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Automotive:

Innovative filtration applications in the auto industry

Filtration and separation processes are widely employed in the automotive industry. Anthony Bennett reviews some of these processes used in engine manufacture, vehicle production and car assembly.

This article focuses on a number of innovative filtration and separation technologies used in the automotive industry. It concentrates on engine manufacture, briefly reviewing technology trends in engine operation and the impact of those on filtration requirements, before describing advances in filtration and separation technology used in engine fabrication, focusing on oil mist elimination, magnetic filtration of cooling fluids and engine parts washing. In automotive vehicle production there are issues of filtration in casting mould production for manufacture of body parts, and the separation of solids from body treatment solutions, coatings and paint. Finally, one innovative technology is reviewed that is used in both vehicle assembly and maintenance processes.

Engine manufacture

Within the internal combustion engine, filtration now employs higher efficiency materials, in both liquid and air filters, with various innovations including for example the introduction of nano-materials on Porvair Filtration's filters. They incorporate P2i Limited's patented nano-coating technology which employs a pulsed ionised gas (plasma), created within a vacuum chamber, to molecularly bond a nanometre-thin polymer layer over the entire surface of the filtration product.

Richard Canepa, business development consultant at RTC Consulting reports that in regards to filter housing design there is a trend developing for compact filtration systems such as Z-pleated filters. Richard Canepa said: "There is also a move towards more ecologically friendly filter housings to minimise the material disposed of in recycling, such as with oil filter cartridges where the housing becomes part of the engine."

Richard Canepa added: "As the automobile evolves through the phase out of internal combustion engines into electronics, the need for combination air and gas filtration will be necessary, especially in the use of fuel cells. There is also much work going on with newer technologies such as HCCI [homogeneous charge compression ignition] engines and also there is increased use of direct injection. Because of the use of exhaust gas recirculation, there will be an added need for high temperature systems to filter exhaust recirculation gases on direct injection engines."

Concentrating on filtration processes used in automotive engine manufacture rather than

Figure 1: A wide variety of filtration and separation processes is employed in the automotive industry.

Figure 2: Oil mist elimination system for a German automotive manufacturer. (Courtesy of Vokes Air Group.)

engine operation, we now focus on three innovative technologies used for oil mist elimination, magnetic filtration of cooling fluids and engine parts washing.

The improvements in engine technology and manufacturing techniques evident have resulted in tightening of tolerances on machined parts. This has enhanced the need for filtration and separation technologies to remove particles and debris from coolant, lubricating and cutting fluids. Short tool life can be avoided by employing effective filtration to reduce defects and rework of machined parts.

Oil mist elimination

Oil mist filtration is becoming an increasingly significant focus for many automotive manufacturers. With machine tools running at high speeds and higher coolant delivery pressures, traditional electrostatic and centrifugal oil mist collection systems can allow the coolant mist to escape into the workshop atmosphere, along with other contaminants, such as fine swarf and bacteria. This has provoked health and safety investigations into the potential link between oil mist and serious respiratory conditions, such as industrial occupational asthma and extrinsic allergic alveolitis.

A new approach to oil mist elimination has been developed by Vokes Air Group. The company's ScandMist technology operates using a three stage filtration process. The first two stages remove the oil from the air and the final filter cleans the air enabling it to be returned to the local environment.

A high performance fan pulls the contaminated air through the series of filters. The oil removal filters operate by collecting oil or coolant and allowing it to drain to the base of the ScandMist unit (see Figure 2). Contaminated air passes through the filter media and the oil particles are attracted to the oleophobic fibres. Oil droplets continue to collide with the fibre and the oil droplet gains in mass. As the oil drop becomes bigger, it becomes heavy enough to fall against the airflow to the base of the ScandMist unit, where it can be collected or drained straight back to the machine tool sump.

The scrubbed air is then passed through a highly efficient coalescer where the coalescing process is repeated. After this second filtration stage, Vokes-Air Group advises that the air is on average 95-98% free from oil mist.

The third filtration stage is designed to completely clean the remaining air to a standard far higher than the surrounding ambient air. Using a HEPA filter, this final stage ensures that sub-micron particles (e.g. trace oil, smoke, bacteria, pollen and spores) are trapped and not allowed to return to the workshop. The HEPA filters used operate at 99.95% efficiency and are rated at 0.3 µm. This means that in a workshop environment, effectively all hazardous particles are trapped ensuring only clinically clean air is returned to the workshop.

Many automotive manufacturers have installed oil mist filtration systems at their production facilities. Vokes-Air Group is reporting strong orders for its ScandMist system in spite of the economic downturn.

Cooling fluid filtration

Now widely used in reaming and boring processes for removal of particles and debris, the Micromag magnetic filter from Eclipse

Figure 3: Sulphur dioxide cleaning system supplied to Volvo Powertrain Corporation's foundry in Skövde, Sweden. (Courtesy of Götaverken Miljö AB.)

Figure 4: Magnetic pre-filtration system for treatment of paint, coatings and body preparation fluids. (Courtesy of Amazon Filters Limited.)

