

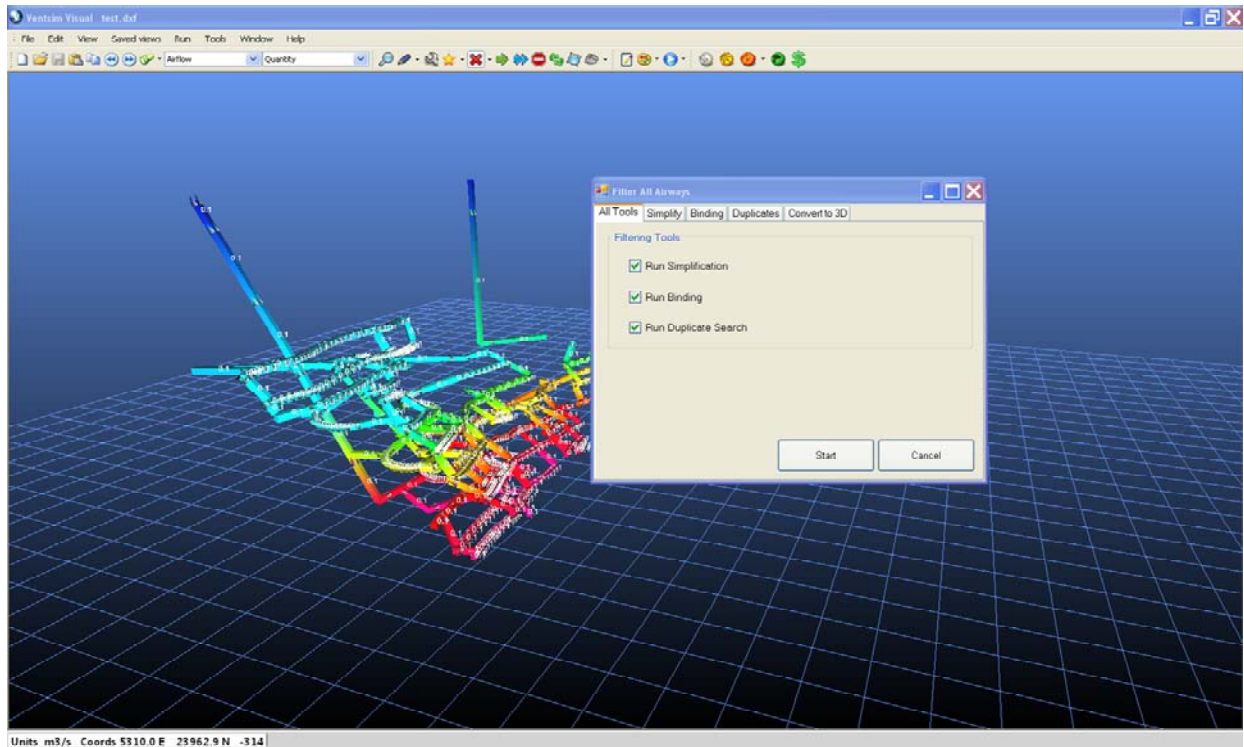
Ventilation Software – Ventsim and VnetPC

There are many different ventilation softwares available on the market today, with a range of abilities and functionalities. Two of the premier softwares are VnetPC by MVS Engineering and Ventsim by Chasm. Both packages allow for accurate simulation of underground ventilation circuits while offering intuitive user interfaces. VnetPC can be paired with the programs ClimSim, MineFire, and DuctSim from MVS Engineering to allow for full functionality. Ventsim can be purchased with different license levels that allow anywhere from a basic ventilation simulation to the fully functional advanced package with thermodynamics, financials, diesel particulates and recirculation. This paper will examine both softwares from the viewpoints of functionality, visual display, outputs, ease of use and cost.

