Modularity and Architecture of PLC-Based Software for Automated Production Systems: An Analysis in Industrial Companies (Journal-First Abstract)\(^1\)

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Abstract—Adaptive and flexible production systems require modular, reusable software as a prerequisite for their long-term life cycle of up to 50 years. We introduce a benchmark process to measure software maturity for industrial control software of automated production systems.

Index Terms—Automated Production System, Maturity, Modularity, Control Software, Software Analysis, Software Evolution.

I. OVERVIEW

Automated production systems (aPS) are long living systems that are exposed to changes over decades. Their complexity including automation hardware as well as system functionality realized by software is increasing. The ability to adapt flexibly to changing requirements by replacing or expanding mechatronic modules, tracing of changes and management of software variants and versions are a prerequisite for evolvable intelligent, self-organizing Industry 4.0-compliant aPS.

To evaluate whether industrial control software is qualified for Industry 4.0, the benchmark process SWMAT4aPS (Software Maturity for aPS) was developed. SWMAT4aPS consists of two elements, a self-assessment questionnaire and an expert analysis for selected industrial companies to validate the results of the questionnaire (cp. Fig. 1). The core of the approach consists of four steps, performed in an experimentation and a reporting phase. The first step is to conduct a survey with the developed questionnaire, which contains 45 questions grouped into three maturity categories. Maturity in design, maturity in test/quality assurance and maturity in startup/operation/maintenance. It allows companies to identify deviations between their own scores, the best available rating and the mean values of all participating companies in machine manufacturing. In the second step, the questionnaires’ results of 16 German world-leading companies in machine and plant manufacturing are analyzed. The third step is the expert analysis in which four selected companies’ software architecture, code structure and the workflow are analyzed. We prove the validity of SWMAT4aPS by comparing the results of the questionnaire with the results of the expert analysis. We identified a huge variation of maturity levels in most of the companies. The best company reached an overall maturity values of 80 %. From the 13 hypotheses, 9 are true, 3 are partially true and 1 is false. Considering the evaluation, the questionnaire delivers valid results. These results are complemented by additional insights gained through the expert analysis especially regarding different methods of code configuration comparing a modular, interdisciplinary engineering approach with template-based and parameter-based configuration approaches.

To reveal modular dependency effects and to gain deeper insights into the use of software modules, a second questionnaire was conducted with more than 68 companies. The detailed analysis confirmed that the SWMAT4aPS approach delivers valid results.

REFERENCES


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