Confined precise removal of reinforced concrete

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1 Introduction

Decontamination and remote handled shredding of reinforced concrete is fundamental to the decommissioning process of nuclear installations. The main target is to select and remove the contaminated material and to return the remaining material to the regular recycling loop, since the contaminated material usually only provides for a fraction of the total mass. Various methods, which are continuously being optimized and developed [1] are available for the only a few millimeter deep surface decontamination. The demolition and deep removal of reinforced concrete, e.g. in cracks or breaks, is still a problem. There are currently no procedures available that remove concrete and reinforcement in a single step in order for the surface to be released.

In a public founded joint project the Institute of Vehicle System Technology and the Institute for Technology and Management in Construction, both at the Karlsruhe Institute of Technology, and Herrenknecht AG are developing a system for the confined precise and remote removal of highly reinforced concrete. Simultaneously, the concrete and reinforcement chippings will be recovered and packed for final disposal in one step. The aim of the project is to develop a new and universal system that allows decommissioning companies for the first time to remove highly reinforced concrete without system and component change and with minimized personnel deployment.

At the core of the process chain is a tool for the removal of the two different materials concrete and steel. Since the different material properties require a fundamentally different ablation tool set, the two processes of concrete and reinforcement removal were at first considered separately in order to systematically identify the optimal sub-solutions. The two solutions that provide optimal specific removal rates and tool lifetimes will then be combined in the next step to one powerful tool.

A number of constraints apply for the deployment in nuclear facilities when selecting cutting techniques and system design. The planned carrier vehicle for the demolition system is a mini excavator with an attachment capacity of about 10 kN. For this reason, the resulting reaction forces of the removal process have to be kept at a minimum. Additionally, no transfer additives can be used. With respect to these constraints, different ablation processes were selected and studied in basic tests for their suitability. For the removal of non-reinforced concrete a stimulated undercutting process similar to the Oscillating Disc Cutting process (ODC) was promising because of its high removal rates at low cutting forces. For the reinforcement removal a milling process based on tools of the steel processing was identified as a possible procedure.

2 Concrete removal by stimulated undercutting disc

The application of a stimulated disc tool is, in this form, a relatively new procedure derived from stone machining and is described in detail in [2] and [3]. Core of this technology is a carbide cutting disc or a disc loaded with carbide inserts, similar to cutting discs for tunnel boring machines. This disc is executed in an undercutting geometry (figure 1) and oscillated during the removal process.

The undercutting technology mainly generates tensile stresses in the removal object in contrast to conventional roll cutters that remove material by exceeding its compressive strength. Therefore, high removal rates involving relatively low reaction forces can be reached as the tensile strength of concrete is less than its respective compressive strength. Also, the reaction forces can be further reduced through the oscillation of the tool. The cyclic loading facilitates the forming of cracks. Thus, tests showed that the reaction forces in the oscillated condition are lower than in cutting without stimulation [3]. Two essential advantages arise from the possibility of relieving hard mineral substances with high removal rates and relatively low cutting forces: The tool lifetime increases and less reaction forces affect the machine. This allows the application of lightweight and flexible carrier vehicles.

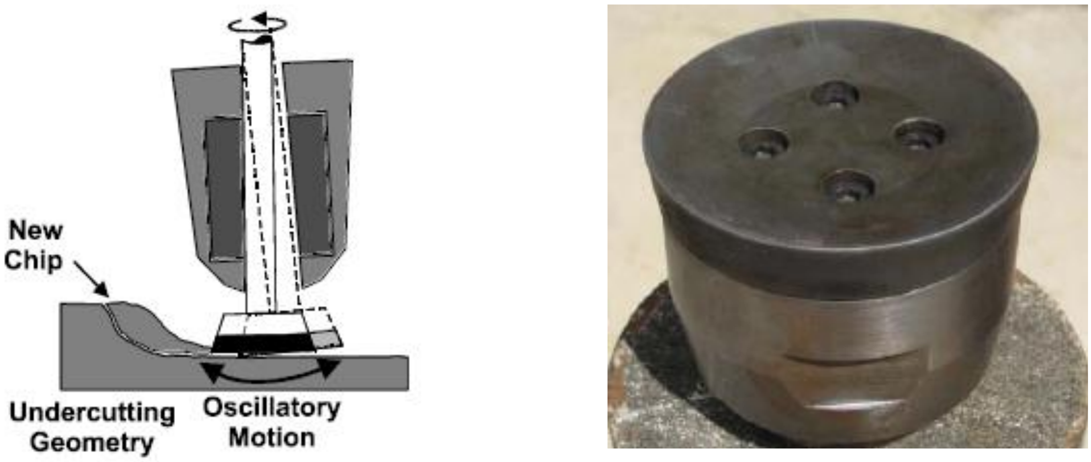

Figure 1: Principle and example of a cutting tool of the Oscillating Disc Cutting method [3]

