Belgoprocess

Techniques for the decontamination of concrete surfaces

1. Introduction

Belgoprocess started the industrial decommissioning of the main process building of the former Eurochemic reprocessing plant in 1990, after completion of a pilot project. Two small storage buildings for final products from reprocessing were dismantled to verify the assumptions made in a previous paper study on decommissioning, to demonstrate and develop dismantling techniques and to train personnel. Both buildings were emptied and decontaminated to background levels. They were demolished and the remaining concrete debris was disposed of as industrial waste and green field conditions restored. The main conclusions of this pilot decommissioning project denoted that emphasis had to be put on:

- The automation of concrete decontamination, and
- The decontamination of metal components.

The main process building is a large rectangular construction of about 80 m long, 27 m wide and 30 m high. About 106 individual cell structures have to be dismantled, involving the removal and decontamination of equipment from each cell, the decontamination of the cell walls, ceilings and floors, the dismantling of the ventilation system. These activities are followed by a complete monitoring to allow for unconditional release of the remaining structures. As such, about 1,500 Mg of metal structures, and 12,500 m^3 of concrete with 55,000 m^2 of concrete surfaces have to be removed and/or to be decontaminated.

Most of the work involves hands-on operations under protective clothing tailored to each specific task. Tool automation and automatic positioning systems are successfully applied.

The specific Belgoprocess approach should be highlighted in which decommissioning activities are carried out on an industrial scale with special emphasis on cost minimisation, a commitment to results within an overall planning, and the use of technology on an industrial representative scale. This approach includes specific actions to reduce standby costs. It takes great care to limit radioactive waste management costs, keeping the generation of radioactive waste to a minimum, minimising the spread of radioactivity as much as possible, and optimising the possibilities for recycling and reuse of valuable components from existing and potential waste streams. Extensive use of adequate decontamination techniques is made in order to allow dismantled components and materials to be unconditionally released, as is indicated in table 1 which can be seen in the "Strategy", taking into account the limited availability of funding.

In addition to the large efforts that were made in decontamination and unconditional release of metal components, some specific actions have been defined in order to improve the decontamination of concrete surfaces. Adapted techniques have been developed with higher and more efficient working rates and lower waste production. They have been integrated into remotely and manually operated industrial systems that capture dust and debris at the cutting-tool surface, which minimises cross contamination.

2. Decontamination of contaminated concrete surfaces by scabbling

In general, cutting and decontamination of concrete structures is carried out either hands-on, or by electrically powered, hydraulically controlled systems. Mini electro-hydraulic hammering units are used when contamination has penetrated deeply into the concrete surface, increasing the decontamination possibilities and reducing the work load for the operators. Cell entrances are created or enlarged with diamond cable cutting machines.

For the decontamination of concrete surfaces, where the contamination has not penetrated too deeply, in the early days scabblers were used. The scabbling technique was developed and is widely used in civil engineering

for concrete surface preparation. In this framework, it is especially useful for the decontamination of cell walls and ceilings. The tools used are commercially available and use tungsten carbide tipped cutting bits. Hand held mono-headed machines, as well as multi-headed machines (3 to 7 heads) may be purchased. Cutting bit lives of around 100 hours are stated by the manufacturers. Both electrically and pneumatically driven machines are available. Work rates are not easy to predict due to the variety of concrete composition and characteristics. In order to avoid the spread of contamination, adapted dust extraction systems have been provided around the scabbler heads.

The scabblers that have been applied for concrete decontamination at the decommissioning of the Eurochemic facilities are all of the pneumatic type. For floors, 5- to 7-headed scabblers have been used, while for the decontamination of concrete walls and ceilings handheld 1- and 3-headed types have been applied. The resulting work rates may be summarised as follows:

- Floor scabblers: 4 to 6 m^2/h;
- Handheld wall scabblers: 0.25 to 0.5 m^2/h at a scabbling depth of about 3 mm.

Concrete waste production rates amount to 180 kg per shift-day, i.e., per 8-hour day with a shift of 5 effective operators.

