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First proof of concept for language independent learnstruments in special machinery assembly

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Abstract

International customers and employees form a cornerstone of today's special machinery industry. Qualifying assembly workers with different language and cultural background in this field appears to be challenging and cost intensive. An opportunity to deal with these challenges is the use of so called learnstruments. Contrary to teacher centered learning methods, learnstruments aim to automatically mediate their functionality to their user. In a previous attempt, a language independent learnstrument has been tested for transferring assembly knowledge with international students. Interactive 3D-PDFs proved to be more efficient than language independent picture based instructions and short instructional Utility-Films in relation to needed assembly time, errors made and displaying complicate relations and processes. Now the proof of concept has to be made for 3D-PDFs within the special machinery environment. A language independent 3D-PDF-learnstrument for the assembly of integrally geared compressors has been developed. Its acceptance by Field Service Engineers was evaluated during a special machinery assembly training.

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Keywords: assembly; learning; learnstruments

1. Introduction

The special machinery industry is a remarkable innovation driver in Germany. However, this industry is barely addressed in today's scientific research due to the complexity and diversity of its products [1]. A special machinery company in Berlin produces one of a kind turbomachinery for the hydrocarbon processing industry and the

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industrial gases industry. Its Field Service Engineers (FSEs) are responsible for the erection and maintenance of new turbo compressors on customer sites. These FSEs have different cultural backgrounds and diverse knowledge of at least two languages. It is quite challenging to improve the training situation for these FSEs for regular trainings at the company and in preparation before they fly to a customer.

In a previous attempt, a language reduced generic model for international assembly instructions for special machinery assembly has been created. Compared to traditionally used instructions, the usage of visualizations of the compressor assembly was extended. Due to descriptive pictures, the instruction became easier and faster understandable, which was highly appreciated by the workers [2].

Subsequently an interactive 3D-PDF has been developed as a learnstrument. It shows assembly step animations and FSEs can interact with the content by rotating parts, displaying part names and getting additional information about problem solving and safety issues [3, 4]. "Each assembly task is different in one-of-a-kind producing companies, considering number, size and appearance of parts. Therefore, it is difficult to compare and test [different kinds of] instructions for one assembly task with a sufficient large sample of skilled [FSEs] in this segment. To be able to compare different instructions, a simple bicycle e-hub motor assembly was documented within three instruction types and tested with different students."[3] The 3D-PDF facilitated shorter assembly times as well as fewer assembly mistakes and illustrated difficult assembly steps better, compared to a Utility Film [5] and an illustrated instruction in a test with 56 international students [3, 4]. Utility Films consist of several short film sequences of assembly steps, which allow users to repeat the assembly step by step on their own [5].

The knowledge of students and the requirements to assemble a simple e-hub motor differ from the knowledge background of FSEs and the requirements to assemble a multiple tons weighing turbo machine. Therefore, an additional assessment has to be carried out with FSEs to prove the advantage of 3D-PDFs for special machinery industry.

2. Typical training situations in special machinery business for turbo compressors

Trainings for Field Service Engineers are usually organized on a yearly basis. A typical assembly training for integrally geared compressors takes about five days with eight hours per day. Theoretical and practical learning sessions are arranged on an alternating basis. The theoretical sessions consist of educational lectures from local experts for specific topics. During practical training sessions an experienced worker shows the FSEs how to assemble and disassemble an integrally geared compressor. For this training part the well-known and established four steps method is used. The method is part of the "Training Within Industry" concept, which was developed during the second world war in the USA [6]. The four steps method is also mainly used for internal knowledge transfer between experienced workers and apprentices. To avoid just repeating previously shown steps, as it is common for mass production, the FSEs are also actively involved in shaping the training sessions. They decide together with the trainer how the next steps have to be performed and which safety risks might occur.

Due to a limited production capacity and a long throughput time of several months for these one-of-a-kind compressors, currently no compressor is available to be used only for training purposes. Therefore, the assembly training has to be carried out on a compressor which will be delivered afterwards to a customer. In every one-of-a-kind production, three big challenges arise with this restriction not to have an exemplary product only for training purposes:

1. A suitable product has to be in a specific assembly state at the time the training takes place.
2. The product throughput time will be delayed by the assembly training time.
3. Assembly errors of the workers might lead to damaged parts. This results in part repair or reproduction, which could take several months. The delay in the manufacturing will lead to a delay in final delivery and might end up in high penalties.

To overcome the third challenge, FSEs are only allowed to repeat steps by themselves, which are not critical to product quality. Critical steps are only shown to the Field Service Engineers by an experienced worker and then discussed afterwards.