European Assembly: Threats and Counter-Measures

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Abstract
Investments in automatic assembly systems applications have stalled, and outsourcing of final assembly operations, to low-wage nations, has been a strong trend. In the meantime, several South East Asian countries have increased their level of automation and product knowledge. The need to modernise European assembly industry is therefore urgent. The robot systems market in Europe is expected to rise if certain conditions are met. The successful implementation of adequate automatic assembly solutions will only boost this rise, but only if it will provide modular, easily configured solutions. This article will illustrate details of these trends and their effects on European assembly. The article will also clarify emerging needs within assembly, such as miniaturisation, disassembly, and process-oriented assembly solutions. Obviously, these new requirements further enhance the urgency of a coordinated effort from European academia and industry. The authors will also provide a short summary of the ongoing research projects at the Royal Institute of Technology and the newly started European Commission funded Assembly Net Consortium, which gathers over 20 universities and 15 companies in a thematic network. Finally, a brief overview of a newly started research project with Ericsson Radio Systems is also detailed.

Keywords: process-oriented assembly equipment, mini-assembly, thematic networks.

1.0 The Background
Assembly automation solutions have become technologically sophisticated since their introduction in the mid-eighties. There has, however, been a rather slow European growth in this particular sector of industry. Investments in automatic assembly systems applications have stalled, and outsourcing of final assembly operations, to low-wage nations, has been a strong trend. The market for assembly automation has been far greater in the South-East Asian sector than in Europe. The figures shown below describe the disproportionate disadvantage facing European companies [1].

In the late 1980’s only about 5% of all European assembly work had been automated [1]. By the late 90’s this figure had not risen considerably, due to the actual decline between 1990-1993. The reasons for this are not solely attributable to the economic recession of the early 90’s, but also to the fact that the automatic assembly solutions provided did not really suit the European scenario. In the meantime, some South East Asian countries have developed from manual assembly-intensive industries to well-automated ones [1].

2.0 The Underlying Threats
2.1 Outsourcing
The potential for increased market shares for both users and producers of precision automatic assembly systems, in the EU, should not even require to be mentioned. The EU has not responded to the need to automate their assembly as well as Asia ([2], [3]). It is no surprise that ever more subcontractors to EU companies come from Asia: the enhanced competence these nations have obtained in this field of production has rendered them more responsive to the market needs, thus making them contract winners. So, whilst many European companies continue to outsource their assembly to South East Asian countries, the competence in assembly and its inherent processes is being handed over to them.

2.2 Miniaturisation
The strong trend to miniaturise products further underlines the importance of automatic assembly requirements. The miniaturisation of parts and products is a strategic issue of
gaining importance: research in mini and micro assembly[4] has only just begun and has focussed on the long-term future possibilities rather than the direct industrial requirements. Hence, it has not resulted in any commercially exploitable results. As pointed out in certain publications [4], the need for such solutions is urgent. The efforts in this field of research have predominantly focussed on future conditions and demands. Unfortunately, a growing number of parts are now so small that conventional equipment and human beings can no longer be used. Any serious project that attempts to attain standardised solutions to the problems affecting assembly must therefore consider these new domains. The academic competence is relevant but must be channelled to the immediate needs.

2.3 Process-oriented assembly solutions

Amongst the academic advances made in Flexible Automatic Assembly (FAA) system design one can name stepwise upgradeable FAA cells [5] and the sub-batch principle [6]. This approach has been shared by other academic research projects (FACCS concept [7], and the DIAC system [8]). These research groups have focussed on FAA cells rather than assembly lines, and still denote flexibility limitations and high initial investment costs. Industrial efforts in the field of standardised assembly solutions have been presented by, for example, SONY FA [9], Flexlink Automation AB [10], GWS Systems OY [11] and the ABB TUFF [12] concept. All of these solutions include standard, closed, robot cells as part of the system. These units only represents one type of automatic assembly cells (see Makino’s definition[13]) since they consist of a closed frame platform and robot, and are aimed at being added to a line-type production flow.

Fig.2- Free Configurability with Standard Assembly Components (Dynamic flexibility)

These industrial solutions may be well suited for very high-volume products and production scenarios, but do not possess, in practice, the required characteristics for mass customisation and short lifecycle products: very fast re-configurability, true stepwise automation, and capacity flexibility issues. In order to achieve the full level of flexibility, assembly solutions must be designed to integrate any form or type of equipment.

This approach, first mentioned by the FlexFactory project [14], represents a shift in thinking since it implies that theoretically very flexible, multi-purpose cells will be replaced by a highly flexible concepts consisting of several well-targeted but not, in themselves, highly flexible components.