To improve the working conditions for the operators, and to increase the capacity, scabblers were progressively automated. A first generation development with a combined horizontal and vertical movement of the scabbling head resulted in machine work rates of about 15 m^2/h. The rather long equipment installation time was a major drawback, however. Further discussions and developments in co-operation with manufacturers of scabblers resulted in a remotely controlled scabbling machine on a 4-wheel base with 2 driving units, a vertical column mounted on the base and a four headed scabbling head that may be moved up and downwards along the vertical column. When the machine was used in the various cells of the Eurochemic main process building, increasing damage was observed to the mechanical parts of the equipment (bolds and screws, traction drive shafts, axles, seals, rollers,...) as a result of the vibrations from the scabbling head created by the very high cutting forces.

3. Shaving as an alternative for scabbling

An evaluation of the progress of the decommissioning program at the end of 1993 showed that, especially at concrete decontamination, actual waste production rates by scabbling proved to be lower than expected. This was mainly due to technical problems with the automated 4-headed rotating scabbler, but also the production figures from manual scabbling were lower than estimated. As a result, an intensive search for adapted concrete decontamination techniques was made.

A self-propelled floor shaver was tested and successfully used as an alternative for floor scabbling. The machine is very similar to a normal floor scabbling unit. It has a diamond tipped rotary cutting head designed to give smooth surfaces which are easier to measure and ready for painting (see Fig. 1). It proved capable of cutting through bolts and metal objects, while with a traditional scabbler this would result in damage to the scabbling head. Actual cutting performance resulted in:

Figure 1. Floor shaver

- A 3.2 times higher mean working rate for floor decontamination (13.6 m^2 per effective shaving hour, compared to 4.3 m^2/effective working hour with a normal floor scabbler);
- A 30 % lower waste production than by scabbling at a comparable decontamination efficiency;
- Much less physical load on the operators due to the absence of machine vibration.

Based on the positive experience with the floor shaver, a remote controlled diamond wall shaving system was developed for concrete decontamination of larger surfaces. The machine comprises:

- A remote controlled hydro-electric power pack for the remote controlled shaving unit;
- Vacuum systems with pads to hold the horizontal and the vertical rails of the shaving unit to the wall and the floor;
- A simple xy-frame with:
    - A horizontal guide rail to be fitted with vacuum pads to a wall or floor and a carriage to be fitted onto the rail;
    - A vertical rail to be fixed onto the horizontal carriage and to be fitted to the surface to be decontaminated with vacuum pads;
- A remote controlled carriage supporting the remote controlled shaving head to be fitted to the vertical rail;
- A diamond tipped rotary shaving head with dust control cover to be connected to adapted dust extraction systems.

The entire system consists of portable sections. Unlike with conventional scabbling systems, surface decontamination by shaving removes the concrete in a controlled, low noise and vibration free manner. Depth adjustments can be set manually in increments of 1 mm so that a minimum amount of waste may be produced. With 300 mm and 150 mm wide shaving heads, both large areas and awkward corners can be accessed. When the vertical rail is fitted to the wall and while the cutting head is shaving, the horizontal rail can be disconnected and can be moved forward, thus ensuring continuous operation.

The system is suitable for the decontamination of flat or slightly uneven surfaces. Depending on the concrete characteristics, it can remove a 3 mm surface layer at 15 to 25 m^2 per effective shaving hour. Depending on the concrete characteristics, the expected life time of a cutting head may amount from 1,000 to 1,500 m^2.

As major drawbacks of the system it should be noticed that installation of the equipment is rather difficult and time consuming, and that it is almost impossible to use the wall shaver in small cells or in cells with irregular shapes.

Based on the positive as well as the negative experiences with the floor and wall shavers, it was decided to develop a mini wall shaving system. It is the objective to create a lightweight machine that may be handled by two operators and that will operate independently after its installation. The use of two or more units in parallel on one location should be feasible. It should also be used in areas where application of the current wall shaver is limited due to its dimensions. However, it should have increased decontamination capacity when compared to the manual shaving equipment described in the next paragraph.

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4. Manual shaving as an alternative for manual scabbling

Two low weight handheld shaving tools were developed as an alternative for handheld scabblers. A handshaver uses a cupped disk with diamond segments bonded onto the face of the disk. It has a controllable dust extraction guard and produces very low hand-arm vibrations. Decontamination rates from 4 to 6 m^2/h machine time are obtained, compared to 1.5 m^2/h machine time for a hand held DK1 scabbler. Operator's impressions were very positive, especially related to work load and hand-arm vibration levels (see Fig. 2).