Functionality

Ventsim

Ventsim allows for either import of a dxf file and conversion to the Ventsim format or directly creating a design in Ventsim. Conversion is automatic, and there are three filtering tools for cleaning of the file. Ventsim considers every section between two points as a separate airway. To minimize the number of airways the simplification function will combine set lengths of airways to equivalent lengths. The vent calculations will produce the same results but with less clutter on screen. The “binding” filter connects airways whose ends are close to touching. This allows a proper ventilation circuit to be created and identifies loose ends. The third filtering tool removes duplicate segments and points to eliminate the possibility of running calculations for the same heading twice. These three tools can be run very quickly to prepare the model for simulating.



A circuit in Ventsim must have an entry from surface and an exit, or multiples of either. A closed circuit is also possible but not practical for underground mining. The directions in headings can be set to match the planned direction of airflow. Ventsim also has automatic heading directions which are based on how air would naturally flow when fans are setup. The airflow simulation can be setup a number of ways, by adding fans each with individual fan curves, setting a fixed flow in a heading or setting a fixed pressure in a heading. By using fan selection a realistic circuit can be created with the amount of airflow that would actually be created by that fan with the given mine resistance. Once an airflow simulation is completed the other packages can be used such as thermodynamic, contaminants, diesel particulates, recirculation and financials.

The thermodynamic simulator is a powerful package that can incorporate the surface temperature, rock temperature varying with depth, equipment heat production and cooling units. The temperatures will be calculated for each airway section, giving a flow of temperature around the mine. Hotspots can be identified and solutions for cooling those areas can be created. The cost of any air conditioning units is added into the final power and financial calculations.

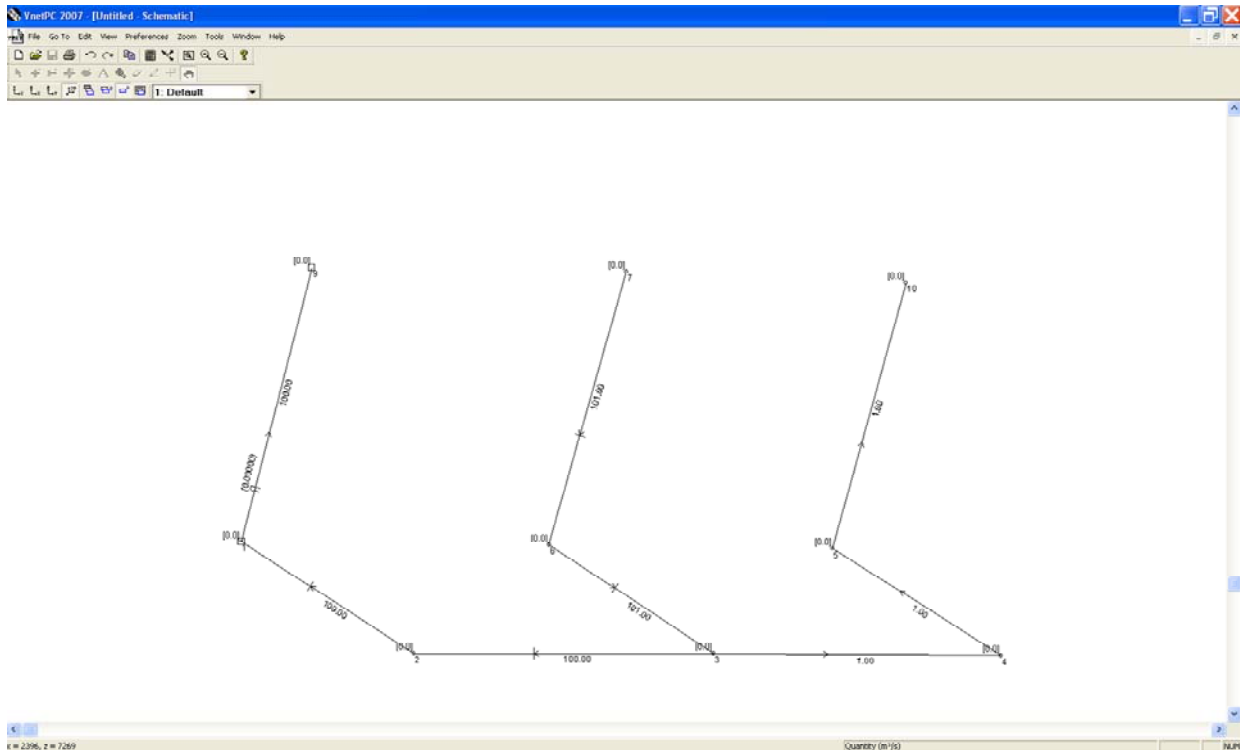
The financial calculator can help to estimate costs based on fan and heater/cooler power. There is also a tool that can optimize heading sizes based on costs for extraction and costs to ventilate. A small raise may be economical to mine, but when high airflow is pushed through it the extra fan power cost may outweigh the savings. This tool can be used on any or all headings to optimize from a purely vent cost over life of mine versus extraction costs.