2.4 Tools for total concept design

Applicable tools for total concept design have, to date, not been applied in industry. Theoretical approaches such as Axiomatic Design [15] only aid in the forming of an adequate list of required functions and driving design parameters. These approaches have mainly focussed upon manufacturing systems and cannot be deemed as suitable as long as a well-defined and stringently classified taxonomy of the assembly process is created. Another drawback is that the methods do not force the user to find the true core of the problem. In an attempt to shed light on these drawbacks, Tichem et al[16] point out that the intimate collaboration of product design, assembly equipment, and assembly process aspects represents a promising approach. Other emerging design methodologies require a far more intimate collaboration between end-user, sub-contractor, and system developer (Corba[17]).

2.5 Disassembly technologies

Disassembly and recycling are topics of growing industrial significance primarily due to environmental, but also political, issues. In this context the planning, design and prototypical implementation of automated assembly and disassembly facilities must be supported. This type of research requires innovative materials and manufacturing processes as well as a close monitoring of the aspects of a loop economy. Terms such as reversed assembly systems are examples of the new taxonomy being formed by these needs. The research in this field has gained momentum but cannot be deemed sufficient in relation to the growing demands. In terms of life-cycle engineering, the disassembly technologies must be included in a more subsequent manner and greater knowledge acquisition is required.

2.6 Application assistance

The users’ acquisition of knowledge and competence must also be enabled in an adequate manner. In attempting to solve all the problems in a single solution, flexible automatic assembly systems have tended to be quite complex technologically. Consisting mainly of robotic cells and their material flow units, these solutions have not been easily assimilated by workforces with limited technological knowledge. Simple and effective in-house use and maintenance must also become part of the flexibility equation. The stepwise flexibility enhancements must therefore not only be very well targeted, standardised, cheap and robust, but must also be supported by a well-documented application assistance. Typical aspects include when a company should step from a manual operation to an automatic one, and the reasons behind the decision: if the question is due to the product parts not being suitable for automatic assembly, the answer is to automate stepwise for each part, or set of parts, which have been re-designed to fit one of the standard automatic assembly processes. However, if the
question refers to capacity or product range increases, the answer becomes far more delicate in nature.

2.7 Summary
The need to modernise European assembly industry is therefore urgent. The robot systems market in Europe is, according to a market survey, expected to rise [3] if certain conditions are met. The successful implementation of adequate automatic assembly solutions will only boost this rise, but, as this survey points out, only if it will provide modular, easily configured solutions.

3.0 R&D Efforts at KTH-Assembly Division

3.1 Hyper Flexible Automatic Assembly/ PROPER project
The Hyper Flexible Automatic Assembly (HFAA) project was initiated in order to meet the future assembly demands being posed by industry in general, and European SMEs in particular. In order to do so, a structured approach to the assembly process itself lies at the core of the project. The project is being carried out at the Royal Institute of Technology (KTH) with close industrial cooperation.

The HFAA project is being partially financed by PROPER (Programme for Production Engineering Research) and industry. The HFAA project will deal with four distinct project areas:
- Analysis of the assembly process and its interactions with product design and assembly equipment.
- Analysis of mini-assembly requirements and its requirements in terms of specific equipment.
- Study of assembly factories concerned with mixed-model production and mass customisation.
- Development of a standardised, modular, hybrid assembly system concept.

The final objective is to create a modular, HFAA system concept which consists of standardised assembly system components.

3.2 The SHARC (Standardised Hybrid Assembly with Reactive Capacity)/EC Project
The SHARC project (CRAF-1999-7 “SHARC”) focuses on the development of a commercially available, modular, Hyper Flexible Automatic Assembly (HFAA) concept based on a set of standardised, low-cost, process-oriented components. The SHARC project is acknowledged by the European Commission and will consist of end-users, system suppliers, software system developers and R&D institutes. The partners are:
- MCA OY (system supplier & project coordinator).
- ACS GmbH (generic robot controller platform).
- Autic AB (software development).
- Easy Living AB (SME/end-user).
- Delft University of Technology (R&D).
- IVF Stockholm (R&D).
- KTH (R&D).

This research group intends to apply the HFAA project results in a true industrial application. The final objective is to create a commercially available modular, Hyper Flexible Automatic Assembly (HFAA) system concept. The HFAA/SHARC solution also intends to adopt earlier research results such as the sub-batch principle.

3.3 Assembly Net (EC project)
The prime aim of the Assembly Net Thematic Network [18] is to establish a well co-ordinated and effective support infrastructure throughout Europe in order to create a network in which existing national and international projects, and available solutions, are linked to urgent industrial needs.

