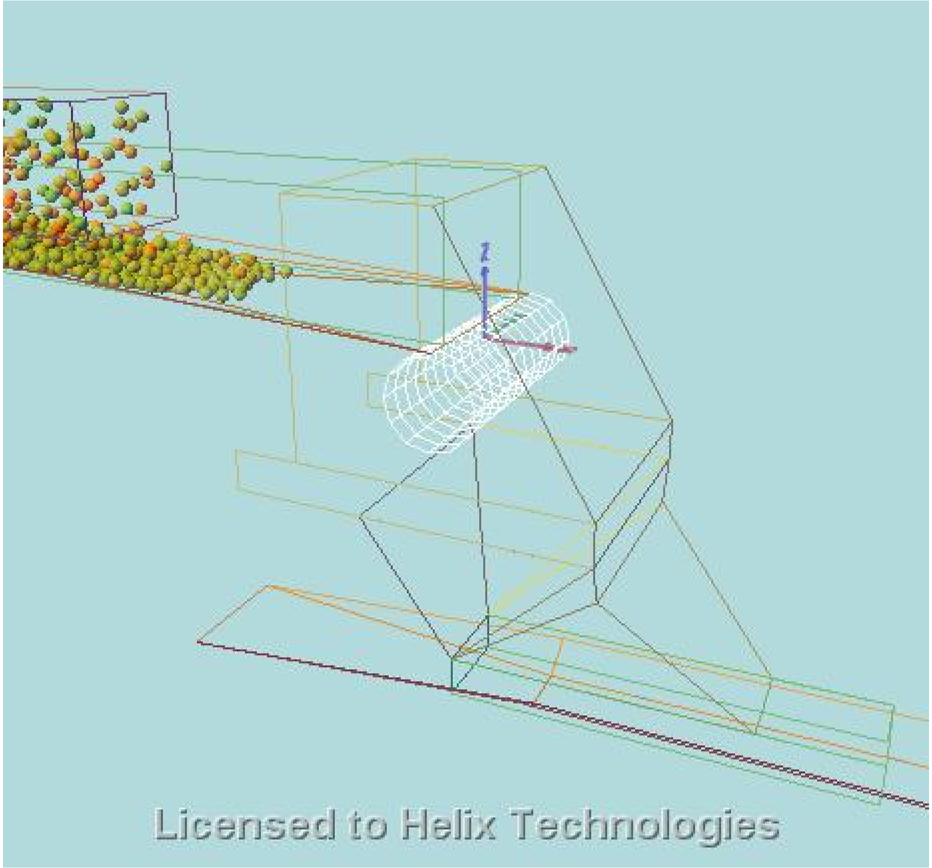
3.2 DEM Input Data



In addition to the above, each 3D face in the chute model has been assigned a co-efficient of restitution (controls particle bounce) and sliding co-efficient of friction as well. These values vary between 0.1 and 0.5 and between

