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Automatically sealing construction components by robot

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Industrial construction methods enable work processes to be streamlined for increased cost efficiency, quality and productivity. Industrial prefabrication has become well established in concrete and timber construction processes but, unlike vehicle manufacturing, the area of sealing has not (yet) been integrated into such methods. B.T. innovation GmbH and Fraunhofer Institute for Factory Operation and Automation IFF have collaborated in developing an automated component sealing system using industrial robots that can be integrated into the production of modular houses and prefabricated components. The automation for the sealing process developed in their PrefabElast cooperation project can also be implemented and exploited practically in intermediate steps in production facilities.

Sealing joints between different construction elements with joint sealants is carried out under greatly changing local weather conditions on construction sites. Automation of the sealing process under defined conditions is possible by shifting this type of sealing operation to prefabrication lines in module and precast production facilities. Automated component sealing for house and concrete construction modules with joint sealants using 6-axis industrial robots was developed, implemented and validated as part of the PrefabElast cooperative project between BT innovation and Fraunhofer IFF with a view to enhancing the vertical integration of manufacturing in module and precast production facilities. The project included the development of both the sealant and equipment with suitable application technology and process chain for automated production. The consistently high quality and precision of automated sealant application by robot enables the process to be employed in manufacturing construction components industrially.

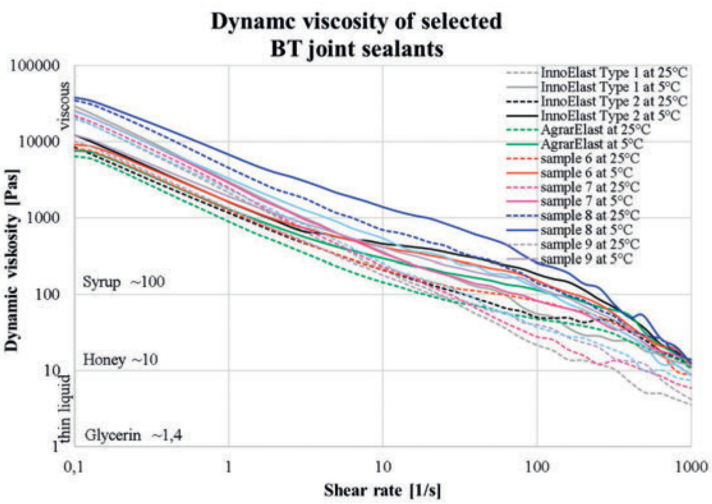

Fig. 1: Typical dynamic viscosity curves of some BT joint sealants

Figs. 2, 3: Stability of fresh sealant pastes in joint U profiles according to ISO 7390

Joint Sealants

BT innovation joint sealants are products found in classic façade and basement sealing operations (InnoElast® product range) and are used intensively in the agricultural sector (AgrarElast) as well. These and new joint sealants were further developed in terms of their properties and suitability for automated machine processing. Their application technique was also adapted to the new process. The sealant paste dynamic viscosity curve, which is important for machine processing, is illustrated in Figure 1 at different shear rates for some of the joint sealants suitable for automation. The pastes were shear-thinning, so they could be easily delivered by machine and utilised for reproducible material applications. At the same time, these fresh sealant pastes possessed very high stability according to ISO 7390. The fresh sealant pastes are therefore very stable after joint filling and processing.

Sealant adhesion was tested on concrete, (softwood) timber and steel. The sealants exhibited very good adhesion to all three surfaces in the adhesion pull test. They can therefore be employed to seal joints between all three material surfaces. A welcome side effect: the automation of sealant application can thus also be applied to construction components and in modular houses made of all three materials, i.e. in houses and structures made of concrete, wood and steel.

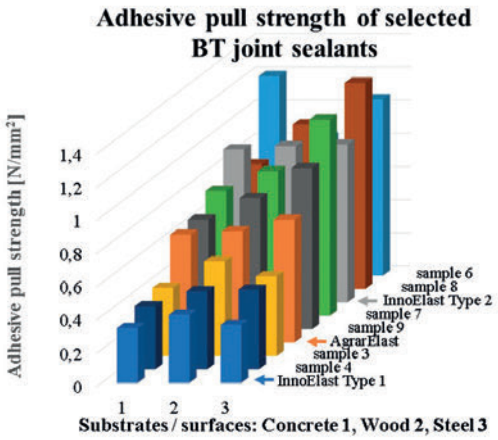

Fig. 4: Adhesive pull strengths of the sealants with concrete, wood and steel at 23°C

Application System

Requirements for the sealant application system were adapted to the production stages of manufacturers in the field of modular construction with concrete, wood, composite materials and metal in Germany, Europe and the USA. Stationary gantry systems and mobile systems with position detection were identified as suitable system concepts for processing sealants automatically.