In an early phase, only electrically powered hand shavers were tested, as pneumatic systems were not yet available in a handy and useful size. The electrical capacity being in the order of 1,400 Watt, and turning at 9,000 to 10,000 revolutions per minute, the mechanical capacity of such systems is about 700 to 800 Watt. Some of them are equipped with a tacho-generator, implying a constant number of revolutions under load. In practice, this was a very positive experience to the operators, as the disk got less often blocked.

Combinations of various disks and shaving machines were subjected to a detailed vibration test. The results showing that the global vibration level might vary from less than 8 up to 40 mm/sec, indicating the importance of an adequate selection in order to limit the level of hand-arm vibrations to the operators.

Current developments show promising possibilities for future use of pneumatically driven manual shavers, however. Tests that were carried out indicate that the decontamination capacity of this kind of shavers is considerably higher than for electrically driven units. Especially the power-to-weight ratio is much more interesting, taking into account the required working conditions. The ratio is about 1 kW per kg for pneumatically driven machines, while only 0.3 for electrically powered ones. A test under similar representative conditions showed that the best pneumatically driven machine delivered an output of 80 kg per shift-day, while with an electrically driven shaver only 60 kg per shift-day could be obtained.

When considering costs, the balance is even more in favour of the pneumatically driven machines. The basic cost for a pneumatically driven machine being twice as high as for an electrically driven model, the service life of the diamond tipped disks is almost three times higher with pneumatically driven shavers due to a much lower vibration level. In addition, pneumatically driven shavers require no maintenance at all, and show a higher efficiency (5.5 m^2 per effective working hour compared to 4 m^2 for the electrically driven ones). The conclusions of the tests that were carried out indicate that the manual pneumatic shaving technique is a predominant competitor for the remote controlled systems due to its simplicity and its flexibility in the application, in combination with its capacity.

Figure 2. Handshaver for concrete decontamination

Figure 3. Milling cutter for concrete decontamination

5. Milling cutter to remove larger concrete, brick or bitumen layer

When decontamination has penetrated deeper into the concrete surface and layers up to 1 cm or more have to be removed from walls, floors or ceilings the use of shavers may require the work to be done in several steps. In order to improve efficiency in these cases, an adapted milling cutter was used (see Fig. 3 above), fit on a conventional fork-lift truck. Such tool enables the single-pass removal of a rather thick layer of material from concrete or brick walls. Using this technique results in a rather smooth surface of concrete or brick material, which may be less smooth than in the case of a shaved wall, but still very interesting for making measurements.

A similar milling cutter with adapted cutting head was also used for the removal of a bitumen layer between the inner brick walls and the outer pre-stressed concrete walls of a former 2,000 m^3 open storage pond for cooling water and sludges of an incinerator for beta-gamma wastes. Also a heavy duty floor model was used in order to remove successfully the contamination from the bottom surface of the storage pond.

6. Removal of produced concrete dust

For dust free decontamination of concrete, all type of shavers have been equipped with adapted dust caps. Practical application shows that for adequate operation of manual shavers the level of under-pressure under the dust cap is very crucial. Not enough under-pressure means that the operator has to carry the weight of the equipment while shaving. Too much under-pressure may drive the cutting disk too deeply into the concrete, with possible engine overheating as a result. A good control system is important, therefore. As this is not a standard on available systems, it had to be developed.

All types of shavers have been integrated into remotely and manually operated industrial systems that capture dust and debris at the cutting-tool surface, which minimises cross contamination. For hand scabblers and smaller systems, dust evacuation is carried out with industrial vacuum cleaners having capacities up to 500 m^3/hour, and being equipped with absolute filtering systems at the outlet.

Larger scabbling or shaving machines are connected to vacuum systems with capacities up to 2,500 m^3/hour or higher. They incorporate a cyclone to evacuate larger concrete particles, a filtering system with cleanable pre-filters and absolute filter, and a vacuum pump. The cleanable filtering system incorporates a fill-seal drum change-out method that allows the operator to fill, seal, remove, and replace the waste drum under controlled conditions. The unit may accommodate different drum sizes and several shavers at longer distances.