ROBOTS REPAIR DAMAGED DRAINS

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1. Introduction

The consequences of our intensive industrial activities have become visible in a number of fields and have led to active reporting in our media which has had a decisive effect on the population's environmental conscience and calls for action.

The effects of underground damage to drains on the environment have long been underestimated.

Industry has for a number of years now been able to offer perfected inspection and test equipment for sewage systems.

The main damages which occur are cracks, damage to sockets, breakages, holes, deposits and not least damage to gulleys in the domestic sector.

There are a number of good systems on the market for the repair of whole reaches of canals. But the more frequent cases of individual, limited damage can only be repaired at great costs.

On the other hand, the KaTe robot system has a distinct advantage in the field of individual repairs since costs are only incurred here for punctual damages.

The firm of Kunststoff-Technik AG Himmler in Zurich has perfected this process up to the present production stage through development work which has been carried out since 1981. The system has been constantly improved. Not only have the everyday practical faults and weaknesses been eliminated, but they have been able to constantly adapt to technical innovations.

This patented technology has also been on offer in the FRG since 1987 through the firms of KANALTECHNIK KUNZ GMBH and Kanaltechnik Brust GmbH.

This is the only technology on the market where the adhesive base is prepared for the repair work through the use of milling heads.

Thanks to the high tenacity of the epoxy resin adhesive the load-bearing capacity and leakproofness of the pipes can be restored, even in the case of cracks, holes and breakages.

The Ka-Te system is particularly suited for the repair of branching pipe sockets.

Concrete, asbestos cement and stoneware pipes of nominal widths from DN 200 to DN 800 can be repaired with this system.

2. Procedure

In the first stage a repair plan is drawn up on the basis of a video tape of a previous TV inspection and a fixed price offer made for the robot repair. The same repair method is in principle used for all types of damage encountered.

The repair vehicle is positioned directly over the manhole on site. The operator takes his place at the control desk. He can control the movements of the milling or filling robot via a monitor. The robots are connected with the vehicle by corresponding cables.
Different sets of wheels mean that the robot's running gear can be matched to the various nominal widths and the tools can be guided along the pipe's axis.

3. Equipment

3.1 The milling robot

The milling robot is hydraulically operated from the repair vehicle and can be moved forwards and backwards with a radius of action of approx. 70 m.

In the case of smaller pipe nominal widths a pressure pad is extended on the back of the robot so that the device is firmly fixed. This avoids deviations during milling. The milling head can be rotated by approx. 540° around its longitudinal axis, in other words it can reach all points in the pipe. The milling head can be moved as close to the pipe walls as required without damaging the inner lining of the pipes by means of a radial milling head adjustment.

Precision is a basic principle of this work. The latest technology and electronics are a guarantee for this precision. The time intervals are minimised so that work can be carried out to the millimeter. An important guiding and control instrument in this connection is the CCD camera installed in the robot.

Different milling heads are used for the various types of damage and pipes.

For example:

- cylindrical millers for gulleys.
- trapezoidal groove millers for cracks.
- mushroom-shaped routers matched to the curvature of the pipes for deposits.
- bevelled cutters with cutting blades or grindstones are used for plastic pipes.
- hollow drills are used in the case of pressurized ground water in order to inject gel into the surrounding soil.

With approx. 4 HP the milling head reaches a speed of around 5,400 rpm. Only with such a power is it possible to carry out milling work with no debris. All milling tools are tipped with universal diamond heads. They are constantly sprayed with cooling water through a nozzle at the milling head to prevent overheating and soiling. In order to remove the spray, and thus ensure perfect vision, a special windscreen wiper has been installed on the lens of the camera.

3.2 The filling robot

This uses the same running gear as the milling robot but is electrically powered. A camera is also mounted here so that the robot can be remote-controlled via a monitor. A replaceable reservoir is mounted on the robot and contains a mixed epoxy resin. The filling robot has two movable arms, one of which carries an ejector nozzle connected to the reservoir via a hose, and the second of which a replaceable trowel.

The filling equipment can be adapted to the various types of pipes and damages by means of different inserts. At the same time a device to set pockets in gulley connection pieces can also be mounted or a movable nozzle for the high-pressure cleaning of soiled milled grooves.

4. Repair materials used

4.1 Mixed epoxy resin (KT-53)

This adhesive has been specially developed for conditions in drains.

The two components are already packed at the correct ratio and are mixed on site with a special mixer.

The mixing time is between 6 and 10 minutes depending on the ambient temperature. A sticky but easily applicable, homogeneous substance is produced which is then compressed in a magazine and mounted on the robot.