3.3 8000tph DEM Calculation Results and Screenshots

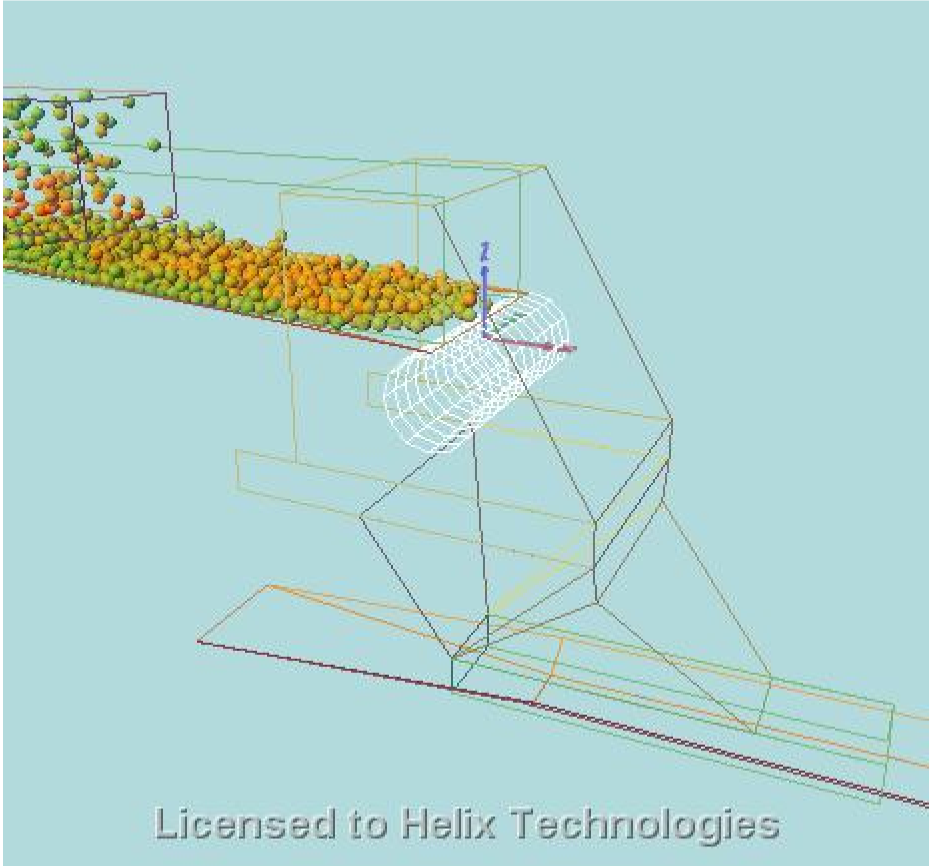
3.3.1 DEM Oblique View after 2 seconds



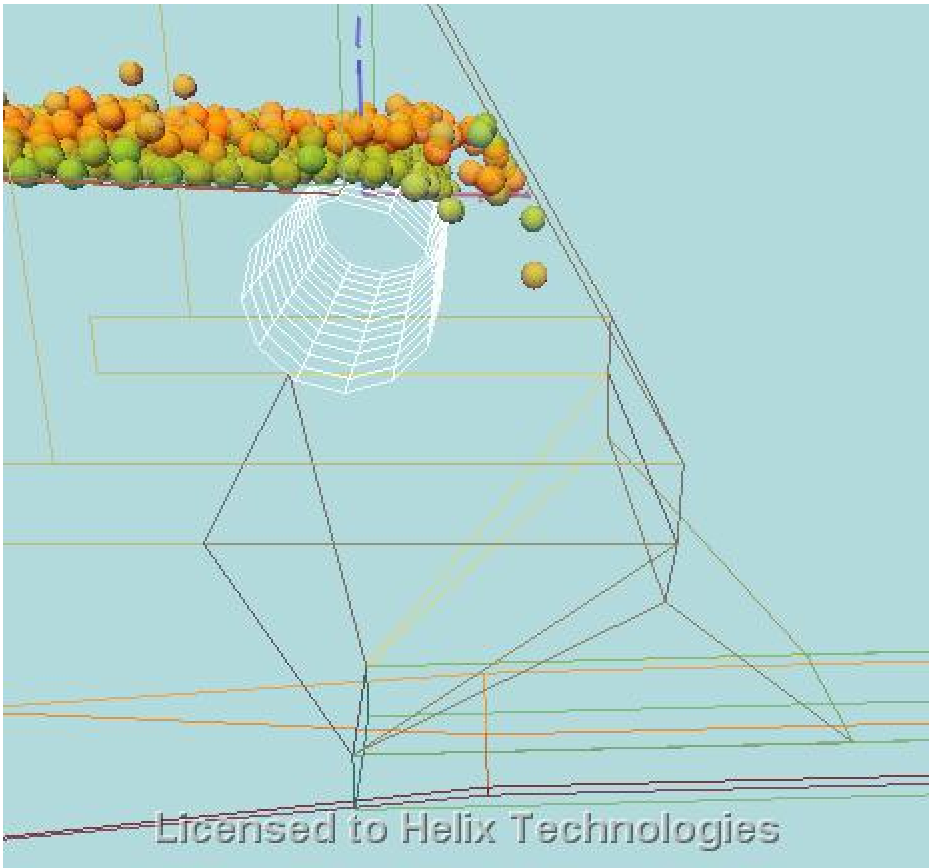
Material particles of random size between minimum and maximum particles diameters are created at random points in space within a volume specified as the feed box, in this case above the moving feed belt in the troughed section. Skirts are provided to guide the material. Note how the material flattens out in the transition section of belt where it goes from 20 degree trough to flat at the pulley.

The program creates enough particles during each time-step iteration to maintain the feed rate at the design tonnes per hour. This ensures that the mass flow rate is maintained at the required rate.

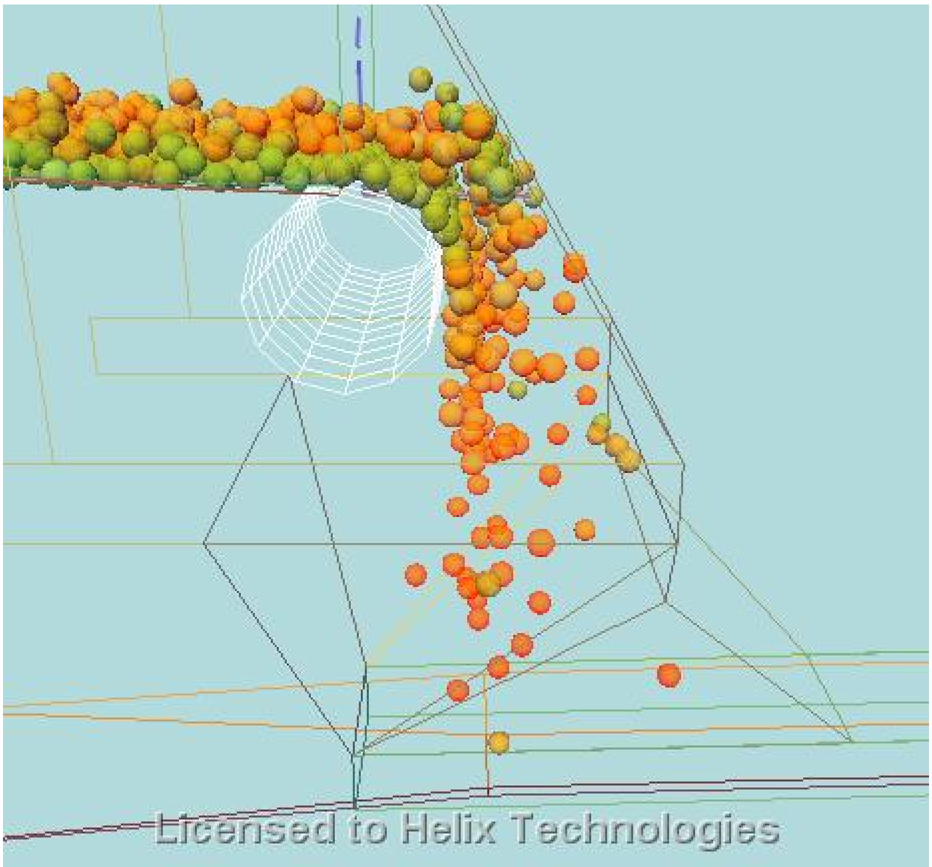
3.3.2 DEM Elevation View after 4.005 seconds.



3.3.3 First contact with the tramp iron magnet.



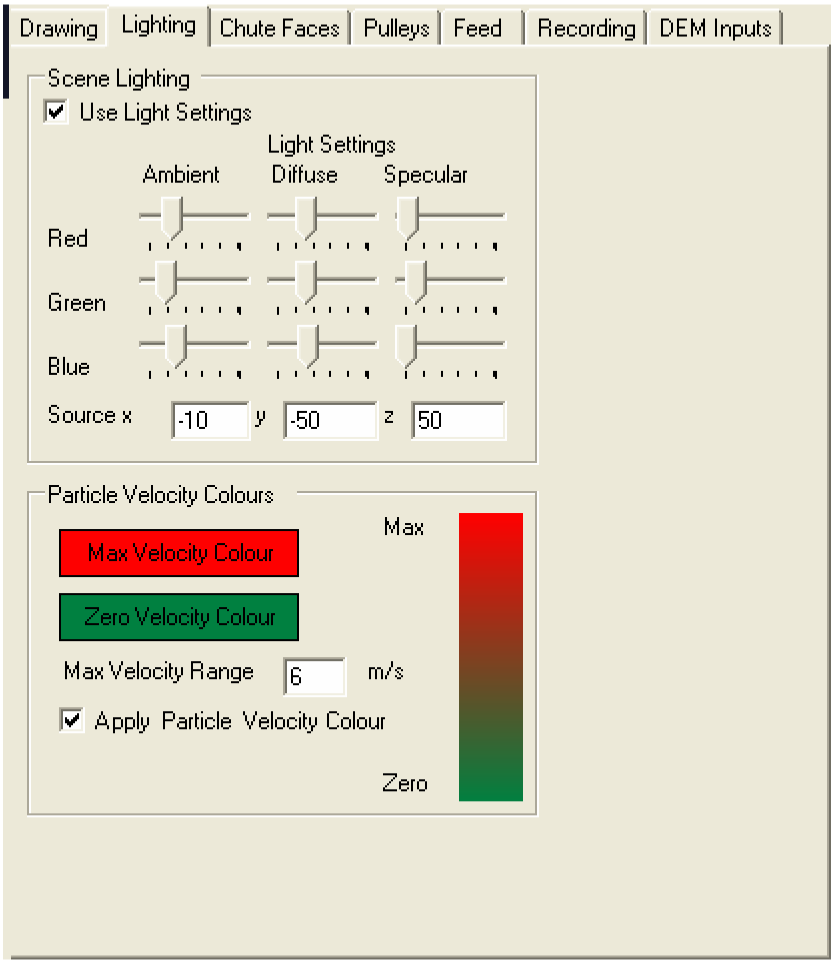
First contact with the tramp iron magnet is made after 4.65 seconds



