Construction Kit for Miniaturised Handling Systems: Further Developments and First Applications

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1. Title:

Construction kit for miniaturised handling systems: Further developments and first applications

2. Suggested topic area (from topic list)

- Design of assembly systems
- Robotics and robot applications for precision assembly
- Modular assembly machines and systems
- Standardisation in precision assembly
- Industrial applications of precision assembly systems

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Construction kit for miniaturised handling systems: Further developments

Purpose of the paper

At the IPAS Conference in 2008, we described in our presentation the idea of a construction kit for micro assembly based on a standardised interface for automatic exchange of (those times mainly) different grippers. In the meantime the construction kit has been developed further and completed purposively. So now automation of a wide range of tasks in the field of micro technology is carried out. At the actual state, the kit is including a miniature modular robot arm, two changing systems, various grippers, suitable storage racks, and additional tools such as cameras and dispensing tips. However the kit is open for everybody to adapt further elements and indeed this is done.
Based on all this new developments first practical applications of the kid both for an appreciable supply in research and development work (inition of micro products) and in the field of micro assembly (economic implementation) will be presented. In this context standardisation of interfaces is obligatory for universal application and expandability of the system. As opposed to established automation systems in micro assembly the presented construction kid offers prospects at an early state of product development. It is very useful for assembly of small and medium batch series, however. One reason is the quick configuration and reconfiguration for adapting customised handling systems to different applications, even during the process in combination with an easily programmable control unit. Another reason is its ability to be ported by one hand e.g. from a laboratory desk to a first production line more or less spontaneously. Usual preconditions for automated build ups, like safety systems, weight- and space restrictions or special energy supplies do not need to be considered.

This paper presents a construction kit for micro robotic applications consisting of the following modules:

- **End effectors** (see example figure 4)
  Beside different grippers (first developments have already been presented in 2008), automation kid´s front end now has been extended by alignment modules, fine positioning units,compliance modules, et.
- **Miniature Tool Change System and Storage Racks** (see figure 5)
  Beyond the mechanical coupling of the gripping module to the handling system, the micro tool change system also comprises electrical and fluidic feed-throughs, as well as a central aperture. It could be changed manually or automatically in a storage rack.
- **Miniature Modular Arm** (see figure 6)
  This positioning system consists of miniature swivel units, rotation units and base profiles, which are variable in length. They are based on a compact set-up concept, and are equipped with integrated electrical and fluidic feed-throughs. Distinctive feature of the exemplary build-up is its central aperture enabling specific process preciseness, feed through and visual process control.

Figure 4:
End effector:
Parallel Micro Gripper MWPG

Figure 5:
Micro Tool Change System
MWS and Storage Rack
MWM

Figure 6:
Miniature Modular Arm MGA.

The micro tool change systems and the end effectors correspond to the national standard ”DIN 32565” which was established in Germany a few years ago. In March 2011, this national standard became an international standard “ISO 29262: production equipment for micro systems – the interface between end effector and handling system". This international standard specifies provisions for the interface between end effector and handling systems in production equipment for micro systems. It specifies principal deviations, tolerances and designations for manually and automatically exchangeable end effectors. The aim is to categorize the end effector’s interface into three levels with an increasing degree of specifications. The standardisation of the interface plays a central role in mounting customised handling systems. It ensures easy exchange of different modules. This is a precondition to perform complex assembly tasks of small batch sizes economically.

The standard will be introduced to an international audience at the IPAS seminar as a platform of experts in micro assembly.

Research method

The construction kid for micro assembly basically has been derived from the following request: Designing a modern product, the ability of an automatic assembling process should be considered from the very beginning of product genesis on. Especially in micro technology outstanding products still now arise from mainly manually orientated laboratory research work. Transfer to an economically justifiable production sometimes ends up with a production line in Asia or even worse the project is abandoned – this maybe due to difficulties in finding an appropriate automation solution transiting the development to mass production without high labour exposures. Automation solutions within the developing process can help to avoid this problem, especially for innovative small and medium sized companies. In fact automation potential is already proofed.

Our research work for the kid is a practical one accompanied by many research facilities and still is in process. The usability of the derived automation modules and its assembly is reviewed directly by making use of it in the daily developing work of our automated micro assembly systems.

In a first step existing solutions have been analysed: Cartesian systems can be realised for high precision and stiffness, but are heavy and cost intensive (like granitic-bed in temperate surrounding). Innovative delta kinematics is absolutely precise in a comparatively small workspace. For micro and nano-positioning in the laboratory environment, piezo electrical actuators based positioning systems have been increasingly applied in recent years. Due to the increasing demand for precision, such systems are extending from scientific to industrial use. However, requiring powerful control units, they are cost-intensive and therefore are just used for sorting tasks.
In a second step demands of a portable laboratory system have been worked out: A current industrial initiative is in progress for miniature robotic handling with the goal of optimizing required space, portability and high configuration variability. As a consequence, new solutions have to be found in order to receive the required preciseness. Especially a two steps precision adjustment in the nanometer range has been worked out. A level of precision suitable for the application can be reached economically, using an optical feedback in combination with closed loop controlled fine positioning axes at the front-end. Here the central feed-through of all relevant modules such as the gripper, its interface and the rotary unit is key characteristic, which finally makes a direct process monitoring possible.