The diesel particulates tool allows calculations for all airways based on the equipment operating underground. This can identify working areas which will be unsafe or require more airflow. This tool can

also be used to convince potential clients of the safe working conditions planned underground. The contaminant tool is used to similarly show the levels of any contaminant along all airways. Contaminants can range from smoke to blast fumes to stench gas. These simulations can be useful for testing the mine plan in a variety of situations. The recirculation tool can also be run after any of these to test if air is being reused from one airway to another.

VnetPC

VnetPC can import dxf files and convert them into airways. It is required that the user prepare the dxf file in AutoCAD or another software to simplify the model and connect all loose ends. The start and end point for two connecting lines must have exactly the same coordinates, or manual movement of the points will be required in VnetPC. Either fans or fixed quantities can be setup in headings to create pressure and allow movement of air. Airflow in other headings is calculated automatically once a fan or fixed quantity is setup. The air will flow naturally due to pressure and resistance unless other fans or restrictors are used. The ventilation requirements and parameters can be setup for each heading to achieve the desired result.



The branch input for airway parameters is an excel type spreadsheet view. Resistance for each branch can be setup as a set resistance value, resistance per length, using k-factor or pressure drop over flow rate squared. The user's selection will normally be based on the available data. Heading length, shock loss equivalent length, area and perimeter are also all added in this window. Headings can be setup as intake, exhaust or just as default. This can set which headings connect to surface. Once a proper ventilation circuit has been created the data can be used in MVS Engineering's other ventilation programs such as Climsim, Ductsim and MineFire.

Climsim is the themodynamic simulator by MVS Engineering. Heat information is added in an excel type spreadsheet view, one row for each airway. The information entered is similar to Ventsim, and equipment or other heat sources can be added to any heading. The calculations update the heat values along each airway path, which are setup using an “air source” window. The connections between each airway must be setup manually from this window. Final results come out in the form of a spreadsheet with values for each airway as well as graphs of any of the parameters.

Ductsim is the fan and ducting simulator from MVS Engineering. It works similarly to Climsim, with inputs in table views, but also through dialog boxes. A duct system is setup along the mine circuit with airflow and pressure being calculated. Fan placements can be set and run to check results, allowing the user to determine the optimum fan setup. Results come in the form of tables, graphs and windows for individual fans.

Minefire is MVS Engineering’s contaminant and fire simulator. Unlike Climsim and Ductsim, Minefire directly works with VnetPC and will import your mine vent schematic. Minefire can simulate the resulting smoke and heat from a fire along the ventilation circuit, showing the quantities in each heading. It can also be used to calculate contaminant flows and diesel particulates along headings.