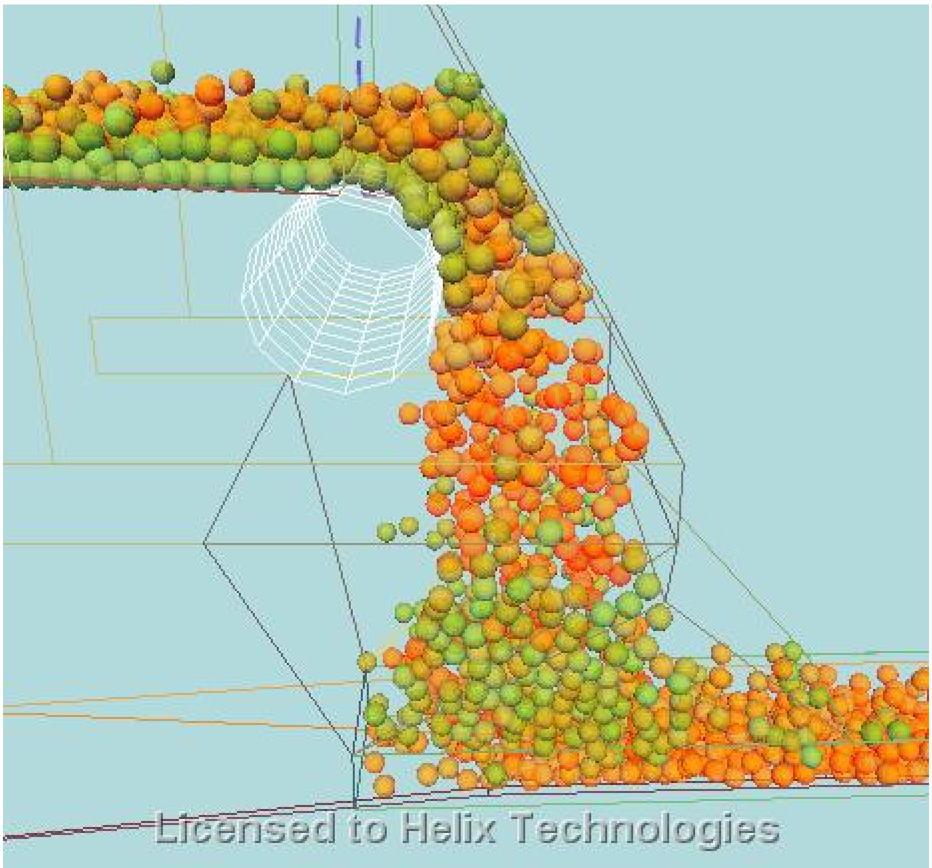
First contact onto the bottom belt after 5.4 seconds.

Note build-up of material on the tramp iron magnet face. The clearance distance is only 750mm and if iron is trapped on the magnet it is possible that this area will choke up. Also note material moving quite slowly against the chute and skirt surfaces.

3.3.4 Particle Speed Colour display



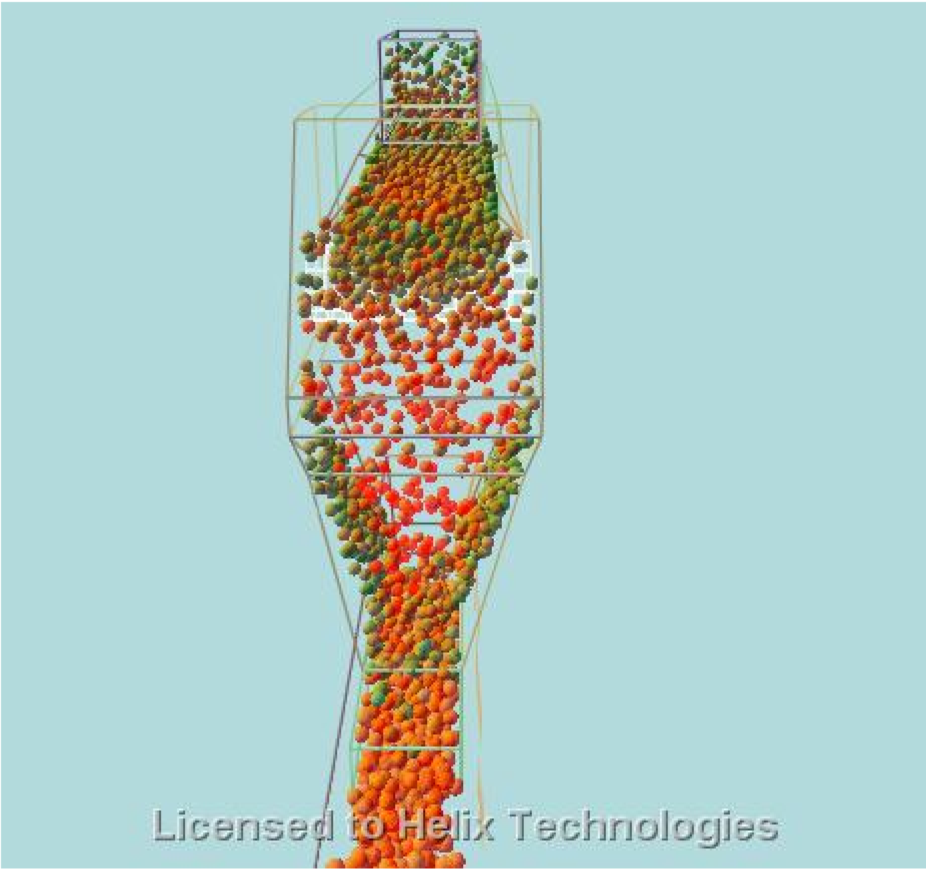
The particle colour is measure of its current speed based on the above colour scale.



Snapshot after 11.3 seconds when the chute is approaching stable feed. Note slow moving particles in rear section of lower belt. This is the acceleration area where the material has to be accelerated from a mainly vertical velocity component to a horizontal velocity of 5.6m/s. This area is confined by the cover over the skirts and the throat of the chute boot. The green colour of particles in the throat shows slow speed and potential for blockage.

