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Robot production of formwork for the manufacture of precast elements with complex shape

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For the Swiss manufacturer Filigran Bauelemente AG, one-off production is no longer a problem, not even for precast elements with complex shapes. A six-axis robot quickly mills negative forms from various materials, with high precision and cost efficiency – including the drainage channels of manhole bases and slender building elements for restoration of architectural-heritage buildings. The next development steps are application of industrial waxes for the formwork and order of custom-made precast elements by smartphone app and delivery within a few hours.

For Filigran Bauelemente AG, flexibility in production is a must in two of the company's business areas. In underground construction, the manhole bases with their often complex drainage channels are individually manufactured. In building construction, Filigran, a medium-sized company, manufactures, among other products, slender building elements for restoration of existing historic buildings, e.g. finely decorated capitals of columns.

In both business areas, one-off productions are the order of the day. The forms are especially made for the respective precast elements and can in most cases be used only once. Manual form building is too expensive, which is one of the reasons why it is not considered as a possibility.

Conversion of form building to automated robot production

For that reason, Markus Hirschi, Owner and Managing Director of Filigran Bauelemente AG, already some time ago converted form building to automated robot production. Apart from cost savings, two additional factors were decisive for the decision: the robot mills the negative forms out of a blank made of the respectively chosen material (EPS, wood, plastics) down to the millimeter and with the highest precision. This, again, ensures that the end product manufactured with help of this form is of the highest possible quality. And, finally, the use of the robot solves a problem with which probably all precasters are nowadays confronted, i.e., the problem of the

Fig. 1: The control of the six-axis industrial robot was programmed by B+S Engineering GmbH, based in the German city of Rheine.

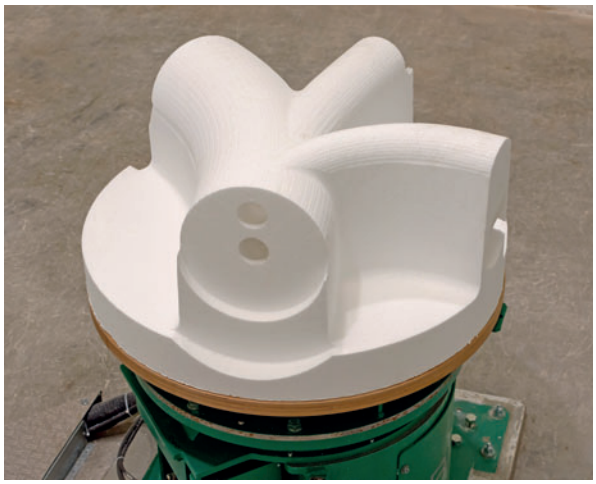


Fig. 2a: Negative form made of polystyrene for the individually designed drainage channel of a manhole base

Fig. 2b: The completed manhole base with the specified drainage channel, the counterpart of the negative form made of polystyrene (compare Fig. 2a)

Fig. 3: Increasingly stronger in demand, especially by architects and producible by robot: building elements of complex shape, such as this capital of a classical column

difficulty of finding qualified, specialized workers – in this case, for the undeniably very demanding process of form building. In the production hall of Filigran Bauelemente AG in the Swiss municipality of Oberdiessbach, located around 25 km from Bern, there now stands a PECO-system from B+S Engineering GmbH. The company is based in the German city of Rheine. Filigran Bauelemente AG markets the precast elements produced with this system to its customers under the catchy brand name of Modellit.

The hardware of the B+S Peco-system includes a robot with a milling tool fixed in front onto its arm, a turntable for the blank to be processed, and from which the negative form is milled, as well as a control panel with visualization display. But the heart of the system is the software developed by B+S Engineering for controlling production of the forms.

Creating a 3D model with the configurator

The first step in production, for example, of a manhole base with the Peco-system is creation of the individual negative form of the drainage channel of the manhole base. This negative form is later fixed onto the core of the steel form for the manhole base and serves as blockout body, embedded in concrete during casting and ensures that the hardened manhole base is fitted with the required drainage channel.

In the first step, on the computer, the geometric parameters of the entire precast element and the drainage channel are entered in the so-called manhole configurator, a software tool for data collection and processing. Via an interface, programmed by B+S Engineering GmbH, basic parameters such as the external and internal diameters of the manhole base, wall thickness, diameter and position of the pipe connections etc. can be directly taken over from the ERP system of the precaster. The input mask of the manhole configurator is then already largely filled and the operator needs now only to add a few data manually. Alternatively to data import from the ERP system and to manual input, it is also possible to import the already completed 3D drawings into the manhole configurator.

