Projektinfo **04**/2014

Detailed information on energy research

Swift construction of pipelines

Method developed for the environmentally friendly installation of pipelines longer than one kilometre in length

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The laying of pipes, for example for heating networks, has previously been a labour intensive and time consuming occupation. With the newly developed "Pipe Express" method, a special tunnel boring machine drills through the ground at speeds of up to 1.2 metres per minute and conveys the soil directly to the surface instead of displacing it sideways. At the same time, the steel or concrete pipe is inserted into the horizontal borehole. In comparison with the open cut method, the process requires less than a fifth of the normal trench width and can also be used without lowering the groundwater level.

In future, an even greater role will be played by geothermal power plants that are to be integrated into the heating supply for urban settlements. The need for underground lines is therefore also growing. However, the increasing pressure to shorten construction times demands methods that enable a high installation rate and require less space. Environmental provisions can also impose extra burdens on a construction project, since the near-surface installation of pipelines in excavated trenches usually causes a considerable impact on the environment. The consequences are often still visible even after many years and elaborate restoration of the landscape. Corridors which are often more than 50 metres in width are created along the entire length of the pipeline route for digging trenches, temporarily storing soil, as well as transporting and storing materials.

This research project has been funded by the

Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU)

As part of the “Pipe Express” project funded by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, Herrenknecht AG has developed a method that makes the costly digging of trenches unnecessary and thus enables quicker and more environmentally friendly connections to, for example, remote heating customers. The system developed (Fig. 1) essentially consists of three parts. The system is remotely controlled and monitored from an operator vehicle. Meanwhile, an excavator unit loosens the ground and conveys it directly to the surface. At the same time, an anchored jacking unit called a pipe thruster provides the required thrust that simultaneously pushes the pipeline into the horizontal borehole.

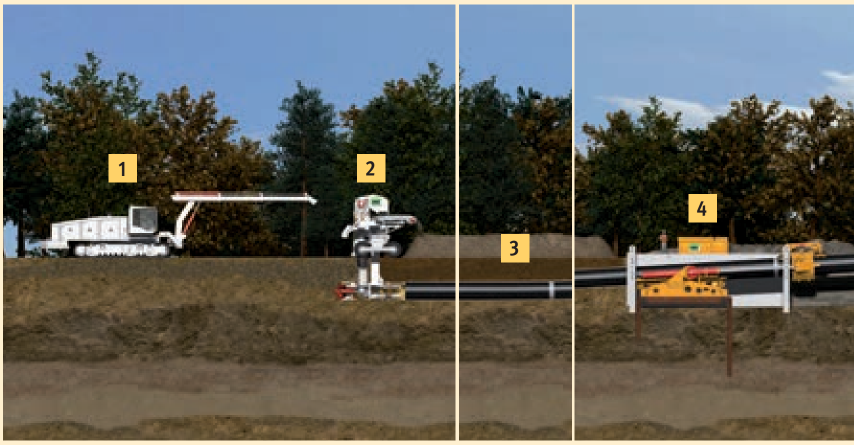

Fig. 1 *The operator vehicle (1) controls and monitors the system. The excavator unit (2) loosens the ground and conveys it directly to the surface. The pipe thruster (4) simultaneously pushes the pipeline (3) into the borehole.*

Milling and transfer of the subsoil to the surface

The excavator unit (Fig. 2), which is also known as a tunnel boring machine (TBM), includes a cutterhead, combined milling unit and screw conveyor, and steering joint. The milling unit both mills a narrow trench along the route and transfers the excavated material from the tunnel directly to the ground surface. Trough-shaped scoops are attached to the chain links of the milling unit, which can be fitted with different excavation tools in accordance with the terrain. The chain’s circulation and the thrust provided by the pipe feeding system enable the milling unit to loosen the ground where the jacking takes place at the tunnel face. Oversized rocks that are bigger than the scoops are crushed by the excavation tools on a specially designed crusher edge until it is possible to remove them. The filled scoops are emptied using the deflective speed of the milling chain, whereby in order to achieve this the rotational speed of the milling chain must be high enough so that the excavated soil is thrown out of the scoops on reaching the top of the milling unit. The soil then lands in a heap on a conveyor belt, which transfers the soil away from the excavator unit. This conveyor belt can be pivoted outwards across a range of ± 90 degrees in the opposite direction from the jacking direction, which enables the excavated material to be dumped directly into or adjacent to the trench formed behind the excavator unit.