The suitability of the procedure for the specific removal of concrete structures has been reviewed with bench tests. These tests have shown that the cutting forces are within an acceptable range, even with relatively high feed rates and removal depths (figure 2). It is expected that the forces can be further reduced through an alignment of the process parameters. Furthermore, the quality of the generated surfaces is very good and thus the release without difficulty (figure 3).

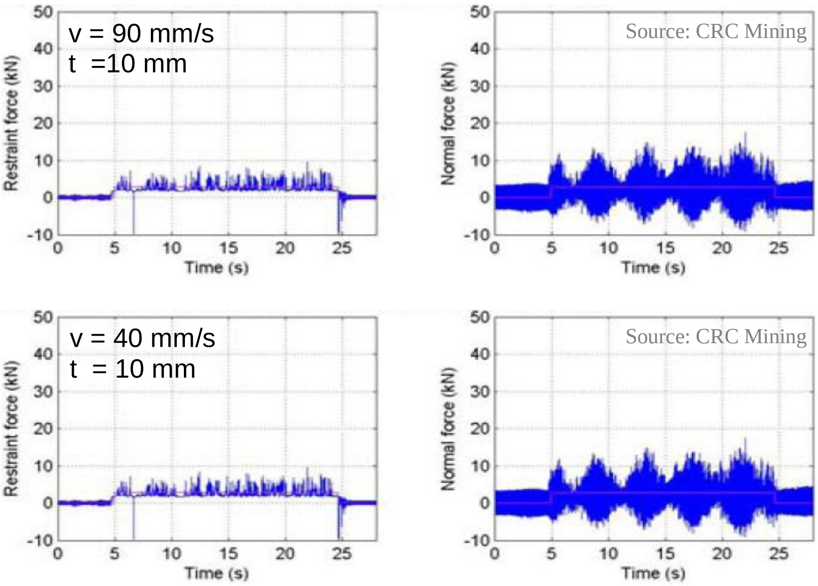

Figure 2: ODC cutting force curves

Figure 3: ODC cutting surfaces

3 Removal of reinforced concrete with cutting inserts

Since the stimulated undercutting process is only applicable to the removal of brittle materials, a different procedure is required for treating reinforced areas. In the course of this progressing project different processes with geometrically defined and undefined cutting edges were considered. Since procedures with undefined cutting edges such as dry grinding generally work but with only very little removal rates, the applicability of millers with cutting inserts were further studied. Therefore, different cutting materials and process parameters have been tested on a test bench with detection of the cutting force (figure 4).

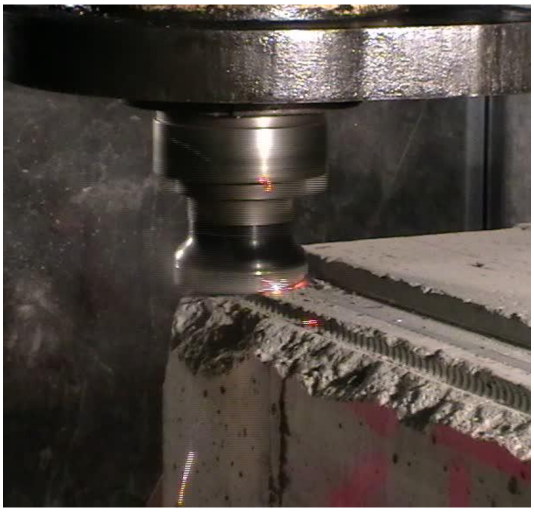

Figure 4: Ablation test bench for milling tests

First tests with the cutting materials polycrystalline diamond (PCD), ceramic, and carbide and cubic crystalline boron nitride (CBN) have shown that PCD and ceramic are unsuitable for this task. However, different carbide- and CBN materials have shown promising process reliability with normal abrasive wear behaviour. As the CBN cutting inserts showed no advantages in the lifetime compared to the carbide materials but are more expensive, the further course of the project was directed towards the group of carbide materials.

