

**THROUGH-THE-ARC SENSING FOR TWO-WIRES GMA WELDING OF ALUMINUM
BASEMENT OF THE FLIGHT SIMULATORS FOR SPORTSMEN TRAINING**

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Abstract

The flight simulators used for the training of the sportsmen are welded structures made of aluminium alloys. The automatic welding of such structures involves specific sensors to track the groove. Two-wires GMA welding could be applied and to maintain the both wires inside the groove through-the-arc sensor is proposed. As a component of the through-the-arc sensor the torch performs an oscillating movement. Whether the torch oscillation mode is chosen the frequency of the oscillation is influencing the shape of the welding current curve. It has been detected 3 different types of possible oscillating modes. For everyone the influences brought by the frequency on the maximum value of the current and on the difference between a maximum and a minimum of the current have been searched. The results were the base of the choosing of the oscillating mode for a through-the-arc sensor. When the frequency is lower than 3 Hz then a low difference between a maximum and a minimum is obtained. That means that some possible errors could appear in the signal translation. When the frequency is higher than 10 Hz then a large scattering of the maximum values of the current is obtained. That could involve an error on the position translation. The range of 4-8 Hz has been considered as the optimum range of the frequency values.

Key words: *through-the-arc sensor, two-wires GMA welding, frequency of oscillation, types of oscillation, flight simulator*

1. INTRODUCTION

Flight simulators (figure 1) are specific training equipment that is used for the preliminary training of the pilots not only in commercial or military flights but for sportive competitions as well. They are welded constructions made by aluminium alloys. The main frame of the construction contains 5 m of continuous weld in rectangular shape, which is an overlapped weld between L profile and 5 mm thickness plate. Such weld is automatic MIG welded and sensor to track the groove is required.

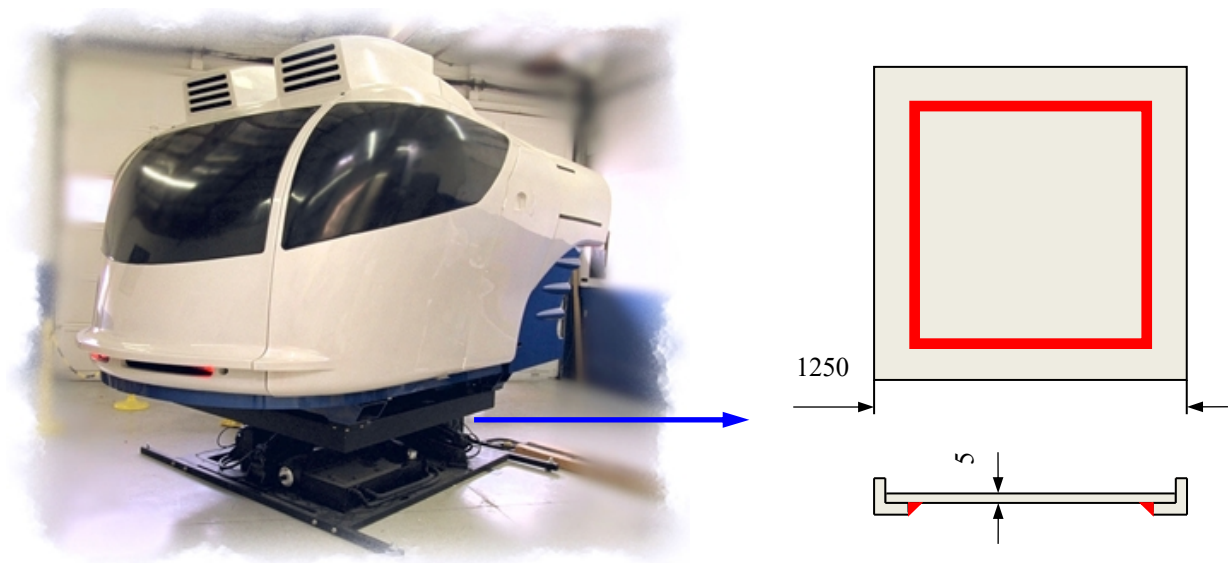


Fig. 1. Flight simulator (a.) and the sketch of the welded base frame (b.)