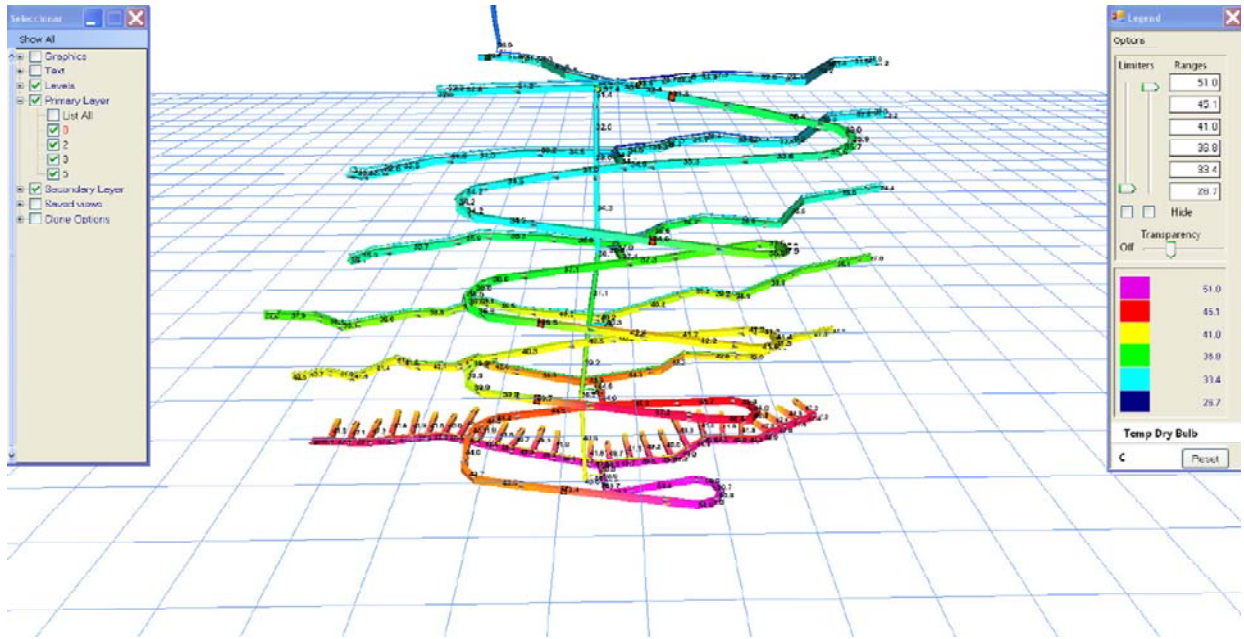
Visual Display

Ventsim

Ventsim has a fully 3d environment which is navigated using the mouse. Simple and intuitive moves make it very easy to look around. A single left mouse button click will recentre the screen while dragging with that button rotates around that point. Zooming is controlled by rolling the mouse wheel up and down. Panning in XY is achieved by holding both mouse buttons, and in the Z plane by holding shift. This allows the user to quickly achieve any viewpoint required. There is a menu bar at the top of the screen with all functions available as well as a toolbar with icons representing common functions.