Cutting material	**Test result**
PCD	Cutting failure because of high iron reactivity
Ceramic	Cutting failure because of exceeded pulse load
Carbide	Normal abrasive wear behaviour
CBN	Normal abrasive wear behaviour

The following test series aims at identifying the optimal process parameters and configuration of carbide materials in order to achieve the longest possible tool lifetime. First tests showed the connections between tool wear and the process parameters cutting speed, feed per insert, cutting depth, and cutting force (figure 5). Furthermore, the analysis of cutting forces showed that with progressive tool wear the cutting ability of the concrete remains largely intact but process forces in steel strongly increase. Different approaches for the lifetime prolongation of the cutting tool will be tested in future experiments.

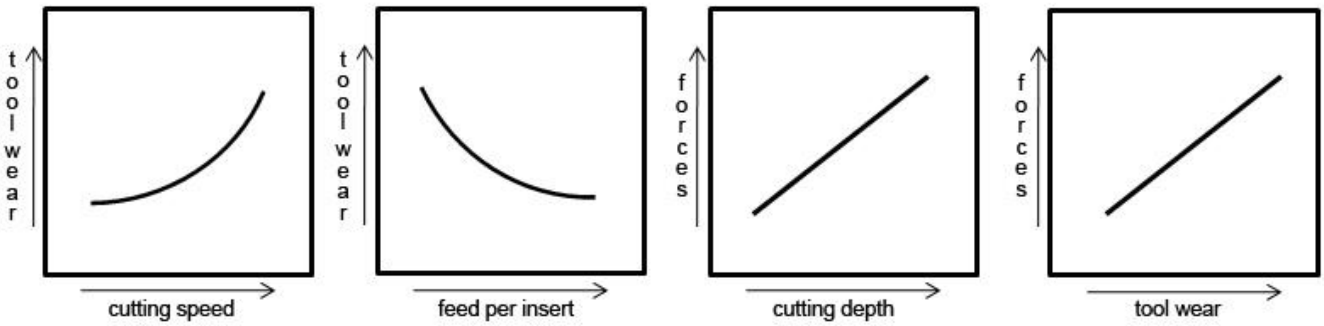

Figure 5: Connections between tool wear and process parameters

4 Combined tool concept

As soon as the analysis and improvement of the processes for the removal of concrete and reinforced areas are completed, the sub-concepts will be combined to a single tool. It is planned to create a flexible tool which can remove reinforced concrete without the necessity of a manual tool exchange. Simultaneously, the high removal rate and the low tool wear of the disc cutting process can be used when working in concrete areas. Figure 6 shows a first concept design of such an attachment for a remote controlled mini excavator.

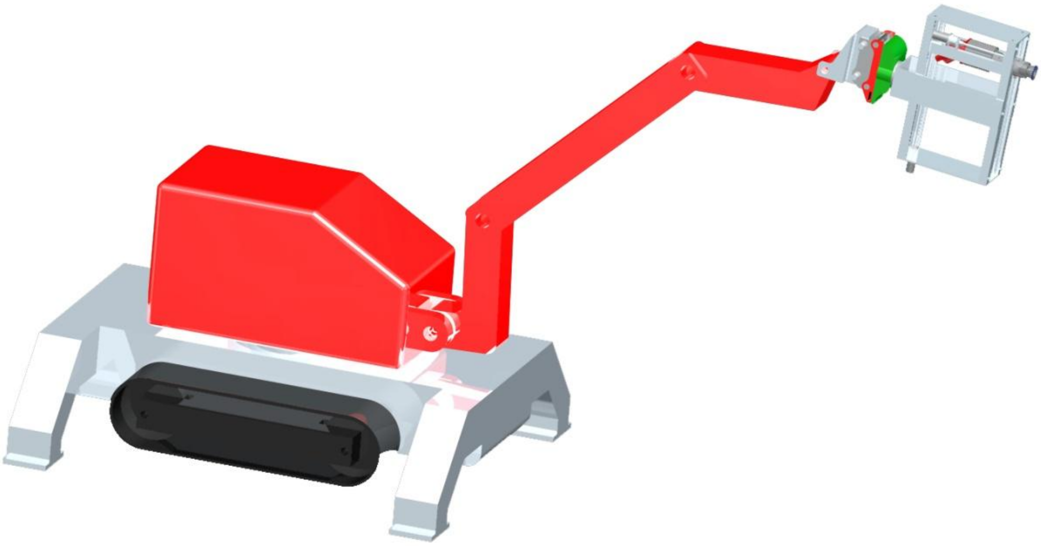

Figure 6: Removal tool concept design as attachment for a mini excavator

5 REFERENCES

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