No any automatic arc welding system can function without a device that can correct the position of the welding wire inside the groove during the welding process. In time different solutions have been proposed, some cheap solutions, some high precision solutions, so, it is possible to say for now that the problem is solved for GMA welding processes. The most used tracking systems are the through-the-arc tracking systems because their precision is not paid and most of the welded structures producers can have this kind of the tracking systems. For single wire GMA welding systems such kind of the tracking systems are in good development. For two-wires GMA welding systems the problem is not solved, yet.

The configurations of the two-wires GMA welding systems are sensitive different of the classic GMA welding systems. Because of that the conception of specific through-the-arc sensor systems should be in different manner developed.

In single wire GMA welding the tracking system is positioning the end of the wire relative to the axis of the groove. In two-wires GMA welding there is a plan that should be positioned relative to the axis of the groove. That is the plan of the two welding wires.

As it well known is the through-the-arc tracking systems are on the variation of the welding parameters when the arc length is modifying based. To have a controlled modification of the length of the arc an oscillating movement of the welding torch is performed. That movement of the torch gives periodical variation of the welding current and of the arc voltage. A logical interpretation of those periodical variations offers important information regarding the position of the end of the welding wire.

The parameters of the oscillating movement of the torch are strongly influencing the signal that is used in the correction process. The amplitude of the oscillation gives the peaks of the signal. But the amplitude is restricted by the shape and the dimensions of the groove. The frequency of the oscillation gives the speed of the correction process, so the precision of the tracking system. But the frequency of the oscillation has an up limit that is given by the mechanical device of the through-the-arc sensor. A bottom limit exists, also, and that limit is given by the correction of the melting of the wire, correction done by the internal self-adjustment of the power source.

The paper aims to present the results of a large study regarding the influence of the frequency of the oscillating movement of the torch on the welding current periodical signal that is used to correct the position of the torch. The study was performed on three types of torch oscillation.

2. THE OSCILLATING MOVEMENT OF THE TORCH

Studying the configuration of the two-wire GMA welding system three types of the oscillating movement can be performed. According to figure 2 a, b and c translation perpendicularly on the axis of the groove, rotation of the welding torch using a rotation axis that is not positioned between the two wires and a rotation of the welding torch using a rotation axis that is symmetric axis of the torch can be applied.

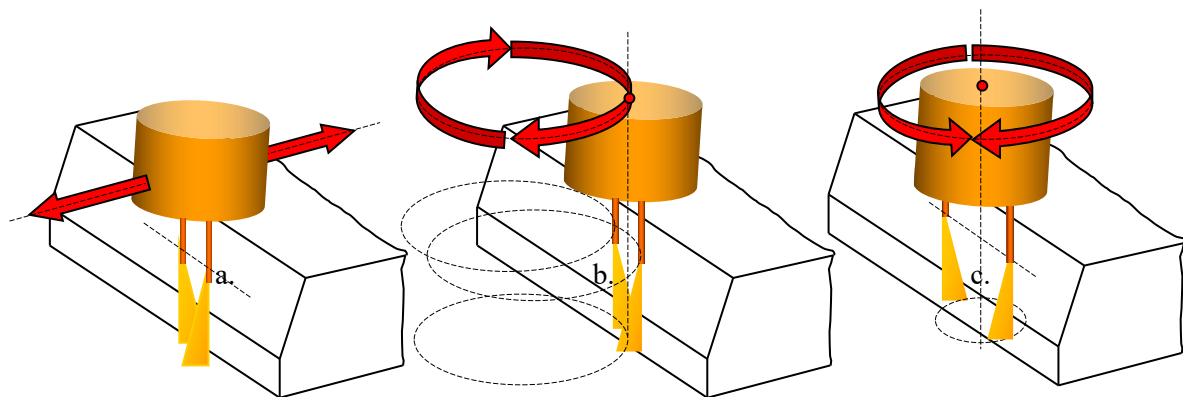
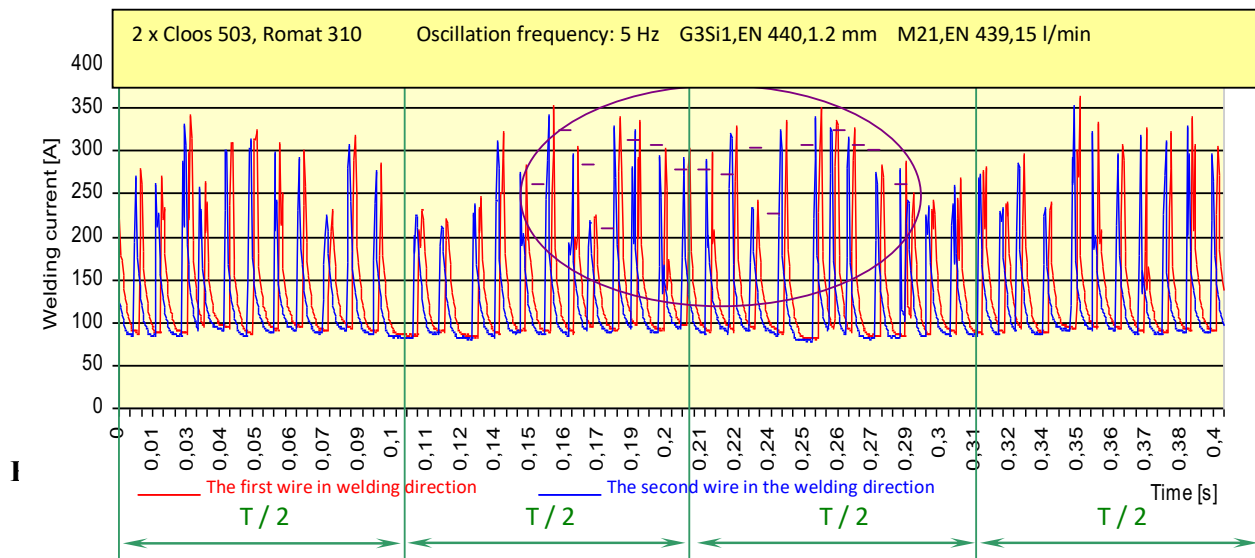