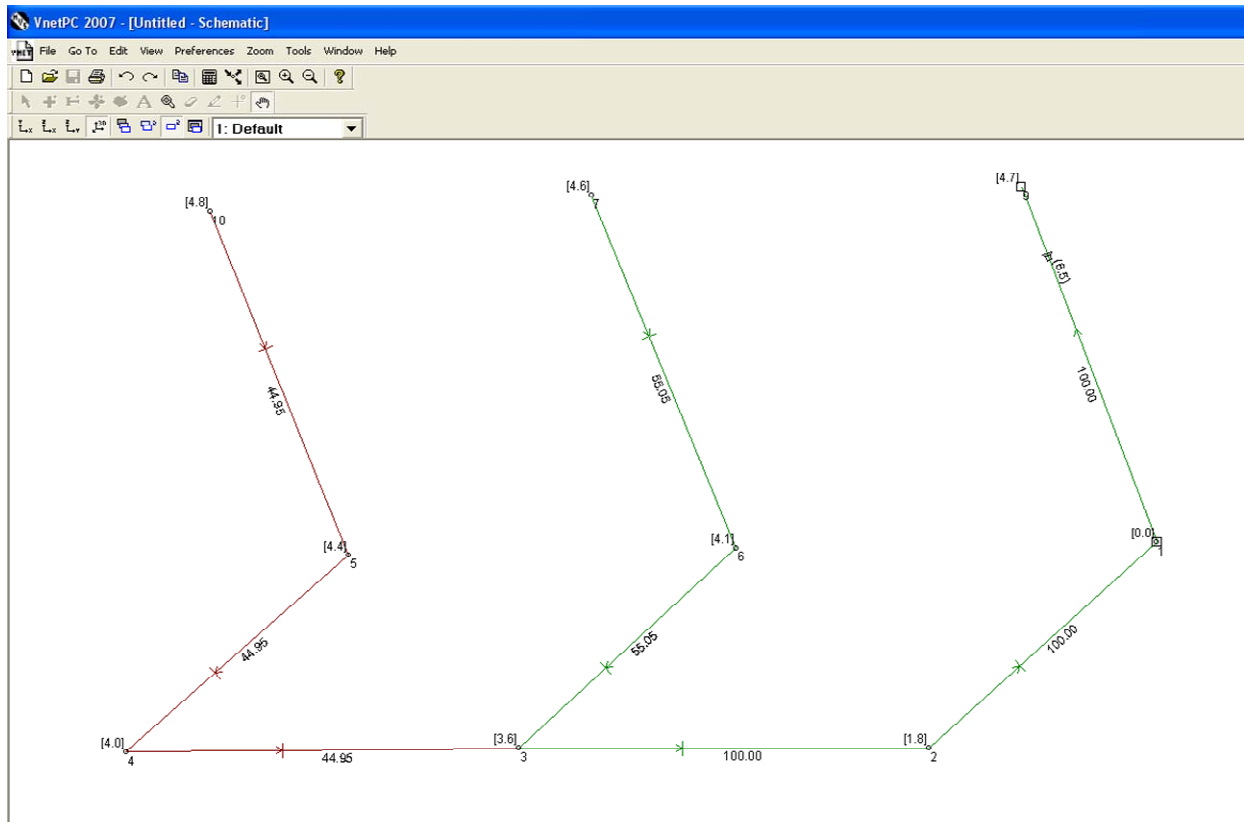
Right clicking on an airway also allows functions to be performed to that individual heading from a pop up toolbar. Functions can be run on multiple heading by clicking the function then dragging a selection box. There is an option to separate headings into different layers which can be turned display on or off. The colour of airways is controlled by a colour manager which creates a legend and range of values for any heading parameter the user chooses. For example the heat in a mine can be seen visually by displaying the dry bulb temperature in colours. Any of these values can also be displayed in number form above each airway.



Colour manager set to display heat in headings

VnetPC

VnetPC is normally in spreadsheet or menu views but can go to a schematic view to see the mine visually. The schematic view can use XY, ZX, YZ and 3d orbit views to display data. Headings can be created in any of the plane views, as well as editing or adding fans or contaminants. The 3d view allows users to rotate and zoom around their data.



Schematic view

The menu bar at the top of the screen changes depending on what section is being viewed (schematic, branch input, fan input etc..) to display only the relevant functions. From these menus in schematic view colours can be set to scales depending on heading parameters such as air quantity, pressure etc. In the branch input section the menus display functions such as adding, deleting or editing branches.



Branch input menus

Outputs

Ventsim

The outputs from Ventsim are mainly screenshots of the model and a mine summary report. The summary report gives details such as: total airflow in, fan power, power cost (yearly), fan details, air circuit resistance, total heat energy in and out, etc... This report gives all the details for whichever functions were run in the program.