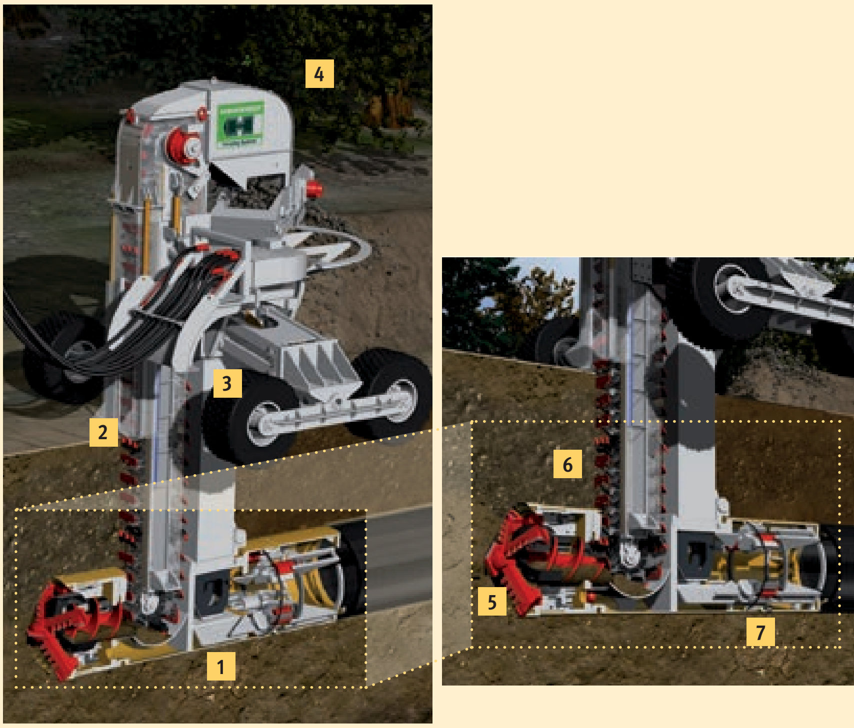

Fig. 2 *The excavator unit consists of a tunnel boring machine (TBM) (1), milling unit (2) with buggy (3) and conveyor belt (4). The cutterhead (5) loosens the ground and transports it via the screw conveyor (6) to the milling unit. The steering cylinders (7) are connected with the machine pipe.*

Remote-controlled operation

The operator vehicle accompanies the excavator unit along the pipeline. From the vehicle, the driver controls and monitors the whole system. The excavator unit is connected to the operator vehicle via an energy chain. This enables the system to be supplied with the required electrical, hydraulic and pneumatic power, as well as operating materials such as grease and bentonite. The energy chain is guided and held by means of a hydraulically telescoping loading arm. During the installation, the vehicle initially remains in one position and controls the height, speed and other logistical parameters. When the pipe thruster (Fig. 4) begins to reset the clamping unit every five metres, the jacking is briefly interrupted and the operator moves the vehicle forward by another increment length and extends the load arm again.

Deployment of Pipe Express

The Pipe Express method is designed for the installation of near-surface steel or concrete pipes. The pipelines can be used for transferring district heating, communications and data cables, power cables, oil, gas and water.

“Pipe Express can be used in various soil conditions, ranging from sand and clay to gravel soils,” explains Boris Jung, project manager in the research and development department at Herrenknecht AG. The small amount of space required also enables the method to be used in inhabited areas. The significantly narrower pipeline width reduces the earthwork to a minimum. It is not necessary to lower the groundwater level. “We also see considerable potential for laying pipelines in open terrain,” adds Jung.
Extensive testing in Schwanau near Offenburg has shown that it is even possible to cut through asphalt or concrete surfaces. The Pipe Express technology can even be used without previously cutting channels in the road. However, the parts wear out considerably quicker compared with normal soils. In addition to straight lines, curves can also be easily traversed. The

Fig. 3 *The excavated subsoil is transferred directly to the surface.*

Fig. 4 *With up to 750 tonnes of thrust, the so-called pipe thruster lays the pipelines into the horizontally drilled borehole at five-metre increments.*

radii are derived from the predetermined diameter and the wall thickness of the pipe.

Energy and financial advantages

The Pipe Express method eliminates many of the preparatory measures used by the open laying method, such as the trenching, or reduces them to a minimum, including the width of the pipeline route and the subsequent return to nature. It also requires less fuel, which in addition to the costs for purchasing machinery also has an additional, not insignificant economic impact. When installing the pipes, only the tunnel boring machine itself and the pipe thruster (pipe feeding system) is supplied with power. This means that the energy supply is limited to the necessary equipment.