Fig. 2. Different types of the oscillating movement of the welding torch

The experiments that have been performed using the three types of the torch oscillation, revealed advantages and disadvantages for all of them.

When use a perpendicularly on the axis of the groove alternating translation the peaks of the signal are not very clear. That involves errors when the interpretation of the torch position is performed (figure 3). Even if this kind of the oscillation is simple and very facile, the results are difficult to be used in interpretation. That is happening when the plan of the welding wires is parallel or contains the axis the welding groove.

When use rotation of the welding torch using a rotation axis that is not positioned between the two wires, on a point of the groove a few welding passes are made, so, for every point, in time different values of the welding current are obtained (figure 5). That means difficulties in interpretation and correction processes.



When the plan of the welding wires and the axis of the groove are not parallel, an angle exists between them and the signal of the welding current becomes chaotic for the interpretation system (figure 4).

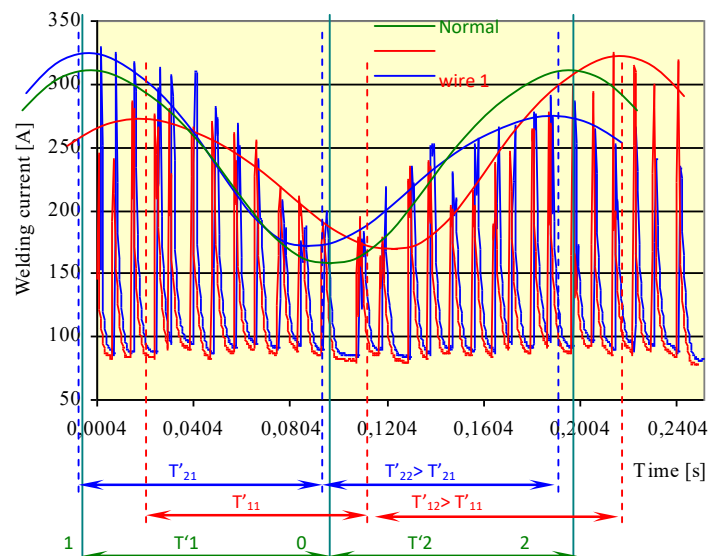
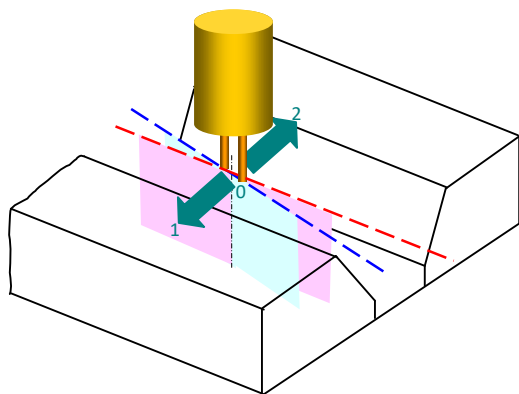