Components, where standardised interface DIN 32565 / ISO 29262 is used, ensure a quick exchange of manufacturer-spanning compatibility. Users, manufacturers of assembly devices and research institutes are cooperating for more than 10 years and did a lot of initiation work for the construction kit and its enlargement. So now surely industrial relevance is reached and consequently first systems could be sold. Beside economic requirements, the development of the micro tool change systems, the grippers and the miniature modular arm robot included the following technical requirements.

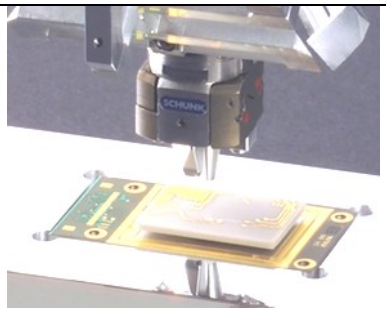
- Preciseness: In this context the repeat accuracy when changing the end effectors is of special interest. Here optical and mechanical test procedures have been worked out.
- Stability: High load capacity combined with high acceleration requires low deformation at high radial moments. Long time test had to be passed.
- Usability: Besides the installation of the interfaces a simple and reliable manual and automatic connection and disconnection has to be ensured. Feedback from the users still is analysed an leads to improvements.

The main challenge in development surely has been the design of the main robotic components, but also a stable manufacturing and mounting process for medium batch sizes had to be taken into account. For the assembly of this highly integrated mechanic and electronic products (robot arm) mechanical principles had to be modified accordingly and still the goal is an automated montage of components making use of the modular arm itself.

Cooperation

In the past, several research projects applied the standard interface and other components of the construction kit for micro assembly processes (e.g. BRIOLAS, EUPASS, etc.). We are the partner of the European-funded “mnt-era.net” in a project called SCALAB, where micro optical components with an edge length of 2 mm were assembled precisely in 6 dimensions, using the SCHUNK Miniature Modular Arm in combination with the fine positioning system “Commander 6” of the Fraunhofer IPT and several grippers.
Moreover, we are the partner of the Cluster “microTEC Südwest” which has been founded by the government of the Federal Republic of Germany for offering a production platform for micro components “PRONTO”. We assemble micro components in a sub-project called “VolProd”.

First set-up in SCALAB: Fine Positioning System “Commander 6” (Fraunhofer IPT) connected to the changeable gripper “MWPG” (SCHUNK) with “Laser-Resonator-Plate” (COHERENT)



Detail of the mounting process for a miniature laser device

Outlook

The future in micro assembly will not be based on pneumatic driven grippers, but on electronically driven devices and systems without air pressure. This is the reason why we are developing electronically driven tools/grippers for further enlargement of the construction kit.
We are looking forward with confidence to the first industry applications of our micro assembly systems, and are sure that there is a growing future market.

Major results

The primary purpose of the paper basically is to demonstrate the advantages of standardisation in micro technology, especially the central aperture in the handling devices. A basic construction kit for the field of micro system assembly has been developed with partners from industry and research in the course of several projects with high industrial relevance. In lieu of special solutions adapted to the application, the construction kit is efficient since it avails itself from the modular micro system. Here the standardised interface is an important step towards cross manufacturer compatibility. The interface between end effector and machine however is only part of an overall master plan.

The standard DIN 32565 was transferred to the international standard ISO 29262, and is currently used in applications all over Europe. It specifies requirements to an interface between end effector and handling system, or between modules. On the front end side of the mentioned micro tool change system several tools can be mounted. An automatic interchange of these tools has been realised, with a micro change storage rack. It has been designed as a superior modular robot system with swivel and rotary units. This system makes use of two exchanging interfaces, one at top of the robot head and one at the bottom. Therefore tools can be exchanged at the top (e.g. camera, dispersing tip, etc.), grippers at the bottom. Process related with additional fine positioning devices.

In addition to the changing system and the grippers, the miniature modular arm is available for setting up a whole micro assembly system. This system allows quick exchange of grippers and tools, and offers the possibility to check the result during the process with the camera at the middle axes of the tool centre point.

References to related works and literature:

- Presentation of the efforts of standardisation and a first embodiment of a change system based on this:
  Micro.tec congress in October 13-15, 2003 Munich (Germany): Proceedings, page: 279-284, ISBN 3-8007-2791-9 VDE Verlag GmbH DIN Standard:
  DIN 32565 „Schnittstelle zwischen Endeffektor und Handhabungsgerät“ (interface between end effector and handling device), Deutsches Institut für Normung e. V., Berlin, August 2003

  ISO Standard:
  DIN 29262 “Production equipment for Microsystems – Interface between end effector and handling system”, ISO office, Geneva, 2011

- Presentations of the SCHUNK miniature modular system based on mentioned DIN standard:

  - IPAS Conference2008, 10 – 13 February 2008, Chamonix: Standardised Interface and Construction Kit for Micro-Assembly

  - Hanser-Tagung für mikroMONTAGE (Expert Forum for microASSEMBLY), 10.-11. May 2011, Stuttgart: modularer Baukasten für wandelbare mikromontage Systeme (modular construction kit for changeable micro assembly systems)