Integration of welding simulation as digital training tool into Industry 4.0 fabrication processes

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1. Introduction

The paper aims to present some studies regarding the simulation welding as part of practical training of the welders who perform atypically welding procedures which cannot be realized by robotized welding systems.

The Industry 4.0 using Cyber Physical Systems to share, analyze and guide intelligent actions for various processes in the industry to make the machines smarter. These smart machines can continuously monitor, detect and predict faults to suggest preventive measures and remedial action [1, 5]. This allows better preparedness and lower downtime for industries. The same dynamic approach can be translated to other aspects in the industry such as logistics, production scheduling and optimization of throughput times, quality control, capacity utilization and efficiency boosting. CPSs also allow an industry to be completely virtually visualized, monitored and managed from a remote location and thus adding a new dimension to the manufacturing process. It puts machines, people, processes and infrastructure into a single networked loop making the overall management highly efficient.

Industry 4.0 in the welding Industry means digitalization of welding process planning and optimizations. The conventional way of process planning for welding production is by making numerous experimental (physical) welding tests and trials [2]. This is highly costly and very time consuming also wasting a lot of materials and human hours, which significantly prolongs the development time and delays launch of new production lines, otherwise leaving many unsolved problems to production maintenance or undetected defects in weld quality. In order to reduce the costs and speed up the developments as well as increase production stability and weld quality, a new way of working is to replace as much as possible the physical tests by digital (or virtual) tests with computer simulations and optimizations.

2. Simulation of the welding process

Simulation welding is not a technology is just a technique which helps the welders to perform a specific process in order to increase efficiency in terms of reducing the costs related to consumables, energy and the number of damaged products. It can be applied for specific welding procedures as training support for welders in order to gain proper skills or as new welding technique. This is a major step taking into account that the welders can improve their welding skills as well as, new welders can be trained before they will perform practical training in workshops. However, the simulation technology from welding simulators manufacturers point of view cannot cover all cases and therefore, they have developed digital tools in order to allow the engineers to elaborate specific study cases according to their needs [3, 4]. The limitations of the digital tools in terms of possibility to elaborate study cases (due to the lack of information from digital database) has led to the development of application as specific solution for special cases. Figure 1 presents few welding simulators developed.

3. Programming the welding procedure specification

By programming the welding procedure specification, the computers (welding simulators) can provide the support

Figure 1. Welding simulators.

for training on specific welding cases. Using augmented reality, virtual reality or other digital tools as technology for simulation, the welders can be trained in order to perform the welding in real life. Starting from basic data recorded on welding simulator, the engineers can create specific welding cases according to their needs. Figure 2 presents few steps in programming a customized welding procedure. The application provides to the programmer different tools related to evaluation of some welding parameters (travel speed, travel angle, work angle, arc lenght, voltage and welding current intensity), welding process (type of process, electrodes), filler material (type and diameter) as well as information related to gas (type and flow).

4. Evaluation of the welder performance

After the training session, the welder can be evaluated using application software in order to see if he is prepared to weld in real life. All welding skills, parameters and the quality of the welds can be recorded and presented as graphical charts and videos. Taking into account that the performance of industry 4.0 is limited by the hardware and software developments, the simulation of welding will allow the testing of specific welding cases in order to increase the performance of the welding production. Figure 3 presents the results obtained by the welders during practical exercise on welding simulator. It can be selected or deselected the parameters it want to focus on. Only evaluable parameters that we chose when designing the exercise will appear (Figure 3a) and a scoring from 0% to 100% will be displayed besides each parameter. Also, it can be visualized the exercise executed by the welder. In the work piece two different graphics will be displayed (Figure 3b):

- Upper side: graphic indicating the input parameters performance. Only graphics of selected parameters will be displayed.
- Lower side: graphic indicating the output parameters performance. Only graphics of selected parameters will be displayed.