Epoxy resin has proven itself for canal work on account of its excellent material properties. Since it adheres just as well to wet and moist bases as to dry surfaces it can be used in the humid atmosphere always prevalent in canals with no loss in quality. The adhesive and bonding strength is not affected by the water in the pipes. Through the admixture of quartz sand the shrinkage behaviour is also very favourable. This prevents shrinkage cracks at the points of repair.

This means that a dense and stable bonding is also possible in unfavourable conditions.

Some technical data on our KT-53 epoxy filler

Modulus of elasticity	5,130 N/mm²
Material density	2.0 kg/dcm³
Material compression strength	73 N/mm²
Tensile bending strength	20 N/mm²
Tensile strength on concrete	4.4 N/mm²

Tensile strength on steel	6.8 N/mm²
Tensile strength on stoneware	4.5 N/mm²
Shearing strength on concrete B 45	3.4 N/mm²
Potlife of the material	50-75 minutes
Open time	at least 220 minutes

A few words on the environmental aspects of the material used:
The Hygiene Institute in Gelsenkirchen has tested the material for toxic effects and has declared it completely harmless.

4.2 Mixed acrylic gel

This material is necessary to stop the water flow in cases where the ground water pressure is very high. This preparatory work is carried out with the hollow drill and the gel is pressed into the soil surrounding the point of water penetration.

At present, we use the normal gel BT/2 from the firm of Rhone-Poulence. However, our process is not bound by any one product and we can use other liquid materials with suitable properties.

The advantage of the gel BT/2 is the quick reaction time of between 4 and 12 seconds.

5. Method

5.1 Repair principle

Unlike processes which use compressed PU or acrylic gels, the Ka-Te system at first mills the corresponding point of damage and cleans this with high-pressure. The existing layer of grease is thus removed once and for all and the base is prepared for filling by the epoxy resin.

The conical shape of the milling heads creates an externally tapering milled groove approx. 2-3 cm wide and deep. This allows a uniform filling of the groove.

The epoxy resin is pressed into the milled groove through a hose and ejector nozzle at up to 8 bar.

The trowel required for smoothing is mounted behind the ejector nozzle and thus leaves a clear view of the area to be filled.

The CCD camera is mounted correspondingly close to the lining of the pipe directly at the point of work.
All work can be supervised and corrected at the monitor and control desk.
The adjustment of the robot along the pipe's axis permits a precise execution of all processes.

Uncontrolled injections through large-scale shutterings are excluded.

5.2 Repairing cracks

Part of the pipe is damaged, the video camera has clearly shown the longitudinal and transverse cracks. The milling robot follows the lines of the cracks and mills them completely. The point of damage is hereby initially cleaned and an adequate base for adhesion created. A high-pressure steam device with a maximum spray pressure of 150 bar is used for subsequent fine cleaning. The filling robot now comes into action. Controlled via the monitor it fills the previously routed cracks inasmuch as a nozzle arm is laid over the crack and the filler material is pressed into the milled groove. The surface is then smoothed with a trowel so that the profile is almost completely free of furrows. This repair method leads to the restoration of a statically portative pipe without - and this is the great advantage here - narrowing the cross-section of the pipe.

5.3 Repairing sockets

The procedure is the same: milling, cleaning, lining with filler.
At the same time any possible pipe offsets can be corrected so that the throughflow is improved.

5.4 Repairing fragments and blow-outs

Breakages are in principle treated the same way as longitudinal and transverse cracks. However, it is recommended that the procedure be carried out in steps so as to avoid the loosening and loss of any fragments. If necessary the open space can be closed with filler and epoxy resin.

5.5 Repairing pipe unions

There are two types of pipe unions: protruding and recessed. Protruding pipe unions are milled flush with the pipe so that the flow hindrance is removed. To ensure that the filler can adhere cleanly the layer of grease at the bedding of the junction must be removed with the miller. The pipe union is then lined and sealed so that infiltration or exfiltration is no longer possible.

Recessed pipe unions are more complicated: once the point of breakage has been milled a special pocket which protrudes into the connection piece is inserted, fastened there and covered with filler. Once the filler has set, which usually takes around 8 hours, the pocket and excess material are removed. A moulded joint must be made from the existing filler which adheres well to the connection piece.

5.6 Deposits

Stubborn furring in all thicknesses or betonite suspensions which have inadvertantly been let into the system must be cleaned with the mushroom-shaped router without damaging the pipe walls. Filling work is generally not necessary.

5.7 Root growths

Root growths are possible in longitudinal and transverse cracks and in socket connections. The roots are scraped out to a milling depth of 2 to 3.5 cm. The cavity is lined, the filler left too set for around 8 hours, and roots can no then no longer grow there.

The question of environmental compatibility also arises here. The epoxy resin comes into contact with the root. However, results of microbiological tests have shown that this has no negative microbiological or phytotoxic effects on the plants.

