

An innovation for remote-controlled work in hazardous environments

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Background and problem description

The German ready-mixed concrete industry alone produced 52 million m³ in 2017, and in total more than 100 million m³ were used - concrete. Hardly any building can do without reinforced concrete, starting with the foundations, engineering structures such as bridges, tunnels, football arenas and even nuclear power plants. And all concrete structures have one thing in common - the reinforced concrete has to be dismantled again at the latest after the end of life. But how can this be done without using staff on site and without changing different tools for the concrete and steel dismantling? And how can we simultaneously minimize environmentally harmful waste and thereby save our resources?

A first-time solution to this problem is provided by the "DefAhS" innovation presented below - an attachment for the defined removal of heavy reinforced concrete in one operation, which of course operates remotely.

Reinforced concrete has many advantages as a building material during construction, but it proves to be a challenge in the defined removal, be it during the dismantling of nuclear power plants, the demolition of buildings or in any other existing buildings. Even during new buildings there is a need of defined removal of highly reinforced concrete. For this purpose there is currently no machine or excavator attachment on the market able to handle this task remotely and in a single operation. The present innovation DefAhS solves this problems in the defined removal of reinforced concrete structures. Since every building at some point reaches its end of life time, the need for this kind of technology is evident.

The dismantling of nuclear facilities, both power reactors and research reactors, require the decontamination of reinforced concrete. One particular aspect is the risk of contaminants within cracks or impurities, making a precautionary cleaning necessary. Only by the defined removal of all potential contamination, can the remaining concrete structure be released from the atomic act and be conventionally recycled, thus minimizing the final radioactive waste repository. To achieve this sustainable goal, a "clearance measurement" must prove the contamination-free structure, thus the removal of all radioactive particles from the former nuclear operations in the structure. In order to carry out the clearance measurement, the surface concrete must be removed. In case of remaining steel beams or deep cracks in the structure, the concrete in

the surroundings is removed by hand, allowing the subsequent removal of the steel compound (for example by steel shears). The resulting surface must be relatively smooth in order to allow the follow-up free-release measurement. The state of the art of these procedures are, due to the complexity and the requirement of different tool types, the manual removal of concrete with chisels and the subsequent manual shredding of the reinforcement. This has to be performed in a monitored environment, requiring detail supervision and protection equipment. Further, due to the low efficiency of the manual equipment, makes this manual work a laborious effort, considering that concrete surfaces in one nuclear power plant can be as high as 150,000 m².

In conventional construction scenario, examples can be found in the refurbishing of buildings, where reinforced concretes must be milled out due to the contamination with hazardous materials. Examples are PCP-containing grout material or the removal of spray asbestos. Here, too, the state of the art is handheld machines resulting in a high workload for the staff (which has to work under breathing masks, while at the same time only low work efficiency values can be achieved). Further examples are the precise removal of reinforced concrete in case neighboring buildings should be preserved, or even during the building of tunnels. In the latter case a tunnel boring machine has to pass through a heavily reinforced concrete wall directly in the access shaft, resulting in a high wear of the cutters often worn out after just a few meters.

In addition, the legal and professional association guidelines for the prevention of released dusts are becoming more stringent. Since dust inevitably results from all demolition of reinforced concrete, this leads, especially in inner-city areas, to a great deal of effort to protect the neighborhood, making demolition more expensive in these environment. The DefAhS concept includes already countermeasures by having a dust protective cover and an attached exhaust system with corresponding filters.

Innovation and solution

These examples illustrate the many fields of application in the civil industry, where high-strength reinforced concrete must be removed and separated. It therefore requires an innovation that can remove high-strength reinforced concrete in one operation - without personnel deployment in human-hazardous environments. For this purpose there is currently no attachment for excavators or carrier systems that can perform this task automatically and without tool change.

This is exactly where the present innovation comes in to play. In the developed DefAhS attachment, two different methods are combined for the first time to form a one of a kind machining tool: the removal mechanisms for crushing concrete and the cutting mechanisms for cutting metal.

The peculiarity of this tool therefore lies in the combination of previously non-combinable process in only one processing tool for the removal of highly reinforced concrete, given by the innovation of the retractability of the impact cutters. Therefore, it can selectively remove and separate concrete and steel independently.

On a drum, both tools are arranged in a combined manner, so that a depth-accurate removal of high-strength reinforced concrete is possible without tool change and manual intervention. Standard concrete is conventionally removed by means of impact momentum, for example by impact cutters. Steel is also classically removed by means of cutting inserts, as in the conventional machining production. The concrete removal requires a higher peripheral speed for high impact velocity. Steel, on the other hand, requires a slower peripheral machining speed. Constant data acquisition via integrated detection makes it possible to precisely set the required operation mode (concrete or steel) for the removal. Concrete and steel can independently be selectively removed and subsequently sorted for unmixed disposal. In the working sequence, however, the concrete has to be firstly removed by the impact cutters. Through integrated measurement, the reinforcement is precisely detected at each point and therefore automatically removed by the cutting inserts integrated in the drum.

This combination of different processes for the removal of highly reinforced concrete with the development of integrated detection and control is a break-through innovation in civil engineering.

Application and practical relevance

The described innovation DefAhS makes it possible to remotely decontaminate highly reinforced concrete in a nuclear facility without the direct use of personnel at the removal place. Since no tool change is necessary, an increase in performance is achieved, the personnel exposure time reduced and, due to the defined removal, the waste amounts minimized. Debris from the process is directly removed by a pneumatic suction system. In addition, the device can also work continuously, without the required resting time of personnel working in hazardous environments.

Due to the high degree of autonomy of the system, it is possible for people to withdraw from the application zone during the processing time. Particular attention is paid to the protection of people in the event of possible contact with contaminated structures such as walls, fixtures, etc. The main focus of application is the nuclear environment, nevertheless the tool can be applied in any hazardous area, such as chemical, biological, radiological or nuclear (CBRN) hazards. The concept provides that the operator only has an observer role. He himself does not come into contact with dangerous substances. The remote operation of

the whole process protects the user in a maximal way possible and in addition allows a fully automatical operation.

The same applies to the entire field of application in conventional construction and demolition, for example in PCP refurbishment whilst milling reinforced concrete structures, in tunnel construction when driving through approach walls or even in completely conventional demolition work with existing neighboring buildings and building upgrades. In order to prevent contamination spread and dust pollution during inner-city application, the DefAhS concept already includes dust prevention by a housing and suction with filtering system.

Outlook

The innovation was developed in a BMBF-funded research project at the Institute for Technology and Management in Construction at the Karlsruhe Institute of Technology (KIT). The early involvement of industry partners has resulted in a research application that can directly be used by the industry.

In Germany, the patent application "Device for removing building material" (DE102015114122B3) was successfully approved, an international patent has already been applied for. Here, the industrial partners Kraft-anlagen Heidelberg (nuclear application) and Herrenknecht AG (conventional application) are directly involved.

Worldwide 440 nuclear power plants are still in operation, which illustrates the high potential of the developed attachment in the worldwide market. These power plants will have to be shut down eventually, joining many already undergoing decommissioning projects. For the conventional sector, the fact that the German civil industry produces about 55% of the total waste in Germany (about 200 million tons per year) shows that here too, innovation has a very wide field of application. Since a large part of the waste is demolition material coming from reinforced concrete – the potential impact is quite significant.

Source: Karlsruher Institut für Technologie (KIT)