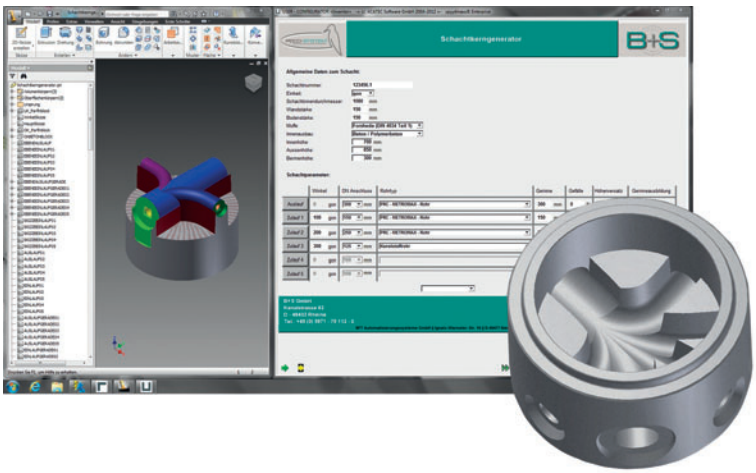


Fig. 4: The manhole configurator, a software tool from B+S Engineering GmbH, generates from geometric data the models of the blockout bodies for the negative form for the drainage channel and the manhole base. The data are entered manually, taken over from the ERP system or a completed 3D drawing.

Once all parameters have been entered, the configurator then computes from them the geometry of the manhole base and the negative form of the drainage channel and generates the respective 3D models. The software subdivides large negative forms and/or blockout bodies, which the robot is unable to mill in one step, into several individual parts – e.g., into main drainage channel and connections for the pipe inlet and the pipe outlet. Subsequently, the robot mills from several blanks consecutive parts. At the end of this step, it is once again possible to reassemble the individual parts to a single blockout body.

The computer passes on the data for production of the negative form to the milling robot, the printer and other interfaces. In addition, the data and the 3D model are likewise displayed to the operator on the visualization display of the Peco-system. During production, the 3D model moreover assists the operator in simplified real-time control.

High-precision milling of the form

In the next production step, a rectangular blank, already cut to the required size, is fixed to the turntable opposite the milling robot. In this example from this blank, the negative form for the drainage channel is milled in one piece.

At Filigran Bauelemente AG, blanks up to a maximum edge length of 2,000 mm can be processed. As material for the blanks, the Swiss company uses Sagex (expanded polystyrene foam), but the blanks can also be processed from other materials such as wood or various plastics. B+S Engineering GmbH moreover, in collaboration with the Technical University of Braunschweig, has investigated the use of industrial waxes for manufacture of negative forms. The use of industrial waxes has one decisive advantage in the sense of sustainable life-cycle management: in that the form/the wax can be reused at the workstation. This will be possible in the near future as a step in the further development of the Peco-system – at that time, possibly also by Filigran Bauelemente AG in Switzerland.

The robot now mills precisely in accordance with the drawings generated by the computer: initially, to form from the rectangular blank a cylindrical body with exactly the diameter that corresponds to the inside diameter of the manhole to be manufactured (alternatively, a cylindrical blank could be used instead of a rectangular blank. This however, paradoxically, would involve additional costs). Subsequently, the oblong milling tool at the head of the robot arm takes off Sagex material millimeter by millimeter from the cylindrical blank and in this manner mills out the desired form of the drainage channel.

Owing to the six axes, the robot is able to position the milling tool fixed to the very front end of the arm into any desired position. In combination with the turntable, the blank can be processed in all dimensions.

Fig. 5: The operator at the control desk scans the job order with QR code generated and printed out by the manhole configurator with a handheld scanner and in this way passes on the required production data to the control of the processing station of the B+S Peco-system.