5.8 Water irruptions

If outside water has entered the pipeline at a point of damage it must first be provisionally sealed with hydrogel. This removes the water pressure which could have a negative effect on the fresh filling material. In detail: a diamond-tipped hollow drill is mounted on the robot's milling head which penetrates the pipe at the fault from the inside to the out. The mixed hydrogel is then pressed into the soil surrounding the pipeline at a pressure of 0 to 15 bar. This forms an impervious coating around the leak and stops the external pressure from ground and external water. The gel is hydraulically pumped into the drain from the operating vehicle. Since it hardens in seconds no more water can penetrate the system. Following this provisional sealing the actual repair is carried out in the manner already described: milling, cleaning, filling. Should the hydrogel shrink or be washed away by flowing ground water the hardened filling material has long taken over the sealing function of the gel.

6. Additional possibilties / Further developments

6.1 Explosion protection

It may be necessary to increase the protection against sparks during milling. The question of explosion protection is an important one in the case of ducts carrying various chemical substances.

An additional piece of equipment for the KaTe milling robot offers extra protection here.

The milling head itself is surrounded by a radially ejected film of water. This seals the contact surface between the pipe and the milling head. If nitrogen is blown into the resulting cavity sparks are practically eliminated. Additional bulkheads are provided before and behind the milling robot.

6.2 Optimisation of the procedure

No repair system can claim to be the best and most economical for all damages which occur in sewage systems.

It would appear obvious that technically equivalent processes should be combined.

A practically tested solution should be mentioned here:
In the case of a heavily damaged drain with a number of domestic connections a tube relining was employed. The punctual excavation of the house connection area was impossible for a number of reasons. The KaTe robot system was used for repairs here.

The method:
The corresponding gulleys were flush milled and measured before the tube relining. Once the tube had hardened this was cut open, milled and the normal KaTe gulley repair work carried out. The joint between the tube material and mixed adhesive was, as expected, very good.

7. Summary

As this report has shown, this repair method can be used for many different types of work and is thus very flexible. The main advantage here, however, is the possibility of a punctual, specific repair. Faults can be remedied from the start with no large subsequent damage - and at a low cost.

An optimum repair alternative for towns, communities, joint authorities and companies. Urgent repairs can be carried out quickly and lastingly and the load-bearing capacity of the section of the drain can be restored. Once the repair has been completed this can be checked and accepted via a TV camera - naturally in the presence of the principal.

The procedure is usually suitable for leaks provided the pipe material is still strong enough. However, more extensive work - such as full-surface coatings or linings - cannot be carried out with the KaTe system.

One can summarise the advantages as follows:

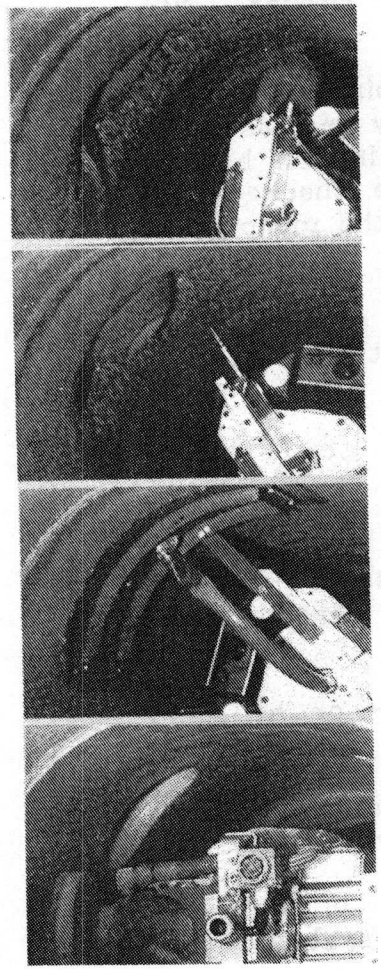
No excavation work is required for the system, traffic is not impaired. Working hours and costs are saved. The environmental load through noise and toxic chemicals is eliminated. The whole cross-section of the drain is retained and its impermeability and load-bearing capacity restored.

The prospects for this procedure of punctual repairs - or as also mentioned - the repair of whole systems, are promising.

Through the additional use of the small robot for drains of 200 mm diameter around 90 % of all public sewage systems can be recorded in this year.

Extensive references confirm the quality of the KaTe robot system.

Zurückversetzte Einläufe:
Perfekt angeschlossen.