Magnetics can reduce machining costs and improve the quality, accuracy and surface finish of the product being machined.

Honda turned to Eclipse Magnetics to use Micromag technology on a custom-built reaming and boring machine at its Swindon plant in the UK. The machine, designed and manufactured by Honda's Engineering Division, is used for manufacturing engine valve seats – an engine component where accuracy and quality of surface finish is critical.

Honda's Engineers found that micro-particles of metal carried in the machine's coolant could adversely affect the surface finish of the machined valve seat, which in turn could impair engine efficiency.

The engineer in charge of this process on site, Peter Jones, believed magnetic filtration could provide the answer. Peter Jones said: "Since incorporating Micromag into our process, we have found that, in addition to it efficiently removing potentially harmful metal particles, the unit's maintenance friendly characteristics ensure that we now experience minimum machine downtime."

The magnetic core in the Micromag comprises neodymium iron boron magnets that generate a high intensity magnetic field. Fluid enters the housing and is evenly distributed around the underside of an aluminium lid via radial tapered flow channels. The fluid passes down the outside of the magnetic core where magnetic particles are attracted by the high intensity magnetic field.

The centrally positioned magnetic core utilises a geometric magnetic circuit. Magnets are arranged around a central magnetic flux return shield to ensure that all of the magnets' performance is used whilst still allowing unaffected fluid flow even when the core is fully saturated with contamination.

Parts washing

Aqueous or chemical washing processes rely on fine filtration to ensure engine parts are free from particulates. High purity water is required to produce aqueous solutions with reverse osmosis (RO) membrane technology being utilised to meet the required specification.

Electropositive RO pre-treatment has been used extensively to extend membrane life on high purity water systems. Virtually all RO membrane manufacturers specify a minimum quality for the feed waters to their systems to maintain system integrity and an economical return on investment. Typical specifications include feed water with < 1.0 NTU (nephelometric turbidity units) and a Silt Density Index (SDI) of < 3.0.

Argonide tested its NanoCeram® electropositive pleated filter cartridge against several commercially available RO prefilters. Argonide claims that its NanoCeram filter cartridge exhibits a significant advantage in removal of submicron particulates when compared to these other commercially available filter cartridges. Under extreme loading, NanoCeram yields NTU values below detectable limits and SDI values comparable to UF membranes – providing long-lasting protection of RO membranes susceptible to premature fouling.

NanoCeram filters have been installed on an RO system at a Toyota Motor Manufacturing facility which utilises a municipal water source. Prior to installation of the electropositive filters, the SDI on the system's feed water averaged 4.42. After installation of NanoCeram filter cartridges, the SDI levels averaged 1.19.

Prior to installation of NanoCeram filters, Toyota was cleaning its RO membranes every 1-2 weeks, and replacing these membranes every 2-3 months due to premature and irreversible fouling of the membranes. After installation of the NanoCeram filter cartridges and an initial start-up period of two months, the membranes were in operation for twelve months without the need for cleaning.

Vehicle production

In this section we focus on innovative technologies employed in the production of automotive body parts, their washing, surface preparation and subsequent multi-coat painting. We look at sulphur dioxide cleaning in mould production, separation of solids from pre-phosphate solutions and another innovative application of magnetism in the paint kitchen to extend the life of existing cartridge and bag filter installations.

Casting

The production of vehicle body panels requires the manufacture of specialist sand moulds. During sand mould curing processes sulphur dioxide gas cleaning is required. Götaverken Miljö has delivered a sulphur dioxide cleaning system to Volvo Powertrain Corporation's foundry in Skövde, Sweden (see Figure 3). The gas stream needed to clean contains high amounts of sulphur dioxide, at approx 70 g/Nm^3. The need to treat the gas arises because the sand moulds, used in the casting process, are cured with sulphur dioxide.

The contaminated sulphur dioxide is taken from the mould using a blower extraction system. The blower pressurises the gas in a reactor where it reacts with lime and forms gypsum. A small amount of sulphur dioxide diffuses out of the mould to the surrounding cabinet. This gas is collected and ventilated to a scrubber where the sulphur dioxide is converted to sulphuric acid. In a second step the sulphuric acid formed is converted to gypsum.

The process does not release sulphates into the water and the concentration of sulphur dioxide released to the air is very low. Gypsum

Figure 5: TyreSaver nitrogen separation unit. (Courtesy of Parker Filtration and Separation B.V.)

is the only residue product formed and it can be reused, for example, in the cement industry.

Surface preparation

Automotive vehicle body assembly requires several steps, each of which may produce waste particulates resulting in contamination during the subsequent painting processes. Welding of car panels and side posts to the vehicle frame generates weld splatter, while finish grinding contributes additional grinding fines and slag. Dirt in the workshop atmosphere may also adhere to the panels. This contamination must be removed from the vehicle prior to initial surface preparation to provide a smooth surface for the painting process.