The actual sealant application was carried out at Fraunhofer IFF by a Fanuc Arc Mate 100iD robot in human-machine interaction. It was possible to equip the robot with an electric or, alternatively, a pneumatic sealant dispensing gun using tubu-

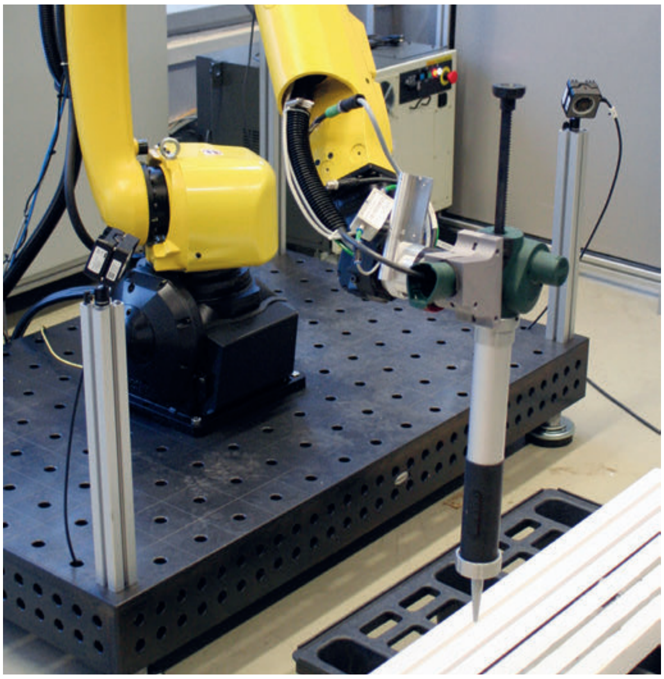

Fig. 5: The robot practices sealing on a jointing board

Fig. 6: Automated joint sealing on a construction component using a 6-axis robot

lar bags, which had previously been converted for automatic use. The course of new sealing joints was programmed for the robot by means of a teaching procedure. An input device especially developed by Fraunhofer IFF can be employed for future applications to simplify the intuitive programming of the robot's paths. The joints were measured by laser scanner for metering the sealant prior to being filled with the same. This allows the exact position of the joints and the ideal process parameters to be determined. The robot was first trained on a jointing board with this self-learning or self-optimising system.

It was possible to optimise the application technique by varying the sealant application and nozzle geometry to such an extent that process tools for pressing, smoothing or taping joint edges could initially be dispensed with. Nevertheless, automatic smoothing with a jointing rubber followed by stripping off excess sealant is easy to implement as an additional automated work stage. Entire components were in the end able to be sealed automatically after a few training cycles of the robot with different processing parameters. This automated joint sealing manufacturing process was able to be monitored and documented with the self-learning system during this time. The automated application of the sealant was carried out by robot with constant quality and high precision.

Component joints can be safely sealed in series with sealants from 600 ml tubular bags with the set-up chosen. Larger work breaks between sealing stages are possible without protective pastes for machine components.

A substantial reduction in set-up times is possible by changing from tubular bags to 20 l buckets when processing BT

Fig. 7: The precision Monoflow gear 20 metering unit made by TSI is especially designed for processing single-component sealants from 20 litre containers [www.misch-und-dosiertechnik.de]

sealants. These container sizes are available for InnoElast and AgrarElast products. BT sealants can be dispensed from 20 litre containers in automated processing work using suitable sealant metering equipment supplied by the manufacturers: TSI or Dopag / Hilger und Kern. The considerable reduction in set-up time associated with changing containers from tubular bags to buckets allows the automation speed to be increased. The metering units can be integrated into the robotics with systems for joint detection and automatic control. It is also optionally possible to process the sealants with metering systems from 200 l containers.

Users primarily only interested in short set-up times by processing sealants from large containers can carry out semi-automated sealant processing with the metering systems on their own.

PrefabElast (robot-assisted component sealing processes that can be automated and integrated into the prefabrication of precast concrete components and house modules) is a project promoted by the European Regional Development Fund (ERDF / EFRE).

SACHSEN-ANHALT

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