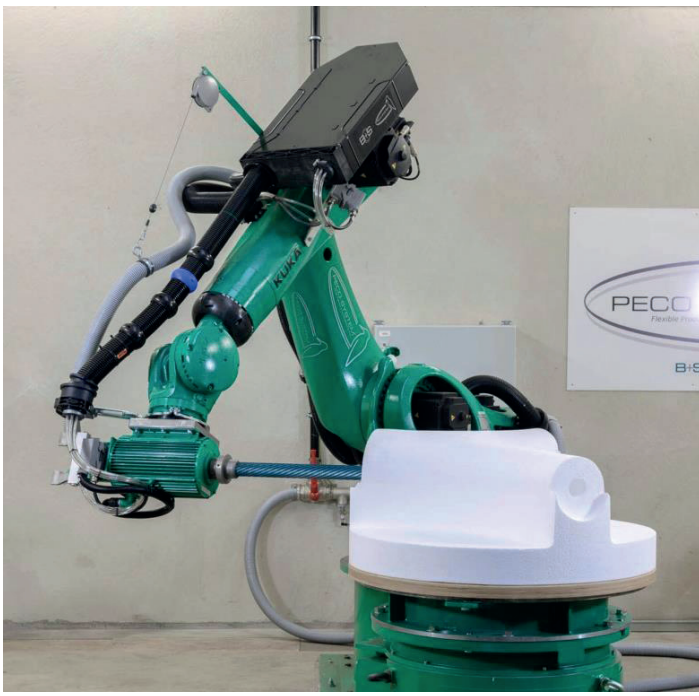


Fig. 6: Onto the arm of the robot a tool is fixed for milling to millimeter precision the workpiece made of Sagex (expanded polystyrene foam), wood or other plastics for producing the negative forms. Tool change is fully automatic.