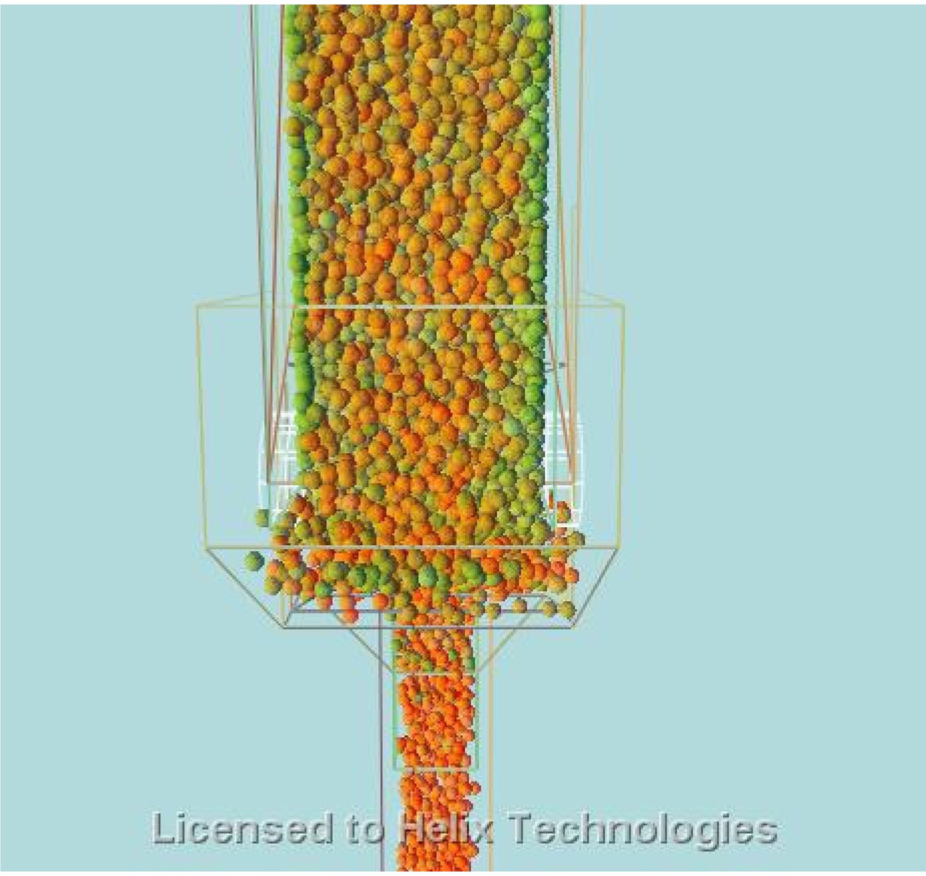
The above screen shot is made with high friction and low co-efficient of restitution, which means that the particle will fall onto the bottom belt and accelerate quickly as it does not bounce much and it “sticks” to the belt due to high friction co-efficient. See below for view with different settings.

3.3.5 Front View of material in chute



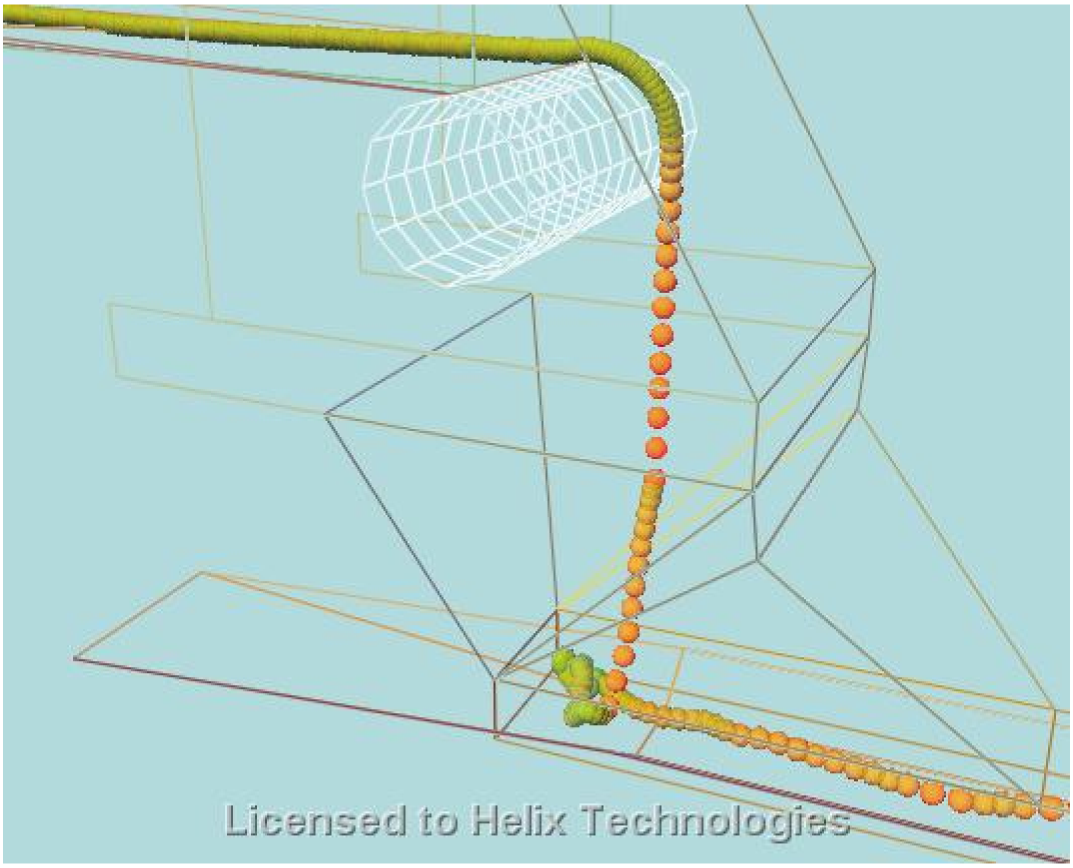
Note build-up in boot section where (green coloured) material is being accelerated. Orange colour further down 01.27 belt shows material is moving at belt speed.

3.3.6 Plan View looking from above discharge pulley



Material spreads across full 2.468m width of chute head box in impact area with magnet. Material is constrained on feed belt by side skirts 2.720m apart.

3.3.7 Single Particle Trace View



Trace of a randomly selected particle number 7 through transfer. The recorded time steps are at a frame rate of 25 frames per second. Spacing of particle and colour indicates speed. Particle accelerates after discharge from pulley, hits the side of the chute and glances off onto the belt, bounces and is then accelerated. Note the particle is moving backwards for short period of time after contact with belt and it is not picking up the direction or speed of the belt immediately, but only after a period of time. A collision with other particles causes the particle to deviate off a straight line, contributing to the build up.