Cartridge and bag filtration systems are widely used in automotive manufacturing processes and in many process industries for coarse and fine particulate removal. In the automotive industry they are primarily used in surface preparation and for filtration of the various paints and coatings found in the paint kitchen.

Initial surface preparation typically utilises phosphate-based liquids. In the subsequent painting process, multiple coatings (generally five layers) are applied to achieve the final appearance. Contamination on the metal surface prior to the first coat of phosphate can lead to a noticeable blemish on the finished vehicle once covered with five layers of coatings. While benchmarks have been established in the industry to allow for a certain number of blemishes per body panel, numbers beyond acceptable limits require manual inspection and hand refinishing, resulting in higher costs and inefficiencies for automotive manufacturers.

Pre-phosphate washing

A major automotive manufacturer, based in Detroit, US, faced unacceptable levels of paint defects and noticeable blemishes on finished cars due to the inadequate under-performance of their existing bag filtration system.

While the bag filtration used was effective for the removal of fibre fines (in the 150-400 µm range), they were ineffective in the removal of the other large contaminants attributed to blemishes, such as weld balls and grinding fines. The use of finer-rated filter bags resulted in maintenance and cost issues, while the larger-rated bags caused too many potential paint defects. Clearly, the bag filters were ineffective in eliminating the weld balls and grinding fines.

Recognising the need to remove all of the solids present in their pre-phosphate body wash operation, the automotive manufacturer installed Lakos Separators as a pre-treatment system on the washwater recirculating line prior to the bag filters, efficiently pre-filtering to remove large particles such as weld balls, grinding fines and slag.

Use of the separators to remove these heavier solids now allows the bag filters to take a higher loading of smaller particles, removing fibres and sealant, maximising filter bag life and increasing the efficiency of larger micron-rated bags. As a result, Lakos advises that paint defects have been reduced by as much as 85% in some automotive plants. The process has now been adopted worldwide for this vehicle manufacturer.

Paint and coating filtration

The Amazon FerroStik magnetic pre-filter is another innovative application of magnetism, also designed to extend the life of bag filters as well as cartridge filters on paint and coating filtration applications. The performance of these filters can be enhanced significantly by protecting them upstream with magnetic pre-filtration technology and the cleanable FerroStik system can increase filter life and improve filtrate quality.

Amazon's system comprises four high intensity magnetic rods which are suspended in a standard bag housing (see Figure 4). The magnetic filter removes both large and small ferrous particles that would otherwise block the final filter or pass through it and remain in the liquid. Once fouled, the magnets can be cleaned in situ and returned to duty.

Amazon FerroStik systems can be permanently installed or used as portable units with flexible hoses. The magnetic filtration systems can be used in singe pass mode or in a recirculating system for maximum particle removal. Key benefits identified by Amazon include improved filtrate quality, improved protection of downstream equipment, increased filter life and reduced running costs.

Assembly

Numerous components are fitted into vehicles once the basic construction has been completed, and a vast array of filtration and separation processes are used in their manufacture, installation and operation. We focus here on one innovative technology that utilises a simple gas separation technique and can be used in the workshop and at the local garage.

Nitrogen for tyre inflation

The TyreSaver systems developed by Parker Hannifin have been specially designed for inflating tyres with nitrogen. The technology can be installed within production lines or on a smaller scale for use by automotive service personnel in tyre fitting and maintenance processes (see Figure 5). Parker advises that dry nitrogen leaks less quickly out of tyres (three to four times) than the normal compressed air generally used for inflating tyres, delivering various benefits including longer-term stability of tyre pressure, less resistance, less wear and tear (up to 25%), less fuel consumption (up to 8%), less carbon dioxide emissions, better performance and increased safety.

Parker's system comprises membrane technology for gas separation based on hollow fibres. The working principle involves a bundle of thousands of hollow fibres which allow oxygen to flow through selectively. A membrane module consists of a fibre bundle fixed at both ends within a tube. The compressed air entering this membrane module contains normal atmospheric proportions of gases, consisting primarily of oxygen and nitrogen, with minor additions of other gases such as water vapour, helium and trace gases. In addition to oxygen, water vapour, helium and oxygen selectively pass through the membrane wall, leaving behind primarily nitrogen for inflating the tyre.

Conclusions

We have seen that a number of the filtration technologies employed have been retrofitted to enhance the operation of existing underperforming equipment. This has provided automotive manufacturers with cost effective solutions involving the installation of advanced pre-treatment equipment involving separators, magnetic filters and electropositive RO pre-treatment. This has resulted in cost savings as well as the environmental benefits arising from reduced use of consumable filtration components.

As we start to move away from the internal combustion engine, the specifications on particulate removal in engine production and operation will become tighter increasing the need for widespread use of pre-treatment technologies on existing production lines. The predicted development of electronic systems in vehicles, the use of electric motors and fuel cells, and the introduction of HCCI engines and exhaust gas recirculation techniques, are all factors that will demand superior filtration products with high removal specifications in the medium term. This is likely to drive development of nano-coating technology and accelerate the ongoing trend for more compact and integrated filtration solutions. ●

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