Automated acid-fume exhaust system in steel pickling line recycles acid components to prevent a pollution problem

The contract awarded to Fabricated Plastics Limited (FABCO) to supply a major Ontario steel plant with equipment to be incorporated in a new pickling line was, in fact, three projects in one:

- The production of a ventilation system that included a fume scrubber, a stack, two fans and all interconnecting ducting;

- The fabrication of covers for 13 acid pickling tanks (where the plant’s product is cleaned) and covers for three rinse tanks;

- The molding of fiberglass reinforced plastics (FRP) drip trays to protect the incoming strip of steel from acid that might splash onto it from the pickling process and mar the appearance of the finished product.

(The pickling tanks, rinse tank and wringer roll mechanism which make up the 122 m (400 ft) long “wet end” of the company’s steel production line, are all elevated to provide room for the continuous strip of steel to pass under them before it is immersed in the first pickle tank.)

The ventilation system

“The plant’s ventilation equipment is the heart of the system we were called on to provide,” says Ken Choi, FABCO’s senior process design engineer. “Its purpose is not only to exhaust acid fumes from the pickling area, but also to remove the acid components of those fumes and return them for reuse in the pickle tanks. Reclaiming the valuable acid in this way is a money-saving feature for the plant.

“And once the acid components are removed, the vapor can then be
exhausted safely to the outside through the stack, and makeup air brought into the plant."

The ventilation equipment supplied by FABCO included a 3 m (10 ft) diameter by 4 m (14 ft) high (40,000 cfm capacity) FRP scrubber, two FRP recirculation pumps, each with a 400 gpm (U.S.) capacity and a 15 m (50 ft) totally dynamic head; and two 40,000 cfm fans with 9 inch static pressure, each powered by a 125 hp motor.

One recirculation pump is a “backup” unit, as is one of the fans, to be kept on standby while the second pump and second fan are operational. (The pickle tanks, rinse tank and wringer roll mechanism were all supplied by other companies.)

“We supplied two fans for the ventilation system,” says Choi. “Each fan had a fan housing molded in FRP, with the fan wheels made of Hastelloy, a sophisticated, highly corrosion resistant metal.”

FABCO molded the interconnecting and bypass ducting in FRP, in diameter ranging from 254 mm (10”) to 1,067 mm (42”) – size variations that were called for in order to achieve a balanced system in terms of static pressure loss.

To complete the plant’s ventilation system, the Maple, ON, fabricator also built a 1.3 m (51”) diameter, 40 m (131 ft) high free-standing FRP stack designed for high wind loading.

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### The tank covers

Twelve removable covers and one fixed cover – all made of PPS, a fire retardant polypropylene – were required to contain the acid fumes in the four 21.3 m (70 ft) long pickle tanks.

A single lid long enough to cover a single tank would have been too heavy to handle, Choi explains, so total coverage was provided by shorter lids fitted in series, approximately three to a tank.

Each removable cover is 7.3 m (24 ft) long and 3.4 m (11 ft) wide; the fixed cover is 2.7 m (8’-9”) by 3.4 m (11 ft).

Three slightly smaller PPS covers were fabricated for the single rinse tank.

“The tanks are normally covered during the pickling process,” says Choi, “but occasionally have to be opened when the steel strip is being tracked through the system, or when the strip breaks and has to be lifted into place again to continue its passage through the tanks.”

The original covers (not supplied by FABCO) on four other pickling lines at the plant were made of rubber-lined steel which eventually corroded and had to be taken out of service.

These rubber-lined covers were replaced with FRP covers which were lifted by crane to open the tanks, then dropped back into place again – a procedure that eventually cracked their hinges and allowed acid to delaminate and attack the glass reinforcements used.

“It was then that a leading manufacturer of steel-making equipment in the U.S., devised a method of using pneumatically activated arms to slowly open and close tank covers and eliminate the problems created by rough handling,” says FABCO technical sales representative Jon Komow.

“We adapted this method, using the pneumatic arms to lift each PPS cover at two points near dead center. When it is raised, the cover seems to float up with no undue stress placed on the structure.

“Perhaps most important of all, however, is the seal we devised to prevent leakage of the acid fumes through the gaps between the covers when they are raised and lowered. We came up with a special seal design that provides for better adjustment of the covers, and better containment of the fumes.”

The covers themselves were carefully engineered to handle structural...
stresses, with cross ribs built into each one to minimize the amount of sag over its length as the cover is raised and lowered.

“Our design for the seals and construction of the one-piece covers (well gusseted and reinforced) by fusion welding, combined with the use of pneumatic activators, have given the customer a completely maintenance-free operation,” he adds.

Three covers for the rinse tank were also fabricated in PPS.

“As for the drip trays, ours are essentially improved versions of those on the plant’s older pickle lines, but with some changes we incorporated to make them easier to install,” says Ken Choi.

“We molded them as interconnecting units, one tray overlapping the next,” adds Jon Komow. “They are all sloped to one side to feed the drips into a single channel.”

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**The benefits of an “active” system**

The ventilation equipment supplied to the customer for its previously installed Number 4 pickle line is a “passive system” provided by one of FABCO’s competitors, according to Komow.

“That is,” he says, “its operation is controlled by dampers which operate in a passive fashion. When the tanks are closed and there is only a low concentration of fumes to be removed from the processing area, the dampers are supposed to open to let fresh air into the system.”

“That is designed to reduce the amount of suction being used to remove the fumes, since too high a rate will exhaust too much of the vaporized acid into the atmosphere. When that happens, of course, the plant is not only losing valuable chemicals but it is also polluting the atmosphere.”

“The passive ventilation system never worked as it was supposed to,” says Komow, because its dampers were not sensitive enough, so the steel plant asked FABCO to redesign the new one. “After a close look at the problem, we concluded the only remedy was to install an ‘active’ system. In other words, the exhaust process had to be controlled by putting makeup air into the system at precisely the right amount.”

“We accomplished that by adding an electronically controlled bypass — ductwork that bypasses part of the atmosphere when the pickle tank covers are closed. That ensures that fresh air will be circulated through the system instead of the acid fumes.”

Noting that at full capacity the ventilation system was capable of exhausting 40,000 cubic ft of air per minute, FABCO’s engineers established that for peak efficiency with all the pickle tanks closed, the main system should be moving 20,000 cfm of air with 12,000 cfm in the bypass ducting.

Branches off the system’s main header are connected to openings in the sides of the tanks. Each branch is fitted with a motorized damper that interlocks with the cover-lifting mechanism, so that when a tank is opened or closed, the damper is immediately energized (to be closed or opened, as required). The same damper is also used for fine-tuning the static pressure balance of the ductwork.

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**Balancing the system**

Because of extended length of ducting in the ventilation system, the biggest problem FABCO faced when it built the equipment was to balance the system — to design it so that there would be an equal amount of suction at each of the tank openings.

“We had to achieve that balance by providing different diameters of ducting along its overall length,” says Ken Choi. “That is, for openings far from the fan, smaller diameters of ducting were required to produce the same amount of suction as at an opening close to the fan.”

“Our ultimate goal was to produce a self-balancing system, and we came so close to achieving that goal that we did not have to change the setting of a single damper during the balancing operation.”

FABCO’s engineering team was so precise in calculating the sizes of ducting required to achieve balance that it has been able to work out a standard procedure for making such calculations, and has written a computer program which could be used on similar projects in the future.

The pickling line was fully operational four months after the installation of all the equipment.

FABCO’s final assignments were to write an operations manual spelling out daily operational and maintenance procedures, and to train the steel plant’s personnel to operate the equipment.