Particle Size is 0.1m radius and mass is 4.6kg.

Discharge Velocity is 1.5m/s when it leaves the belt and impact velocity at bottom belt is 5.55m/s.

Impact velocity on receiving belt is

V_x = -0.12m/s

V_y = -0.17m/s

V_z = -5.43m/s

V = 5.55m/s. This velocity can be used to calculate belt wear rates and impact energy.

Single Particle Trace Report

Helix Technologies

Helix Technologies Pty Ltd

Project	3D Expansion	Client	Port Waratah
Project No	TBA	Date	13/03/2007
Designed By		Licensed To	Helix

i	No	Mass	Radius	Time	Vel.	Velocity (m/s) Vx	Vy	Vz	Position x	y	z
754266	7	4.61	0.100	1.285	1.39	1.37	-0.11	-0.21	-11.006	0.601	0.497
754884	7	4.61	0.100	1.29	1.39	1.36	-0.10	-0.27	-11.000	0.600	0.496
755504	7	4.61	0.100	1.295	1.39	1.35	-0.08	-0.33	-10.993	0.600	0.494
756127	7	4.61	0.100	1.3	1.40	1.34	-0.07	-0.40	-10.986	0.599	0.492
756752	7	4.61	0.100	1.305	1.40	1.32	-0.05	-0.46	-10.980	0.599	0.490
757379	7	4.61	0.100	1.31	1.40	1.30	-0.03	-0.53	-10.973	0.599	0.487
758009	7	4.61	0.100	1.315	1.49	1.42	-0.10	0.45	-10.966	0.599	0.490

Refer to appendix file called **Helix Chute Design DEM Trace Report 01-21 Particle 7.pdf** for details of position and velocity of particle at each recorded time step.

Particle reports for every particle are available but due to file size constraints only selected extracts have been included with this report. These particle reports can be imported in programs such as Excel for data sorting to determine average particle velocity, maximum and minimum velocities, impact energy, belt wear rates etc.

i	No	Mass	Radius	Time	Vel.	Velocity (m/s) Vx	Vy	Vz	Position x	y	z
1188480	7	4.61	0.100	8.405	1.47	1.17	0.09	-0.89	0.433	0.752	0.200
1192504	7	4.61	0.100	8.445	1.49	1.12	0.07	-0.98	0.480	0.756	0.163
1196545	7	4.61	0.100	8.485	1.53	1.07	0.03	-1.09	0.524	0.758	0.122
1200599	7	4.61	0.100	8.525	1.55	0.99	0.04	-1.19	0.565	0.759	0.076
1204669	7	4.61	0.100	8.565	1.60	0.91	0.06	-1.32	0.604	0.761	0.025
1208750	7	4.61	0.100	8.605	1.56	0.74	0.07	-1.37	0.637	0.764	-0.028
1212846	7	4.61	0.100	8.645	1.60	0.67	0.03	-1.45	0.666	0.765	-0.084
1216957	7	4.61	0.100	8.685	1.64	0.54	0.00	-1.54	0.691	0.766	-0.144
1221084	7	4.61	0.100	8.725	1.59	0.40	-0.04	-1.54	0.710	0.765	-0.206
1225222	7	4.61	0.100	8.765	1.80	0.34	0.01	-1.77	0.725	0.764	-0.269
1229375	7	4.61	0.100	8.805	2.82	0.20	0.25	-2.80	0.737	0.769	-0.365
1233544	7	4.61	0.100	8.845	3.14	-0.14	0.43	-3.10	0.737	0.784	-0.485
1237725	7	4.61	0.100	8.88	3.53	-0.15	0.39	-3.50	0.732	0.799	-0.602
1241918	7	4.61	0.100	8.92	4.04	-0.19	0.30	-4.03	0.725	0.812	-0.753
1246122	7	4.61	0.100	8.96	4.52	-0.22	0.26	-4.50	0.717	0.823	-0.926
1250335	7	4.61	0.100	9	4.91	-0.22	0.26	-4.90	0.708	0.834	-1.115
1254564	7	4.61	0.100	9.04	5.30	-0.22	0.26	-5.29	0.699	0.844	-1.319
1258800	7	4.61	0.100	9.08	5.69	-0.22	0.26	-5.68	0.690	0.854	-1.539
1263046	7	4.61	0.100	9.12	6.08	-0.22	0.27	-6.07	0.681	0.865	-1.776
1267307	7	4.61	0.100	9.16	6.51	-0.32	0.58	-6.48	0.670	0.882	-2.028
1271581	7	4.61	0.100	9.2	6.90	-0.44	0.94	-6.82	0.655	0.914	-2.295
1275869	7	4.61	0.100	9.24	7.23	-0.46	0.99	-7.15	0.639	0.948	-2.540
1280169	7	4.61	0.100	9.28	7.62	-0.46	0.99	-7.54	0.620	0.987	-2.835
1284483	7	4.61	0.100	9.32	8.01	-0.46	0.99	-7.93	0.602	1.027	-3.145
1288807	7	4.61	0.100	9.36	8.29	-0.46	0.93	-8.22	0.583	1.066	-3.471
1293140	7	4.61	0.100	9.4	2.39	0.00	-1.35	-1.97	0.580	1.024	-3.552
1297486	7	4.61	0.100	9.44	3.06	0.17	-2.08	-2.24	0.585	0.952	-3.635
1301844	7	4.61	0.100	9.48	3.43	0.20	-2.18	-2.65	0.592	0.866	-3.734
1306214	7	4.61	0.100	9.52	3.75	0.20	-2.18	-3.04	0.600	0.779	-3.849

Page six of the particle no. 7 trace report shows the particle hits the bottom belt at time step 9.36 seconds. The velocity just before impact is

