

# Welding simulators - green training for top welders

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## Abstract

Welding simulators, slowly but surely, are becoming an indispensable part of the training of novice and professional welders. For the past ten years, VWTS (Virtual Welding Training System) has progressed from a serious game to a system that has brought continuous welder training to the level of the Olympic motto: "Faster, more, stronger". Generational barriers have been breached. The coaches realized that the simulator was an excellent assistant to them and not a threat to their work.

In the application of simulators in welding training, the important factors are:

1. All-green training,
2. Approach to training adapted to young generations,
3. System destined for lifelong education of welders,
4. Shorter training with a higher level of competencies.

The paper will discuss the research conducted in connection with the application of simulators in welder training. Examples of good practice in improving welder training. Possibilities of simulator application in various situational problems in production processes. Possible further directions of development and application of welding simulators in the education and manufacturing sector.

Keywords: welder training, green training, welder simulator, Vocational education.

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## 1. Introduction

The first welding simulator was patented and manufactured in 1990 in Canada under the name LENCO. The device was applicable for three welding processes, namely MMA, MAG and TIG. It had real electrode holders or burners and like all prototypes certain shortcomings and limitations. However, it has great merit in the breakthrough, development and use of simulators in welder training. Many simulators and training systems have been developed on this idea, that today globally contribute to the quality education of welders. In these thirty years, as welding simulators appear more and more in welding training, some dilemmas and resistance to their use have been resolved:

1. Welding simulators are not intended to replace real welding training. They can be considered as devices that participate equally with real welding in an integrated interactive system of training, education and testing of competencies of trainees and experienced welders in their system of lifelong learning.

2. In vocational and adult education, welding simulators precede real welding. According to all available research, they speed up training and raise the quality of welded joints made with a real welding process. The use of simulators reduces the cost of education (there is no basic material, filler material, reduces the cost of energy and consumables) and provides 100% environmentally friendly education, which is especially important for students of vocational schools.



Fig. 1 Soldamatic Simulator, Spain

3. In the manufacturing and industrial sectors, welding simulators can be used to test and train welding personnel. It is important to mention, that in such cases they do not have to use production facilities, take out welding devices from the production cycle or use large amounts of base, filler and auxiliary materials.

## 2. Education in an integrated interactive system

Welding simulators are mainly based on digital reality technology: Virtual - VR, Augmented - AR and Extended reality - XR. They can be used in two ways. The first is a welding technique training led by a virtual trainer and the second is a simulation that fully corresponds to the real welding conditions. A virtual trainer can fully replicate the welding technique of a real trainer if the trainer enters trainings into the simulator. The simulator scores each weld performed, and the minimum score for successful training is determined by the trainer.



Fig. 2 Skills training Learn Virtual Europe, Hungary

In manual welding processes, the welder must be at the center of attention. In addition to the knowledge to implement the prescribed welding technology and psychophysical stability, the welder must possess a good welding technique that requires skill with attention to details. The quality of the welded joint depends on the welding speed, the distance of the electrode, the angles of inclination of the electrode holder / burner in relation to the workpiece, welding positions and the position of the welder's body for the entire length of the weld. This technique, numerous research has proven, is achieved with significantly lower costs and in a shorter time, by combining training on welding simulators with real welding.

By combining the simulator with real training in the interactive training of welders, the following results are achieved: green training (training without radiation, smoke and user hazards), significantly cheaper training, technique with burner or electrode holder, maintenance of welding parameters at the set level: welding speed, distance of the electrode from the workpiece, inclination of the burner/ electrode holder, correct placement of the welder in different welding positions.

During and after the training, the welding simulator provides a range of useful information: it directly shows the results on the screen, gives group rankings, acoustic information, digital analysis of welding techniques, etc. Most importantly, the users of the device have accepted them. Of course, there are still older trainers who approach simulators with scepticism, but once they understand their compatibility with real training and their advantages, scepticism disappears.

Research done in the scope of European projects InteractivWeld and WeldChance, on a sample of nearly 600 vocational school students and over 100 professional welders and ten years of practical application, proved the assumption correct that an integrated interactive education system for welders combined with simulator training in real conditions gives the best results. Figure 3 shows the ratio of simulators in trainees' training.

