

Modular HVAC systems for adverse applications

Johan Pienaar of SME – Specialist Mechanical Engineers – talks about his company's MicroKool MK series industrial HVAC solutions and describes an implementation success in the aluminium smelter industry.

Energy efficiency, dynamic balance, swift adaptation, accurate predictability, zero downtime and instant repair are all competing imperatives faced by engineers in the ongoing industrial race to keep at the cutting edge of innovation and to satisfy the never-ending demand for investment returns.

It is easy to relate to the latest car enhancements and we all look forward to the innovations embedded in new and future vehicles, but there is less excitement when it comes to heavy industries such as mining, raw materials processing and manufacturing. Embedded in these 'dirty sectors', however, are the most rigorous demands for continuous improvement, because the success of these industries is at the heart of economies all over the world.

The aluminium smelter industry is a good example. Manufacturing hundreds of thousands of metric tonnes of aluminium over 100 years has resulted in an insatiable demand for energy to feed massive furnaces, which concentrate giga-scale heat sources in an environment where people have to



The MicroKool series of air conditioners provides reliable cooling for industrial enclosures in extremely high temperature environments.

work and deliver every day. The extreme heat can yield operator proximity temperatures of 65 °C. Adding to this are immense magnetic fields, ultra-fine aluminium dust and hazardous gases such as sulphur dioxide

(SO₂) and hydrogen fluoride (HF).

An extraordinary burden is placed on the physiological performance and health of human operators, although no compromise is made with respect to the required operational health standards. Likewise, the severity of corrosion, heat and dust results in the need for exceptionally rigorous design criteria for HVAC systems, for which the 'make it bigger and heavier principle' cannot be applied.

SME recognised this engineering challenge back in 2003, at which time the life expectancy of aluminium plant HVAC systems was a mere five years. An expensive and less familiar refrigerant blend, extremely high leak rates, inadequate controls and poor reliability were par for the course.

The development of unique systems

In line with SME's strategy to analyse client-specific and distinctive demands, the company set about developing a unique fit-for-purpose solution for a client in the aluminium sector. The requirement was simple: 'to create a safe dust-free, controlled micro-environment of 25 °C in smelter conditions'.

Our design starting point was to systematically eliminate the weakest links. 'Analyses surpass intuition': and this engineering methodology was engraved as a discipline to adhere to, without exception.

Durability was addressed right at the start

with the exclusive selection of 304L stainless steel material for use for all fabricated parts, apart from areas where its use was impossible, such as the stainless evaporator and condenser coils which would be almost 50% bigger in size for the same heat transfer capacity, and triple the price compared to aluminium or copper coils.

Specific analysis of the gaseous substances that were causing aggressive corrosion

led our engineers to a significant value-adding life improvement involving activated carbon granules to clean the toxic gas passing into the system. This enabled us to incorporate a gas filter pack into each operator cabin, a solution that ticked the 'safe environment' box for three months between replacement intervals, an achievable service cycle relative to the plant maintenance profile.

The air, however, also had to be dust-free upstream, and an array of small cyclonic filter tubes with a 95-98% efficiency proved to be the 'ace' for achieving this.

In terms of reliability, this application was off the OEM specification graphs for any of the sub-components. The adopted solution? Redundancy. We decided to fit two compressors in tandem, ensuring a lower duty cycle for both by alternating primary and secondary designations with every second start-up. The same was done with switchgear, although the enclosure IP rating was also increased and filtered cooled air was bled off the cooling system and passed over the solid state switchgear devices.

The SMART-MAC controller

SME's experience of over 30 years in the defence industry, especially in the Middle East, cross-pollinated into the system wiring and circuit design to incorporate lightning-fast system protection for the refrigerant cooling circuit. But the game-changer for us came with the development of our own

SMART-MAC (Multi-Application Controller) into which unique control features have been embedded.

The MAC is a specially designed, ergonomic and modular multi-application control system which embraces the complete control system requirements of an HVAC unit. It is a comprehensive control system with an ingenious design, vast capability and stackability, which enables additions at any later stage, making it ideal for upgrades and new feature additions.

The General-Purpose Controller at the heart of the system acts as the master controller to all MAC modular stacks and contains digital inputs and outputs, analogue inputs, relays, USB and CAN bus connectivity.

The Electronic Surveillance Module (ESM) provides data logging and receives the data from all other modules in the system. It then writes the data in a recognisable format to an SD card. The HVAC system can be monitored with Real-time System Monitoring via Bluetooth or a USB connection. A cellular phone can be used to retrieve real-time data and send commands to the unit. Status and control can also be done from any global location via the internet.

The SMART-MAC module can also be used

as a solid-state relay for switching compressors or fans. The module provides superfast protection against short circuits, overvoltage, over current and protects the downstream components from overheating.

SME is proud to finally be able to say we have 'created a safe dust-free controlled micro-environment of 25 °C in smelter conditions', but moreover, at up to ambient temperatures of 72 °C. We also managed to add durability and reliability, reducing system breakdowns by 96.7% per year.

In addition, we have added UV-C decontamination on all our designs, a long-overdue fundamental necessity sparked by the COVID-19 pandemic.

SME specialises in custom high-efficiency industrial heating, ventilation, and air conditioning (HVAC) systems for use in many other adverse environmental conditions, including systems for rail locomotives and coaches, cash in transit vehicles, military armoured personnel carriers as well as mobile and stationary support systems. Applications extend to environmental control systems (ECS) for plant equipment, ground control shelters and panel mounted coolers for sensitive electronic racks and power panels.

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SME's production facility in Koedoespoort, South Africa, is well equipped to cater for most ferrous and non-ferrous metals such as structural steels, cast iron, stainless, aluminium, armour plate, etc.



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business@specmech.co.za | www.specmech.co.za