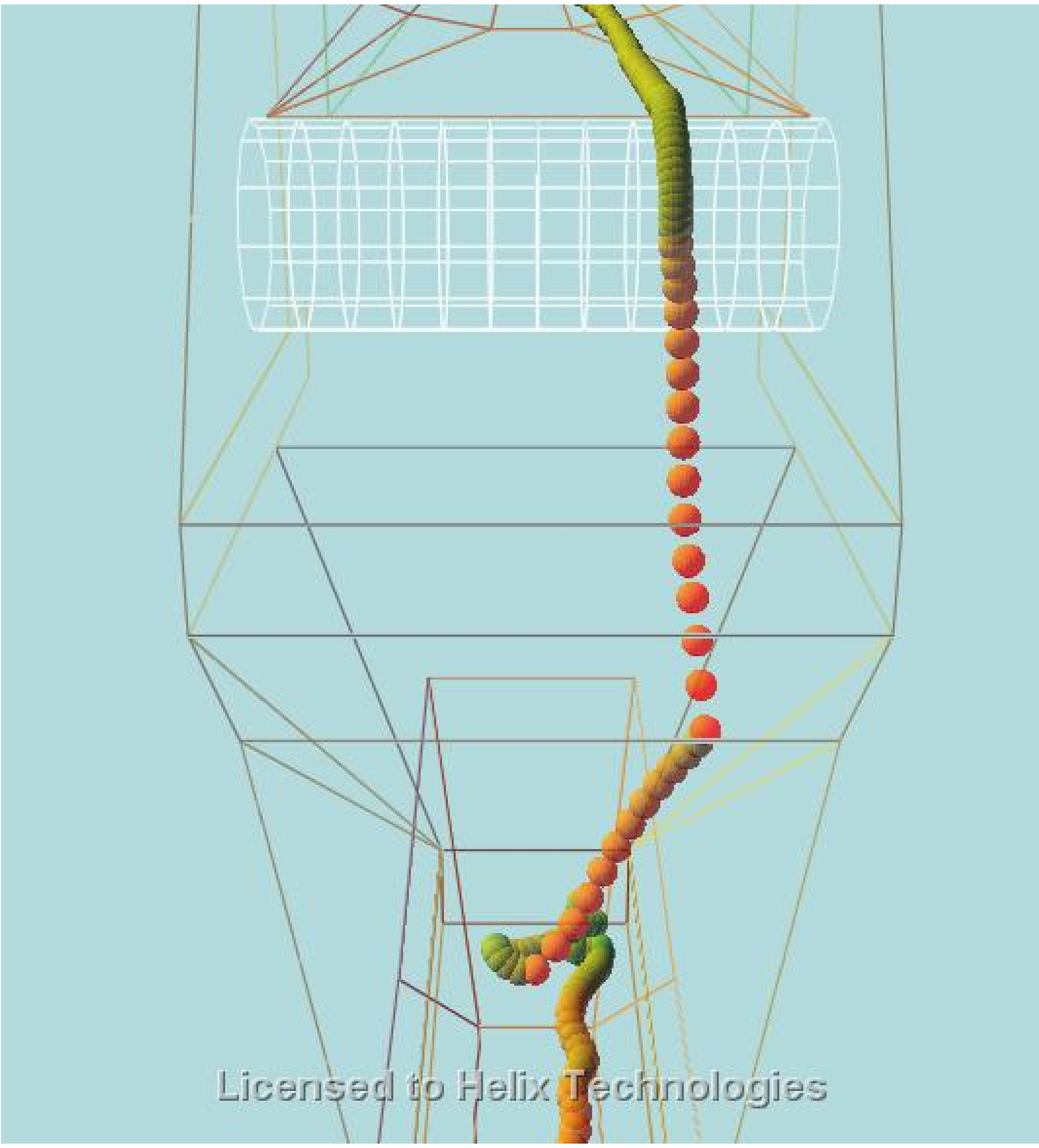
Vx = -0.46m/s (this indicates the particle is moving backwards as +X is in belt direction)

Vy = 0.93m/s – moving sideways too

Vz = -8.22m/s – moving down at this speed

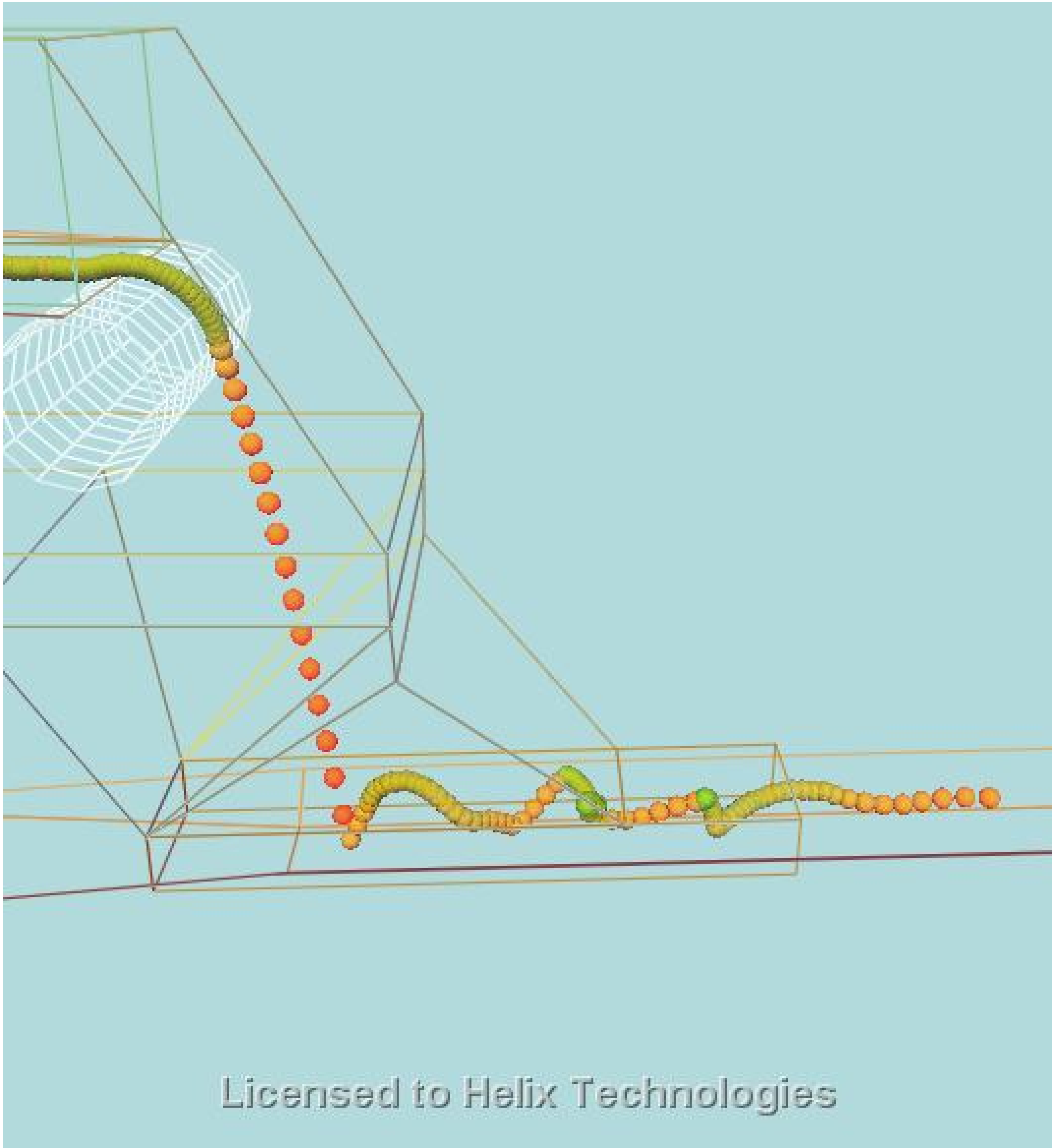
Velocity = 8.29m/s.