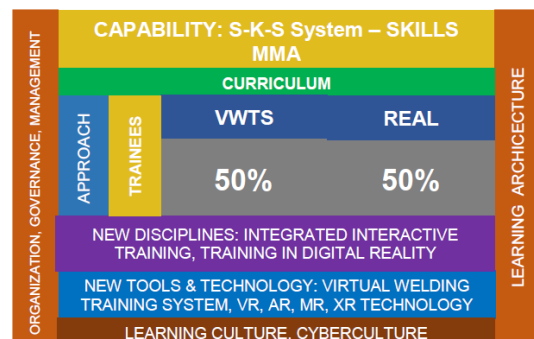


Fig. 3 Integrated interactive system for education of trainees in MMA process

The ratios for the MAG and TIG welding process were obtained in the same way. MAG / MIG / FCAW / MCAW - 40% simulator: 60% real welding; TIG: 60% simulator: 40% real welding.

For experienced welders, the training is performed 100% on a welding simulator. By training experienced welders at regular intervals, on a welding simulator, the correct welding technique is continuously achieved and skills are raised to a higher level. This significantly contributes to the lifelong education of welders and the quality of welding and greatly reduces the percentage of defects in production processes. The diagram in Figure 4 shows the increase in skills, knowledge and stability through continuous training over certain time periods.

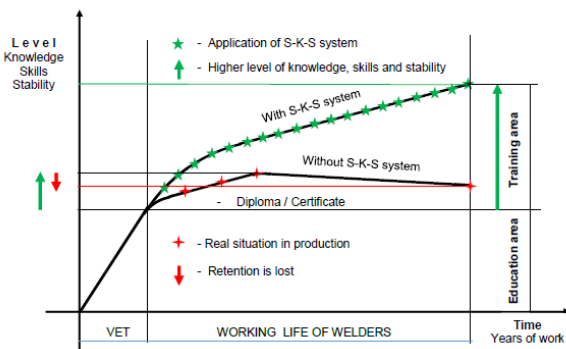


Fig. 4 Diagram of lifelong education of welders

User feedback is very favorable.

Welder training institutions and production plants that use welding simulators state the following advantages of their use: reduction of training and coaching costs, green training - completely environmentally friendly, use of simulators does not affect production (no need for welding machines, base, filler and auxiliary material), most of the training relies on the principle of self-education. The use of simulators for continuous training reduces defects in production.

Trainees and experienced welders highlighted the following positive characteristics: learning through play - serious game, challenging environment, raises motivation, immediate feedback, fast and accurate results, the ability to analyze training errors, compete with colleagues in the group, work in an ecological environment. This opinion is very important, because it will certainly encourage more young people to opt for this globally deficient occupation.

## 2. Conclusion

Thanks to twelve years of experience in working on welding simulators and conducting training for trainees, adults and experienced welders, the following can be concluded:

1. It is indisputable that welding simulators must be introduced into the lifelong education system of welders. In addition to quality skills training, three factors contribute to this:

- Safety, from the aspect of health and safety at work for all participants - especially for trainees,
- Environmentally friendly - no waste materials, no shielding gases, reduced energy consumption, etc.
- Economically, because the cost of training trainees and experienced welders and testing the competencies of welders is significantly reduced.

2. Not even half of the standard welding machine manufacturers are currently involved in simulator development. However, these companies have a great responsibility to carry the development of simulators in order to bring the digital reality as close as possible to the real one. This means that:

- Simulators must be closer to actual welding devices in terms of appearance and method of selecting welding parameters;
  - Graphical - visual interfaces must be intuitive and easy to use;
  - It is noticeable in all simulators from this review that the control of the electrode holder / burner does not achieve sufficient interaction between man and device (computer), i.e. there is insufficient communication between the welder and the welding pool, resistance and force are not felt during welding. This means that a further step in the development of this type of simulator is in the application of haptics, i.e. haptic interfaces, that will achieve the necessary human-device interaction.
  - Electrode holders and burners must match those used in real conditions (e.g. as does the Soldamatic with Abicor Binzel burner);
  - Glasses or screens should be placed inside welding helmets.
- And finally, this training system, based on digital reality, provides a good experience for working in real welding conditions.

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