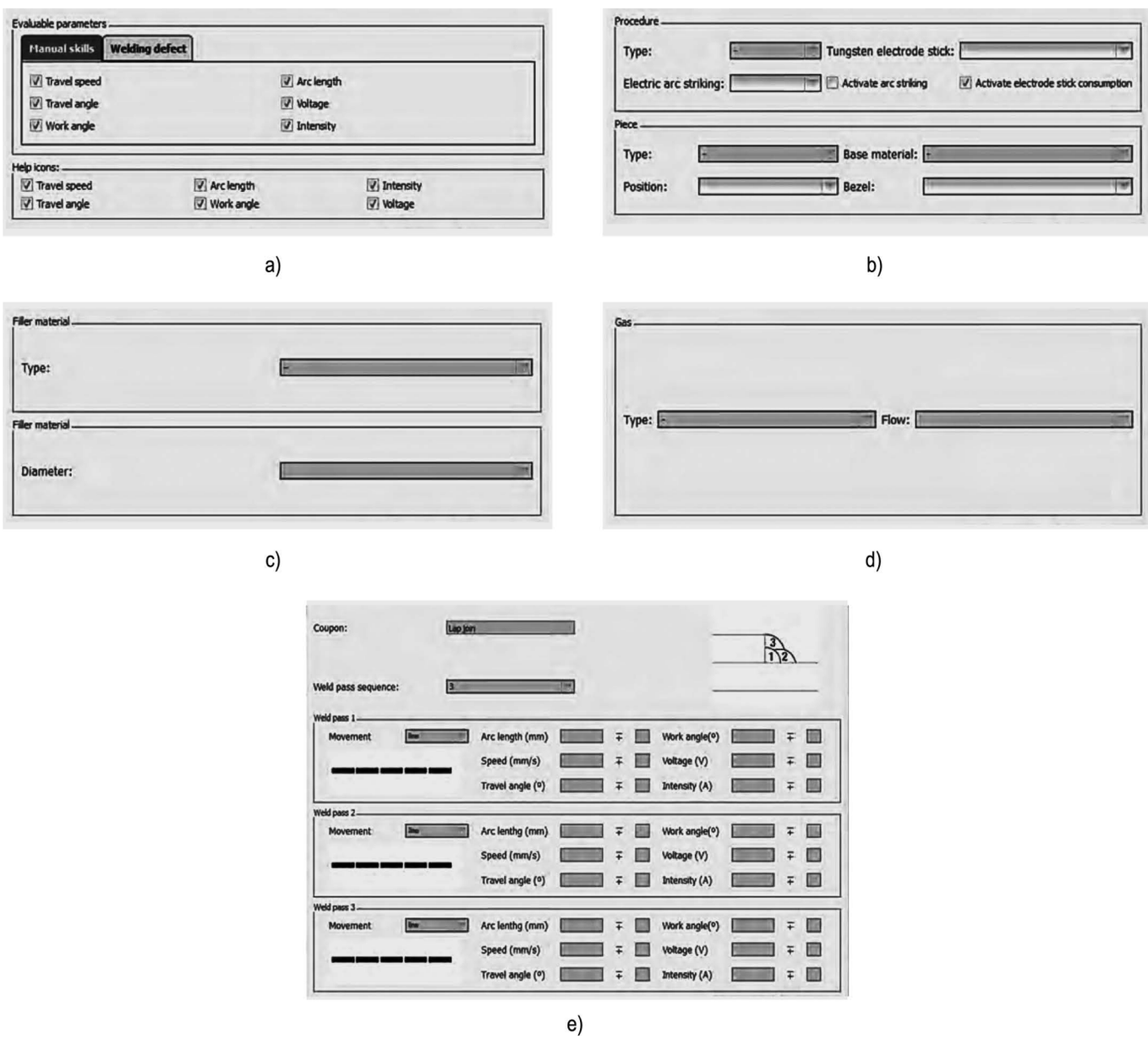

Figure 2. Steps in programming WPS (Soldamatic, Teacher software).
a. selection of manual skills, b. welding process, c. filler material, d. gas, e. welding passes.