Horizontal differential velocity between particle and belt is 5.6 + 0.46 = 6.06m/s.



Front view of trace path for particle no. 7

3.3.8 Trace view of another particle



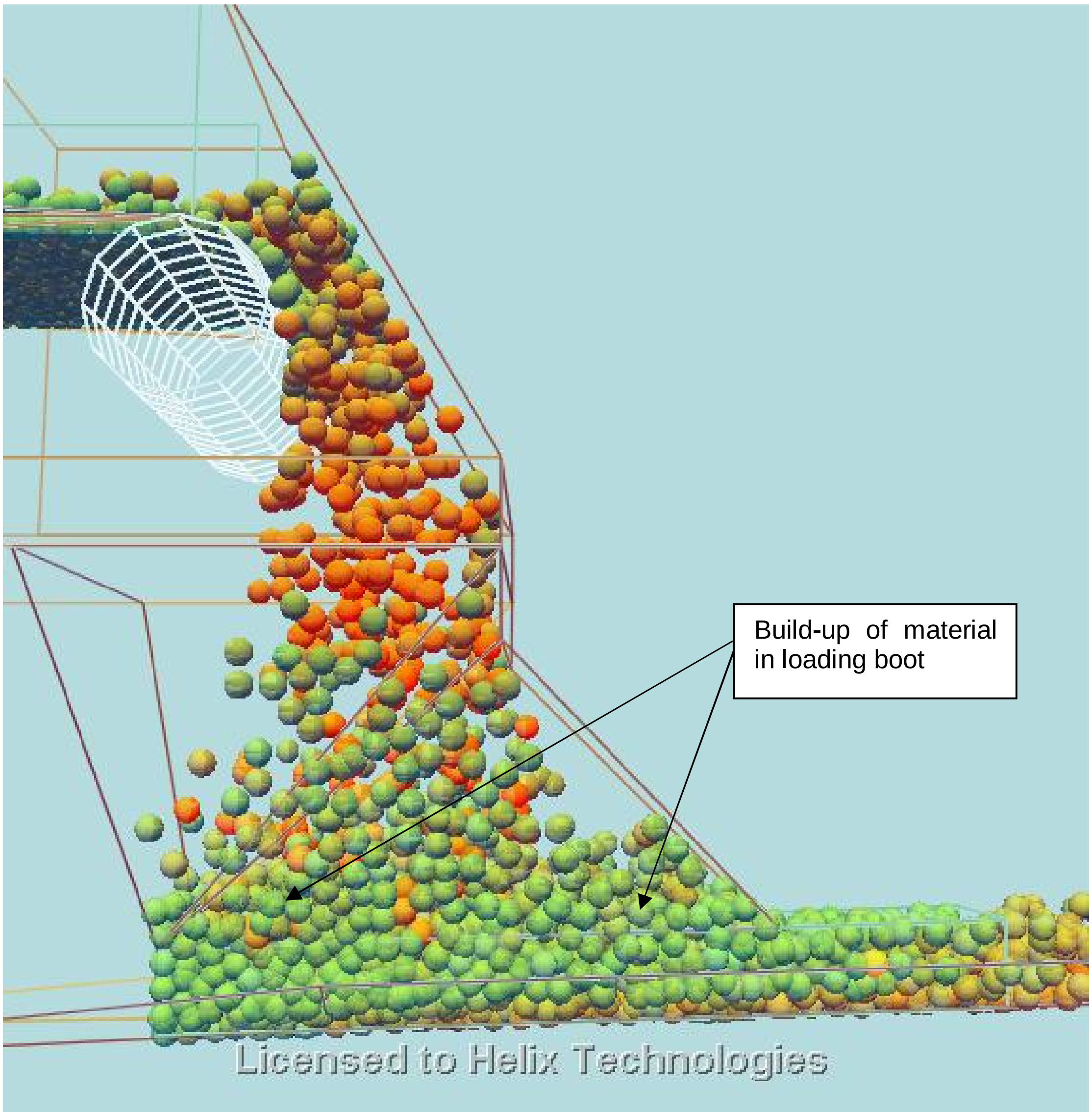
Note stop – start acceleration of particle until free of loading boot.

3.4 **8000tph DEM View with reduced friction on bottom belt showing blocking chute**

This view shows the effects of the material failing to accelerate quickly enough in the loading boot of the bottom belt. The material tends to “boil” and bounce and does not accelerate to belt speed quickly enough to clear the enclosed skirted area. Note colour change from green to orange at end of loading boot. The green indicates slow moving material and results in a build up of material in the chute. If the calculation was run for long enough, the chute would eventually fill up.

The DEM settings in the program can control the amount of bounce and grip on the moving belt. If a low co-efficient of restitution is used coupled with a high friction co-efficient, the material will hardly bounce and will “stick” to the belt and accelerate quickly. If a high co-efficient of restitution is used coupled with a low friction factor, the material tends to bounce more and is slower to pick up speed, resulting in the chute blocking.

A “spoon” feed onto the lower belt will assist in accelerating the material by ensuring that it hits the belt with a horizontal component of velocity. Also, more space above the skirts on the bottom belt will prevent hang up in the boot and allow the material to pick up belt speed.