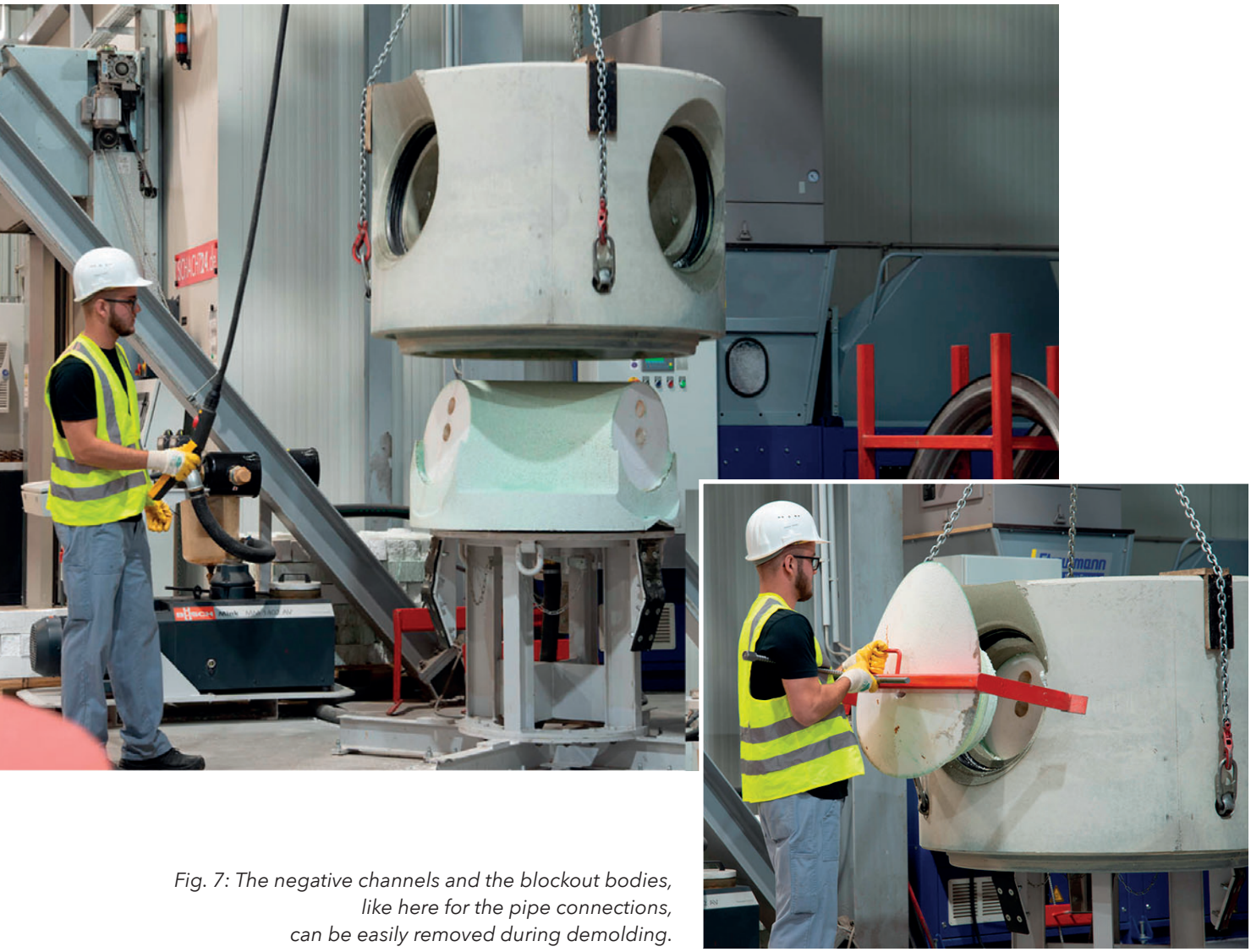


Fig. 7: The negative channels and the blockout bodies, like here for the pipe connections, can be easily removed during demolding.

A change of tool – e.g. when a finer milling tool with smaller diameter must be used – the Peco-system is also able to a utonomously carry out in accordance with the specified production parameters, without requiring the operator to intervene.

The three-dimensional negative form for the drainage channel of a one-off, made-to-order manhole component is manufactured within a minimum of time.

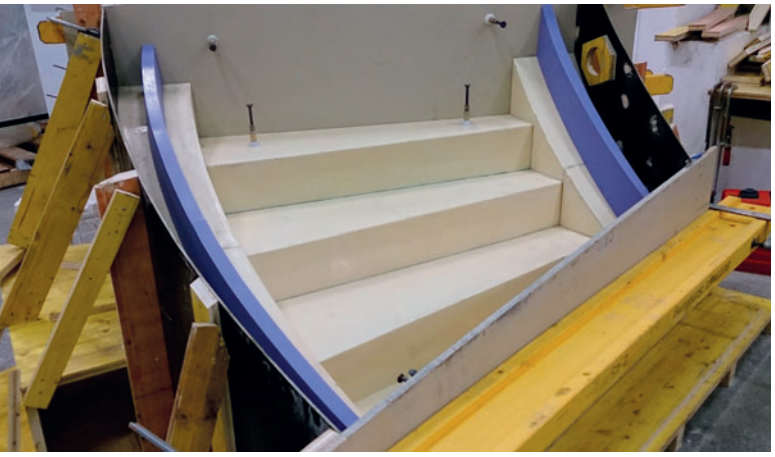
This negative form, as already indicated, is fixed as blockout body to the core of the steel form for the manhole base, and during concreting is secured against buoyancy. Following concreting and after hardening, the jacket of the steel form is opened and with the help of a hall crane the manhole base, that has been concreted overhead, is lifted out of the steel form (for that purpose lifting anchors have been cast into the concrete body of the manhole base). The EPS blockout body for the drainage channel is now located on the underside of the manhole base suspended from the hall crane and is pulled off the precast concrete element utilizing a vacuum cup. Finally, only the manhole base with the drainage channel formed in it is suspended from the crane. The channel is now so precisely formed that reworking is virtually unnecessary.

Ordered by WhatsApp, produced and delivered within a few hours

Filigran Bauelemente AG uses the Peco- and/or Modellit-system not only for manufacture of negative forms for production of manhole bases. One business area that, according to Managing Director Markus Hirschi, is enjoying growing demand from architects and planners, is the manufacture of building elements of complex shape, as frequently required for restoration in historic preservation projects (see Figs. 3, 8a+b). Normally, the extremely complex building of forms in manufacture will considerably raise the cost for the end product and more often than not exceeds the available budget. For elements with highly complex structures, such as finely decorated columns, manual form building is virtually impossible.

Figs. 8a+b: Part of formwork made of polyurethane foam for a fountain in the English garden in Interlaken …

… and the completely assembled fountain installation



Figs. 9a+b: Individually manufactured formwork made of Sagex (expanded polystyrene foam) …

… and the completed stair

The Peco milling robot in contrast, which operates with the highest precision in all dimensions, manufactures forms such as these with ease. One-off products are therefore no longer a problem in this business area.

Hirschi's vision of an automated production process extends beyond the measures that were so far already implemented. His company works on the development of an app that will further speed up the production process of manholes. In future, one worker on the construction site will take a photo of a damaged manhole element with a smartphone. Based on the photo, the app, with the smartphone, will generate the required drawings for the replacement manhole. These drawings will then be transmitted to production at Filigran Bauelemente by WhatsApp, e-mail or SMS. And the newly produced manhole element will arrive at the construction site within a few hours – that would mean time savings of several days. ■

FURTHER INFORMATION

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