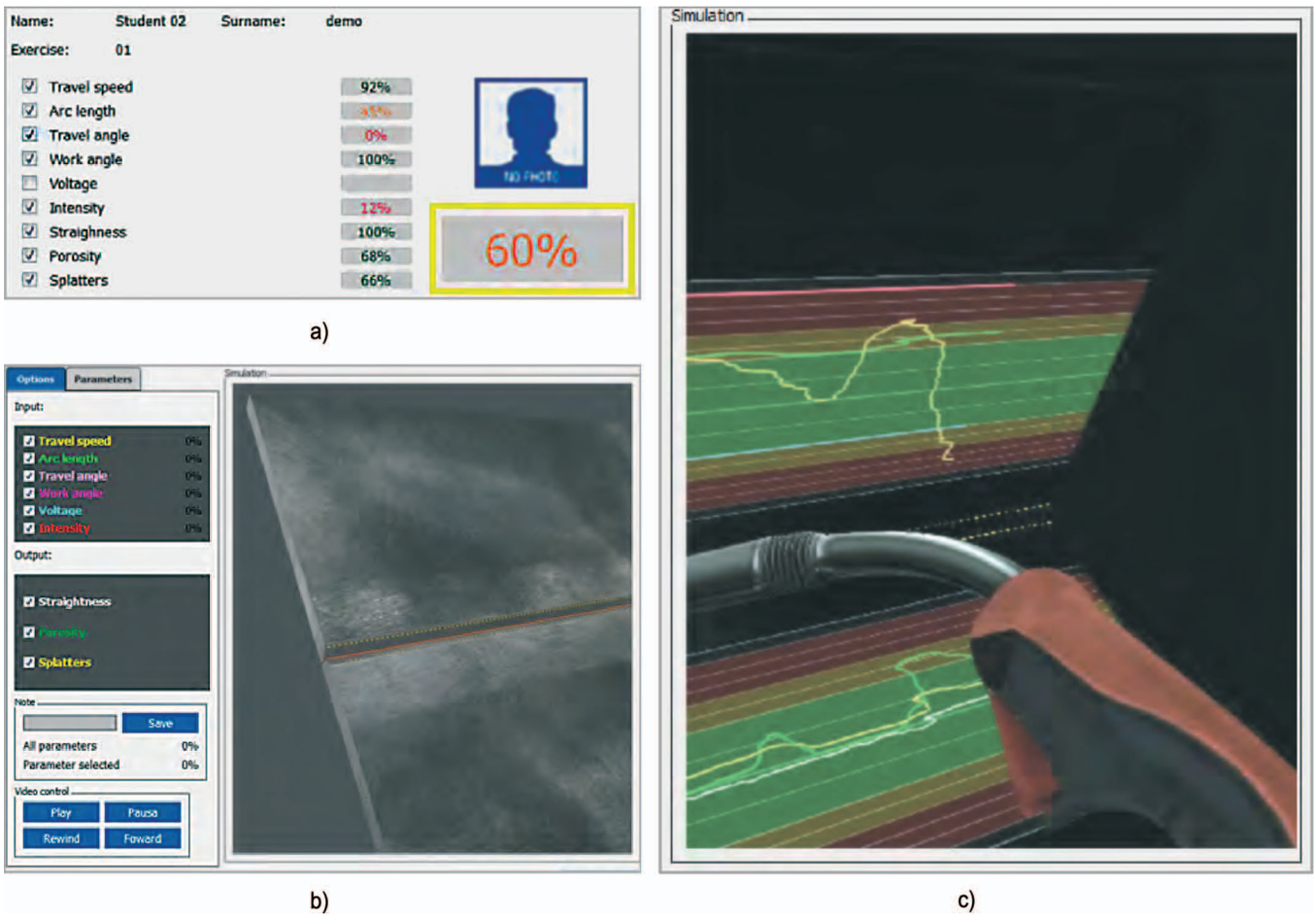

Figure 3. Evaluation the performance of the welders.
a. individual and overall scores, b. augmented reality weld, c. simulated welding

5. Conclusions

Welding simulator can be integrated and complementary for Industry 4.0 by providing reliable solutions for building welded structures there where the robotized system cannot perform welding due to the limited space, position or any other issue such is for instance, the high costs related to the designing and production of specific hardware parts for robotic welding systems.

By training on welding simulator, the welder will gain proper skills in order to perform specific welding procedures which require special abilities. The welding simulator can be programmed for training before welding in order to reduce the costs with consumables materials and energy, but the most important aspect is related to avoidance of damaging the products during welding process.

The evaluation of the welder performance can be done using the software application but it is recommended that the final result to be established by the trainer on real life welding process.

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