Variable Frequency Drive Applications in Non-makeup Air Exhaust Systems

G. Wang and M. Liu

Exhaust systems are often found in laboratory buildings, medical buildings and industrial plants. These systems collect the toxic air from buildings and send it to the atmosphere. Exhaust systems can be categorized as the makeup air type or the non-makeup air type based on stack exit velocity and existence of the makeup air duct at the inlet of the exhaust fan. In the makeup air exhaust system, the makeup air damper is modulated to maintain either constant fume hood static pressure or constant stack exit velocity. In non-makeup air exhaust systems, the stack exit velocity decreases proportionally to the fume hood exhaust airflows. The stack height in the non-makeup air system is much taller than the stack height in the makeup air exhaust system in order to prevent toxic air downwash to human inhabited spaces.

Constant speed fan is typically used for makeup air exhaust systems. Research found that the actual fan airflow is much higher than the design airflow under partial fume hood exhaust airflow. Consequently, a VFD technology was developed to control the fan airflow at design level and to reduce fan energy. To further reduce the fan energy, multi-stack systems with low fan airflows under partial exhaust airflows were also developed. These technologies can reduce annual fan energy by 30% or more for typical exhaust systems.

The constant speed fan wastes fan energy and causes excessive noises in non-makeup air exhaust system, where stack exit velocity decreases proportionally to the laboratory exhaust airflow. A variable frequency drive (VFD) can maintain the required static

pressure at the fume hoods by modulating the fan speed. The VFD reduces the fan power and eliminates the noise problems. A theoretical study has been conducted to investigate the system performance of the constant fan non-makeup air exhaust system, the impacts of the VFD, and the optimal VFD control for multiple stack systems. The results show that the VFD can potentially reduce annual fan energy of the constant speed fan non-makeup air exhaust system by as much as 51%.