Laying pipelines mechanically

The cross-country construction of pipelines has always been very labour intensive, with up to 200 specialists deployed at every construction site. First of all, the pipeline route is prepared – for this purpose, openings need to be cut through forests or cultivated fields crossed, whereby construction roads have to be built, bridges constructed over streams for construction vehicles and trees clad with protective jackets to shield them from excavators. The topsoil is then removed with bulldozers and the pipes to be installed are laid out and – if necessary – pipe sections bent on site. Before laying the pipes, roughly 500 metre long sections are welded together and the weld seams tested. Before workers secure the connection points with plastic, auditing companies once again examine the seams with ultrasound and x-ray methods. Excavators then dig out the installation trenches. Several caterpillar pipelayers, which are positioned at distances of about 25 metres, then lift the welded pipeline into the trench. This is then backfilled and renaturalised.

Dutch reference project

After the developers conducted initial test drilling in Schwanau during the first year, the new machine technology was able to be used at the end of 2012 in its first reference project, the “North-South gas pipeline” in Sevenum (Limburg Province) in the Netherlands. “The technology has surpassed all our expectations,” says a satisfied Boris Jung and reports that the system managed to lay 500 metres of pipeline in three days. This formed part of the 66-kilometre-long gas pipeline from Odiliapeel to Melick. This transport pipeline has a diameter of about 1.22 metres. The sandy soil loosened easily so that performance rates of 1.2 metres per minute were achieved. The technology allows for deviations of ± 1 m above or below the nominal laying depth of roughly 1.5 metres, which enables unevenness in the terrain surface to be efficiently balanced out. The machine used can degrade and transfer grain diameters of up to 200 millimetres. “That roughly corresponds to the size of a football,” says the proud project manager.
With the experience gained, the developers now want to further improve the system. In addition to constructing a self-propelled surface vehicle for supplying energy to the drilling and milling unit, it is also planned to place the milling unit on a caterpillar vehicle, which will minimise the ground pressure. The engineers also see further potential for optimisation in regards to lubricating the pipe string.

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Laying trenchless district heating pipelines

When laying district heating, gas and water pipes as well as electricity cables, the trenchless jacking of pipes is already a well-developed technique.
The district heating pipe most used for distributing heat, the plastic sleeve pipe, uses soil friction forces for restricting expansion under operating loads. Until now no reliable information has been available on the friction forces that are applied to the sheaths of plastic sleeve pipes over a 30-year service life following the trenchless installation. As part of the "Innovative district heating distribution" research project, researchers are investigating the possibilities and limitations provided by trenchless laying techniques in district heating pipeline construction. Various trenchless methods have been tested by scientists from the AGFW (German Energy Efficiency Association for Heating, Cooling and Cogeneration) and a research consortium. In the spring of 2013, they laid ten district heating pipelines and are investigating practical experience in the industry in using, for example, horizontal directional drilling (HDD) for district heating pipes. With this method, an underground channel is drilled in which the pipe can be inserted. If smaller district heating pipes are to be laid, for example to house connections, so-called earth piecing also offers advantages. To use this technology, launch and target pits have to be excavated. Using sighting optics, the target point is located from the launch pit. Compressed air is shot through the soil displacement hammer, which creates the desired cavity. This technology can be used for all kinds of pipes. In particular, this method has been successfully used many times for flexible district heating pipes and steel casing pipes. The aim is to develop the necessary basic knowledge for using these procedures in district heating, to therefore reduce the existing barriers for rigid plastic sleeve pipes and thus enable trenchless installation technology to be applied on a wide scale in district heating pipeline construction.
The German Federal Ministry of Economics and Energy is funding the project as part of the EnEff:Wärme initiative until mid-2015. The research project is being conducted by research institutes and experts from the district heating and trenchless pipeline construction fields. The participants want to continue evaluating the load-bearing behaviour of plastic sleeve pipes laid using trenchless installation together with investigations of the construction technology and pipe structural loading. In field and laboratory experiments they are studying the frictional behaviour, soil-bentonite mixtures and wear protection.

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Links and literature

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- http://www.eneff-stadt.info/en – category „Heating/cooling networks“
- Video on the Pipe Express process: http://www.youtube.com/watch?v=fEb2vE2fNCI
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