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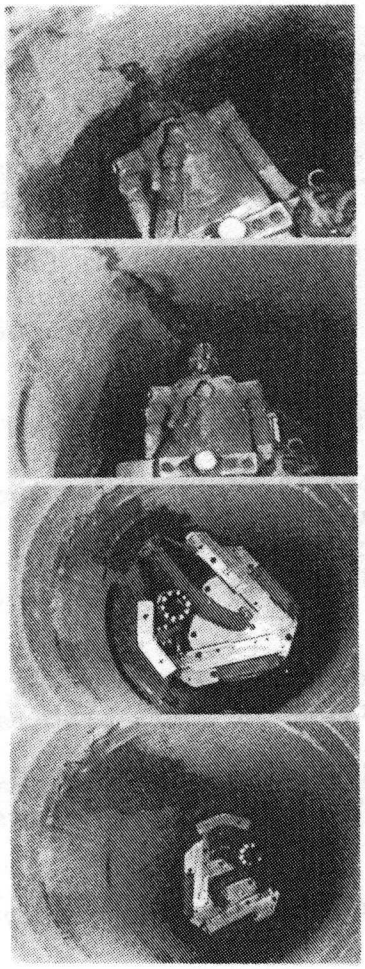

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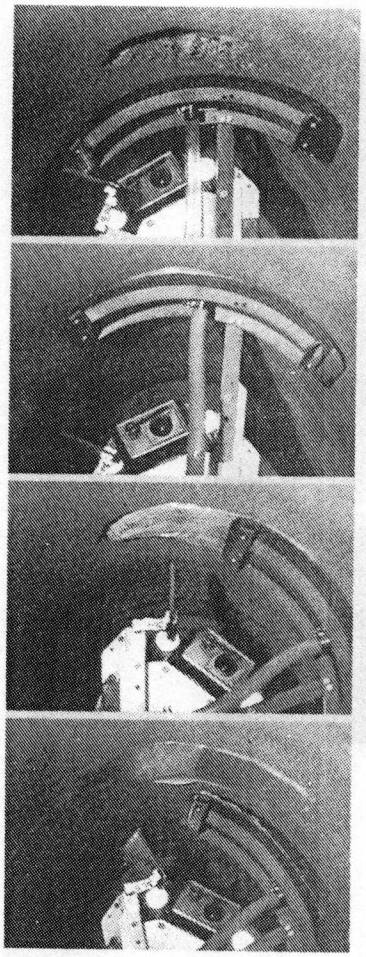
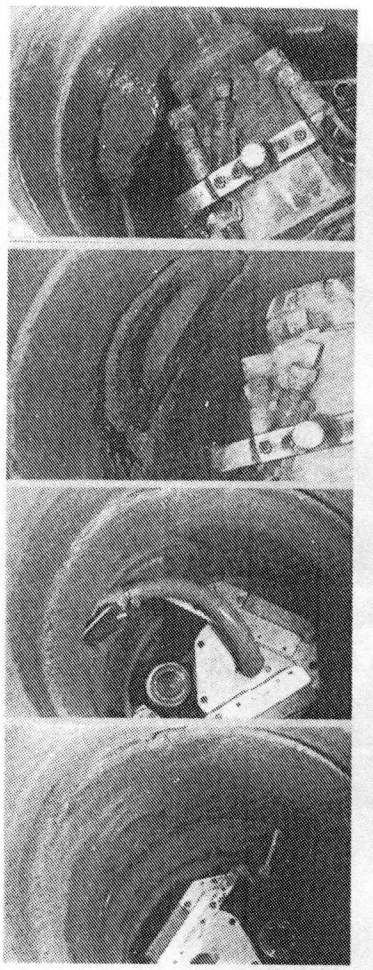
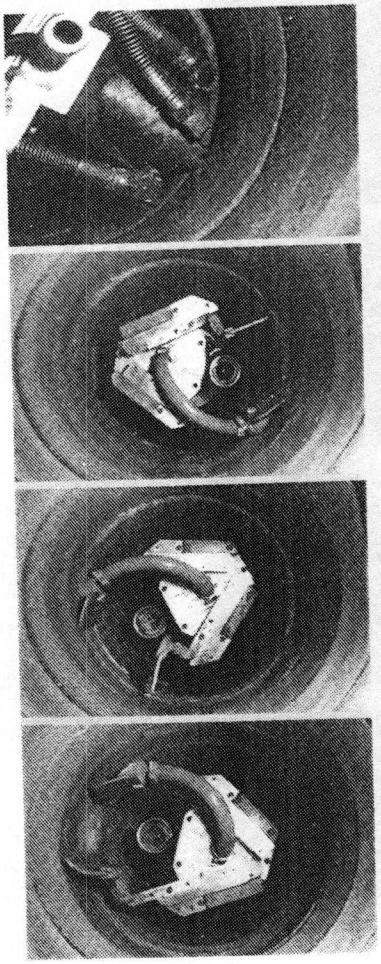




Muffen-Sanierung



Exklusiv:
2-fach-Abdichtung