The critical technologies to be brought into focus include assembly system component design, system design tools, control systems, assembly process analysis, mini and micro assembly developments, etc. The partners propose to set up the following activities:
- At least one conference per year.
- The distribution of a Newsletter twice a year.
- Organise workshops on subjects requiring attention (defined by SIG-Special Interest Groups).
- Offer summer courses in theoretical (academia) and practical (industry) topics.
- Create and maintain an official website in which all of the above are well listed, as well as links to existing local and national projects, project partners and associated companies.

These activities are to be seen as a first stage of events. The aim is to broaden, in due time, the scope of activities to include the entire lifecycle of such products. The main objectives are:
- To analyse current trends and provide a strategic vision on Assembly Automation.
- To act as a catalyst for the implementation of innovative assembly practices by industry. Links between academia, end-users (SMEs) and system developers will be built.
• Assist partners in finding funding sources, educational resources, existing solutions, etc.
• To provide a forum for developing focused and applicable initiatives and international collaboration.
• To collect and present knowledge on Assembly Engineering to the industrial and academic community.
• A stimulus for the development of new initiatives, actions, activities and projects.

The proposed Consortium currently consists of over 25 institutes from over 10 countries. Orchestrated by the foremost academic institutions in Europe, it intends to merge several national & international research forums and already includes a vast number of industrial members. This group consists of large and small users of assembly systems, assembly system providers, industrial consultancy groups, and research institutes & universities. The network is expected to expand and will focus on incorporating more SMEs. The network partners cover a very wide range of competence. The network will also strive to establish even international contacts with associations and networks with similar goals, such as the CIRP, IEEE Robotics & Automation Society, IFR/International Symposium on Robotics, IFAC/IAD, etc.

4.0 Future Research Intentions

Our research group intends to consolidate the view that the key to truly flexible, affordable and easy-to-use FAA systems lies in the creation of a set of standard, simple, assembly process-oriented components. Two research projects have already been started (HFAA, SHARC, ) with these intentions, and the Assembly Net project will be used to monitor coming needs. Collaboration with academic and industrial partners has been established. However, some problems will remain unsolved if no other research activities are started. These are:

• An in-depth study of a given set of existing & future products must be carried out in order to clearly establish what type and concept of assembly equipment is really required.
• Wide collaboration on all levels to establish some accepted form of standardised interfacing procedures. The requirements must come from users.
• The entire chain of research events should be linked to a large scale project with direct industrial applicability in order to attain deep, wide and industrially realistic project requirements.

The core of the research requirements detailed above resides in the need to link the product design stage to the actual equipment available, at the earliest possible stage in product design:

Although the framework detailed above is self-explanatory, let us consider some details. The project begins with the dissection, or analysis of a given company’s products (1). This analysis should result in a vast list of the assembly equipment required to assemble these products. These components should then be separated into functional classes (2). This list should be

The assembly process itself, and the automatic assembly process in particular, are not treated in relation to commercially available solutions for specific assembly tasks. The creation of a standard set of assembly-oriented components, based on the assembly process itself, would definitely create a driving force for assembly-friendly design. Basically, the designers would know, a priori, if there are technical solutions available and which particular constraints they pose on the design. The ideal scenario would be to have a standard set of assembly components with guidelines to their specific process specifications.

4.1 The idea

Our research team has already ongoing research projects. The problems detailed above will not be fully resolved by these projects, mainly due to the fact that there are some very complex and wide-ranging issues to be tackled. The project idea has been initiated in collaboration with Ericsson Radio Systems.

![Fig.5- Proposed Framework for a five-stage R&D project](image-url)
analysed in-depth in order to classify the equipment requirements in terms of the functions and flexibility required. Basically, a preliminary list of assembly sub-processes is derived (3). One then returns to the existing assembly equipment and, with these new assembly sub-processes in mind, forms the new assembly module requirements (4). At this stage, a clear picture of the required module functionality and standard interface requirements has been drawn, and a methodology has been formed. The project partners now invite selected system suppliers to a discussion on the possibilities of implementing such a concept in practice (5). Note that the system suppliers should ideally be part of the project from the start. Collaboration with the Assembly Net, SHARC and HFAA projects has been ensured. A project framework is therefore formed. The project partners now invite selected system suppliers to a discussion on the possibilities of implementing such a concept in practice (5). Note that the system suppliers should ideally be part of the project from the start. Collaboration with the Assembly Net, SHARC and HFAA projects has been ensured. A feasibility study based on this project framework is currently being finalised out with Ericsson Radio Systems [19].

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