Machine Ventilation Modeling and Analysis

A model of the ventilation is constructed and verified with the existing machine ventilation. The methodology used to model the ventilation is analogous to an electrical circuit analysis except the pressure (voltage) is related to the square of the flow. This difference is presented in the following equations.

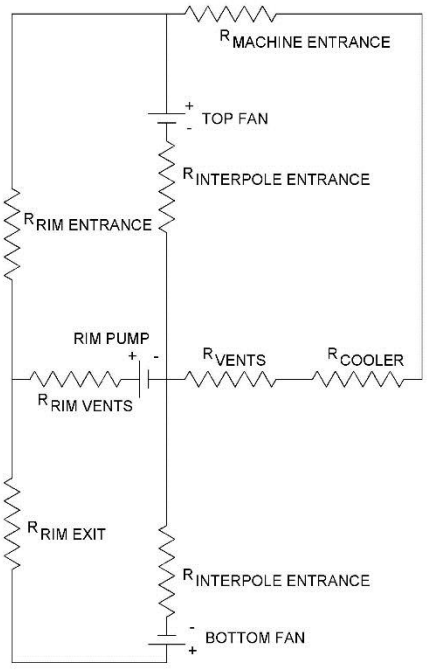
$P = R \times Q^2$ Fluid flow circuit analysis

$V = R \times I$ Electrical circuit analysis

An equivalent resistance network model of the ventilation circuit is constructed. The circuit contains equivalent resistance values that represent the various flow passages through the generator (stator vents, coolers, inter-polar space, rim vents, etc.). The fans are modeled with mathematical representations of the fan performance curve. The circuit is then solved to determine the flow (current) through each resistor by solving simultaneous equations. The equations consist of Maxwell loop-current and Krichhoff node-voltage equations similar to those used to analyze an electrical circuit with the exception that Pressure (voltage) is related to the square of the flow (current). The model is constructed and solved on a computer with EME's proprietary ventilation application using MathCad.

The detail of the model is established in accordance with the requirements of the analysis. If for example the interest is to evaluate the total flow through a machine, the model can be reduced to a few resistors, blowers, and other pressure sources combined in a simple network circuit. A simple model like this is depicted in Figure 1.

In evaluating more complex ventilation issues, such as in the case where air flow distribution through the machine is unbalanced, a much more detailed model would be utilized that would include smaller groups of vents or even all of the vents, blower shroud leakage paths, and pressure regain for branch-off ducts. A circuit for this more complex analysis is depicted in Figure 2.



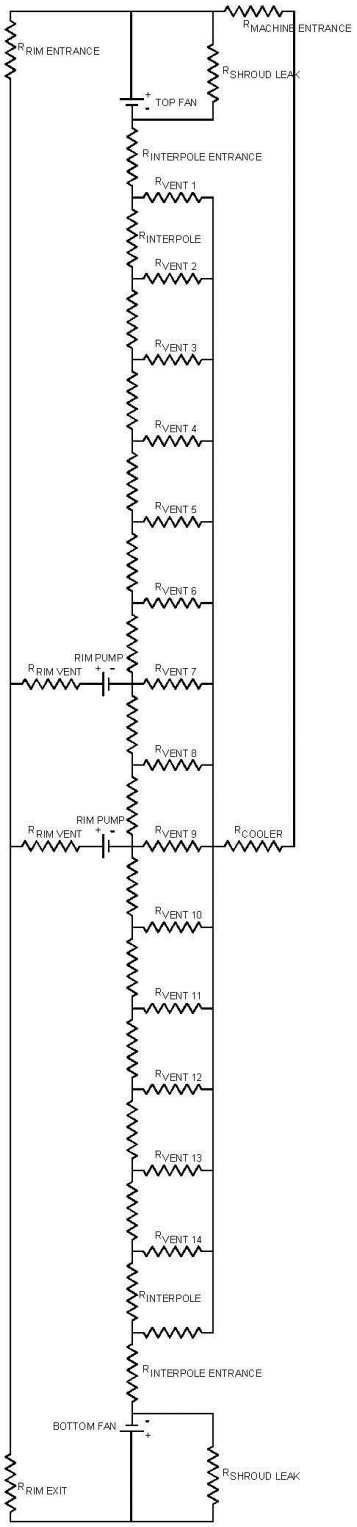

R MACHINE ENTRANCE
R RIM ENTRANCE
R SHROUD LEAK
TOP FAN
R INTERPOLE ENTRANCE
R VENT 1
R INTERPOLE
R VENT 2
R VENT 3
R VENT 4
R VENT 5
R VENT 6
RIM PUMP
R RIM VENT
R VENT 7
R VENT 8
RIM PUMP
R RIM VENT
R VENT 9
R COOLER
R VENT 10
R VENT 11
R VENT 12
R VENT 13
R VENT 14
R INTERPOLE
R INTERPOLE ENTRANCE
BOTTOM FAN
R RIM EXIT
R SHROUD LEAK

Figure 2