NETWORK SYSTEM SUMMARY

Compressible Airflows	Yes
Natural Ventilation Pressure	Yes
Fan Pressure Simulation Type	Total Pressure Method

Network airways	356
Total length	12,334.8 m
Total airflow intake	136.6 m3/s
Total airflow exhaust	147.7 m3/s
Total massflow	168.31 kg/s
Mine resistance	0.16965 Ns2/m8

POWER SUMMARY

AIR (friction loss) Power	487.1 kW
INPUT Power Electrical	715.9 kW
Network Annual Power Cost	\$627,129
Network Efficiency	68.0 %

Consisting of ..

3 Fans	715.9 kW
0 fixed pressures	0.0 kW
3 fixed flows	0.0 kW

NETWORK FAN SUMMARY

Fan Installations	3
Fan Numbers	3
Fan Sites Switched Off	0
Fan Sites Stalled	0
Fan Sites Low Pressure	1
Fan Sites Negated	0
Fans running reversed	0
Total fan electrical power	715.9 kW

Pressure Loss Summary

Wall Friction	487.7 kW
Regulator Losses	0.0 kW
Shock Losses	0.0 kW
Orifice Losses	0.0 kW
Exit Losses	4.8 kW

Energy Summary

Pressure Losses	492.5 kW
Fan Efficiency Losses	187.6 kW
Motor Efficiency Losses	35.8 kW
Electrical Input	715.9 kW

VnetPC

The outputs from VnetPC can be printed from the branch results or fan results menu. This prints the data in a similar view as it is inputted. Screenshots can be printed from the schematic view as well to give either plan, section or 3d views of the mine. The outputs from MVS Engineering's other programs are similar, with spreadsheet style reports and screenshots of any visuals in the program.

Branch No.	From	To	FBR	Total Resistance (Ns ² /m ⁸)	Quantity (m ³ /s)	Pressure Drop (Pa)	Air Power Loss (kW)	Operating Cost (\$/yr)	Description
1	1	2		0.00018	-100.00	-1.8	0.18	97	
2	2	3		0.00018	-100.00	-1.8	0.18	97	
3	3	4		0.00018	-44.95	-0.4	0.00	0	
4	4	5		0.00018	-44.95	-0.4	0.00	0	
5	3	6		0.00018	-55.05	-0.5	0.03	15	
6	6	7		0.00018	-55.05	-0.5	0.03	15	
7	1	9	B	0.00018	100.00	1.8	0.18	97	
8	5	10		0.00018	-44.95	-0.4	0.00	0	

Ease of Use

Ventsim

Ventsim is a very easy to use and easy to learn program. Functions are intuitive and mainly graphical making them quick to learn. When errors are encountered a dialog box pops up and gives a clear indication of what and where the problem is. The problem headings are also highlighted and flash. Much of the work and calculations are automatic allowing for a much quicker setup for simulations. Having all packages such as the thermodynamics and diesel particulates available in one program is an asset.

VnetPC

VnetPC is a fairly simple program to learn with intuitive menus and function names. Some features are not as automatic as they could be such as cleaning imported dxf files and inputting branch information. All of the subsidiary programs such as Climsim and Ductsim work well but would be more convenient if packaged as additional menus or sections in VnetPC itself. The creation of networks and running calculations is straightforward with a minimal learning curve. Errors are reported by problem and heading name, but not always with obvious solutions.

Cost

Ventsim

Ventsim Visual is available in either standard or advanced versions. Discounts are available for multiple licenses or rentals but only single license full versions will be considered here. The standard version is limited to only airflow calculations, it lacks the thermodynamic, financial and recirculation modules. The advanced version includes all modules as well as some additional benefits such as extra data types and natural ventilation pressure. The cost for a single standard license is USD \$2495 and the advanced cost is USD \$3995.

VnetPC

VnetPC is sold separately from Climsim, Ductsim and Minefire so prices of each software will be listed individually. All programs offer discounts for multiple licences, but only a single license of each will be considered here. VnetPC costs USD \$1500 for a single license, Climsim costs \$1000, Ductsim costs \$600 and Minefire costs \$2000. If all programs are purchased the grand total is \$5100.