Fig. 4. Errors given by the non-parallel position of the plan of the welding wires to the groove axis

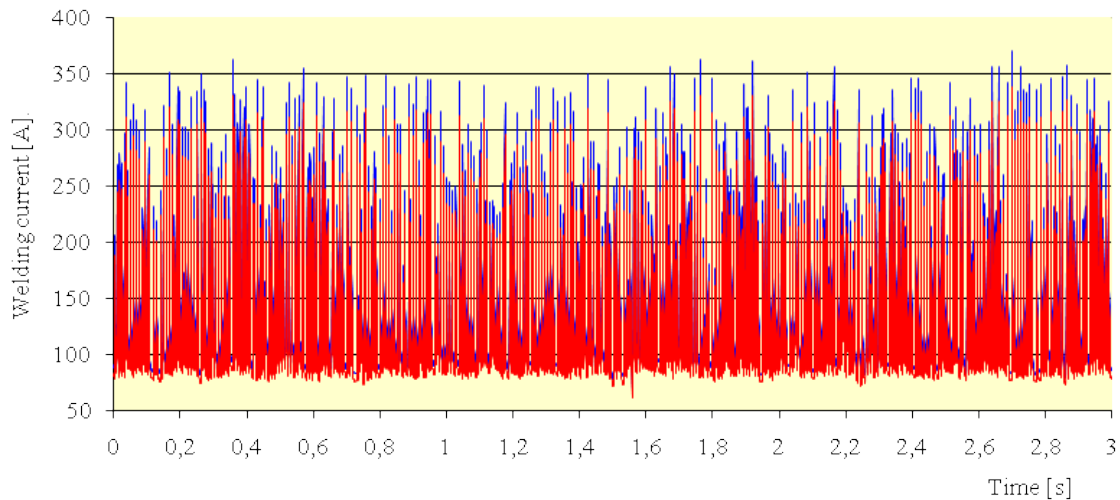


Fig. 5. Welding current when rotation of the torch is performed

When use rotation of the welding torch using a rotation axis that is symmetric axis of the torch, facile to understand and translate the signal it will be obtained (figure 6). The difference between a maximum peak and the next minimum is large and that will help the comparison unit. The values of the maximum peaks exist in a small range and that is helping the interpretation of the signal in the process of correction.

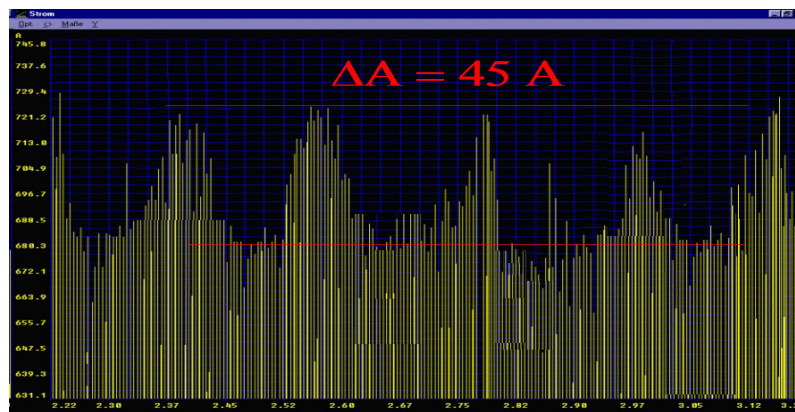


Fig. 6. Signal of the welding current for the third type of movement

The three types of the oscillation are mixed movements. They are a continuous combination between the travel movement of the torch and an oscillation movement that creates the periodical modification of the welding parameters. Because of that the equation of the mixed movement is a relation in frequency of the oscillation. That means that the trajectories of the wires depend on the frequency. The signals of the welding parameters, on every wire, are in strong relation with the trajectory of the wires, so the signals depend on the frequency of the oscillation, too. For example, considering the third type of movement (figure 7) the equation of the trajectories of the wires is as follows.