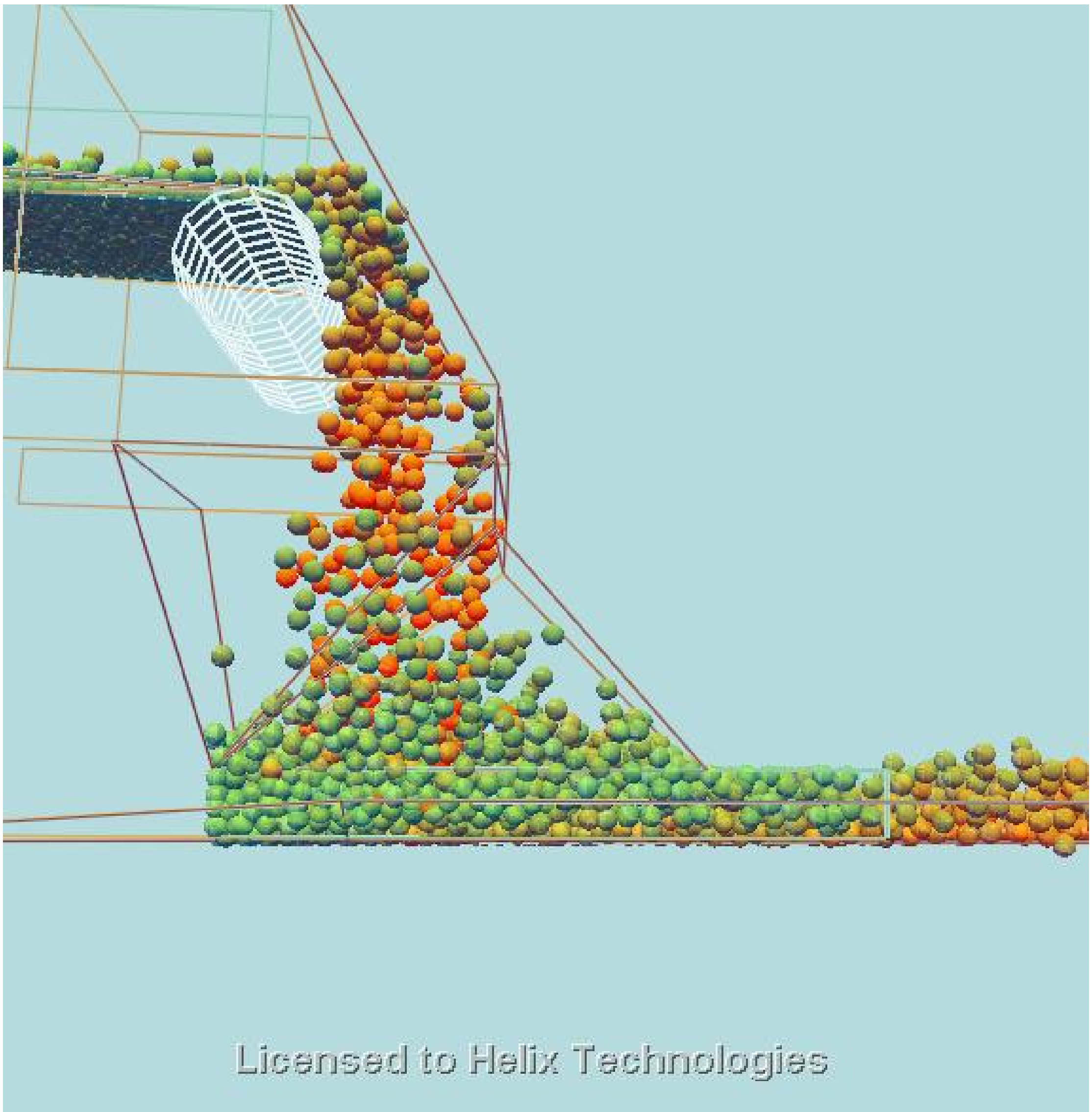


View of chute gradually blocking up – this is taken 14 seconds after start of simulation. See avi movie file for animation.

4 6600TPH DEM CALCULATION SCREENSHOTS

The existing chute is currently operated successfully at 6600tph. A simulation run has been made at 6600tph in order to compare the build up in the loading chute with the 8000tph case. All other settings in the model remain as for the 8000tph (reduced friction), except the capacity change to 6600tph.

4.1 View of chute after 15 seconds at 6600tph – reduced friction



6600tph Screenshot after 15 seconds simulation.

At this capacity there is build-up of material in the loading boot, but the problem is not as severe as the 8800tph case. After 15 seconds of run time, the number of particles in the chute model stabilises at around 4000 particles. This indicates that the model has reached an equilibrium state where inflow equals outflow. However, the model shows that the chute is very near to full capacity at 6600tph.

5 PARTICLE POSITION AND VELOCITY REPORT

The Helix Chute Design Program allows the user to trace and record the position and velocity of each particle in model. The number of particles is in excess of 5000 particles and in this case the calculation was run for more than 15 seconds at time steps of 0.005 seconds (200 steps per second) so there is a lot of data recorded which when exported to a PDF or xml data file is in excess of 5000 pages. It is impractical to include such large report with this report due to file sizes, however, an extract of this data is shown below and also a few pages are shown in the appendix.

6 WINDOWS MEDIA PLAYER AVI MOVIE

The Helix Chute Design program allows you to capture a video movie of the model into a Windows .avi movie file. Click the following link to download the movie file which has been zipped to compress it. Save this file to disk and then extract the .avi file and double click on it from windows explorer to view the movie.

http://www.helixconveyor.com/ChuteAvi/HelixChuteDesign0121at1000tphMaterialAccelerationZone.zip

http://www.helixconveyor.com/ChuteAvi/HelixChuteDesign0121ChuteBlocksGradually8000tph.zip

http://www.helixconveyor.com/ChuteAvi/HelixChuteDesign0121ChuteOperatingAt6600tph.zip

Note: Requires Windows Media Player to view movie. Zipped file sizes are less than 10Mb in size.

7 SUMMARY AND CONCLUSIONS

This model shows that the loading boot on the lower belt will block up at 8000tph. This correlates with site observations – the chute gradually blocked up when the feed was set to 8000tph.

At a capacity of 6600tph, the chute is operating near to full capacity but does not block-up.

The narrow opening between tramp iron magnet and discharge pulley is shown to be a restriction to flow, but the flow manages to get through due to gravitational forces. No blockage is expected at the magnet unless a large iron object restricts the flow pattern.

8 RECOMMENDATIONS

Improve the flow direction in the loading boot to impart a horizontal velocity towards belt direction. Use of a deflector plate in the chute will do this.

Also increase the hight of the loading boot so that the material cannot hang up in this area.

Remodel the new geometry in the Helix Chute Design program, using the same settings as before to confirm the new geometry will achieve the desired results.

9 DISCLAIMER

This report and its appendices have been compiled from information supplied by ABC Port Operations and other parties. The information has been used in the Helix Chute Design software to perform various calculations relating to conveyor transfers, and the results of these calculations have been presented. No guarantee is given that the data presented here is one hundred percent accurate and the recipient uses this report entirely at their own risk.

11 APPENDICES

The following files in electronic file format make up the appendices to this report.

11.1 Windows Media Player .avi movie file

Click the following link to download the movie file which has been zipped to compress it. Save this file to disk and then extract the .avi file and double click on it from windows explorer to view the movie.

http://www.helixconveyor.com/ChuteAvi/HelixChuteDesign0121at1000tphMaterialAccelerationZone.zip

http://www.helixconveyor.com/ChuteAvi/HelixChuteDesign0121ChuteBlocksGradually8000tph.zip

http://www.helixconveyor.com/ChuteAvi/HelixChuteDesign0121ChuteOperatingAt6600tph.zip

Note: Requires Windows Media Player to view movie.

11.2 Single Particle Trace Report no 7

Refer to file called **"Helix Chute Design DEM Trace Report 01-21 Particle 7.pdf"**