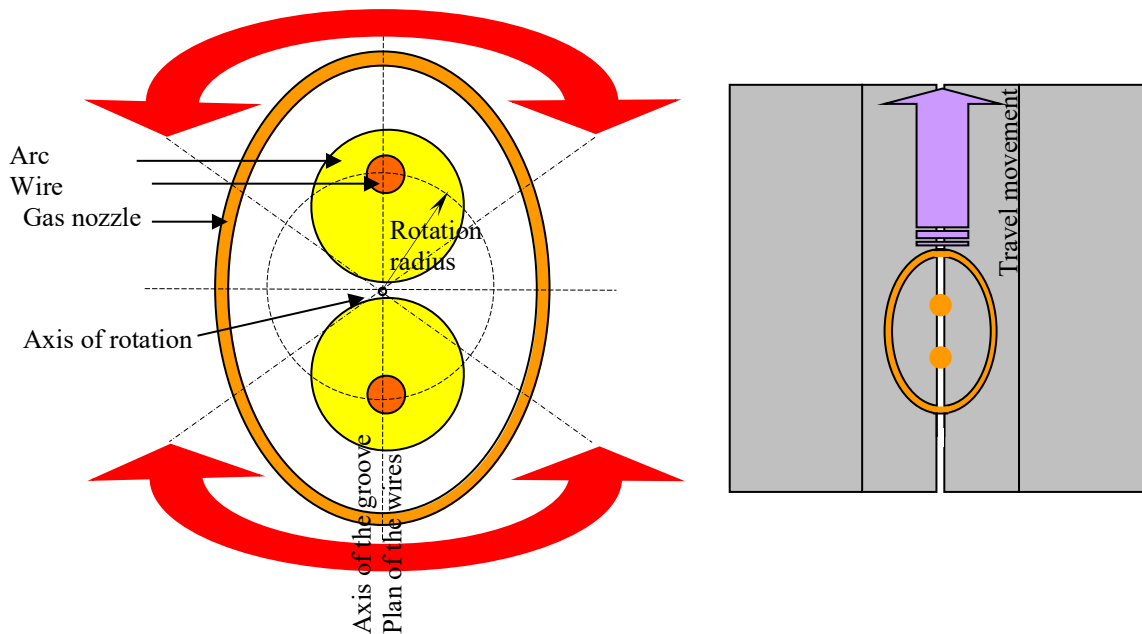


Fig. 7. Mixed movement of the torch in the third case

The instant position of a wire, in the travel movement is done by the equation 1.

$$y_t = v \cdot t \quad (1)$$

The instant position of a wire, in the rotation movement is done by the equations 2 and 3.

$$x_c = R \cdot \cos \omega \cdot t \quad (2)$$

$$y_c = R \cdot \sin \omega \cdot t \quad (3)$$

Using the time variable to mix the two movements, the equation of the combined movement can be obtained (equation 4). The equation shows that the instant position of a wire depends on the frequency of the rotation.

$$y = R \cdot \sin \left(\arccos \frac{x}{R} \right) + v \cdot \frac{\arccos \frac{x}{R}}{2 \cdot \pi \cdot f} \quad (4)$$

3. EXPERIMENTAL TESTS TO REVEAL THE INFLUENCES OF THE TORCH OSCILLATION FREQUENCY

Equation 4 shows that the frequency of the torch oscillation influences the instant positions of the wire inside the groove. Because of that the frequency is influencing the current signal, also. The through-the-arc sensor needs clear, periodical and repetitive signals. That means that for every type of the groove large differences between a maximum and a minimum that are successive should exist. A

second characteristic of the signal is the range of the peaks. If the differences between the peaks are large, the interpretation of the position is difficult to be done.

The frequency of the oscillation influences the range of the signals peaks. A small range gives good conditions for the interpretation of the torch position. Experimentally have been determined the dispersions of the peaks values for the three types of movement (figure 8 a, b, c).

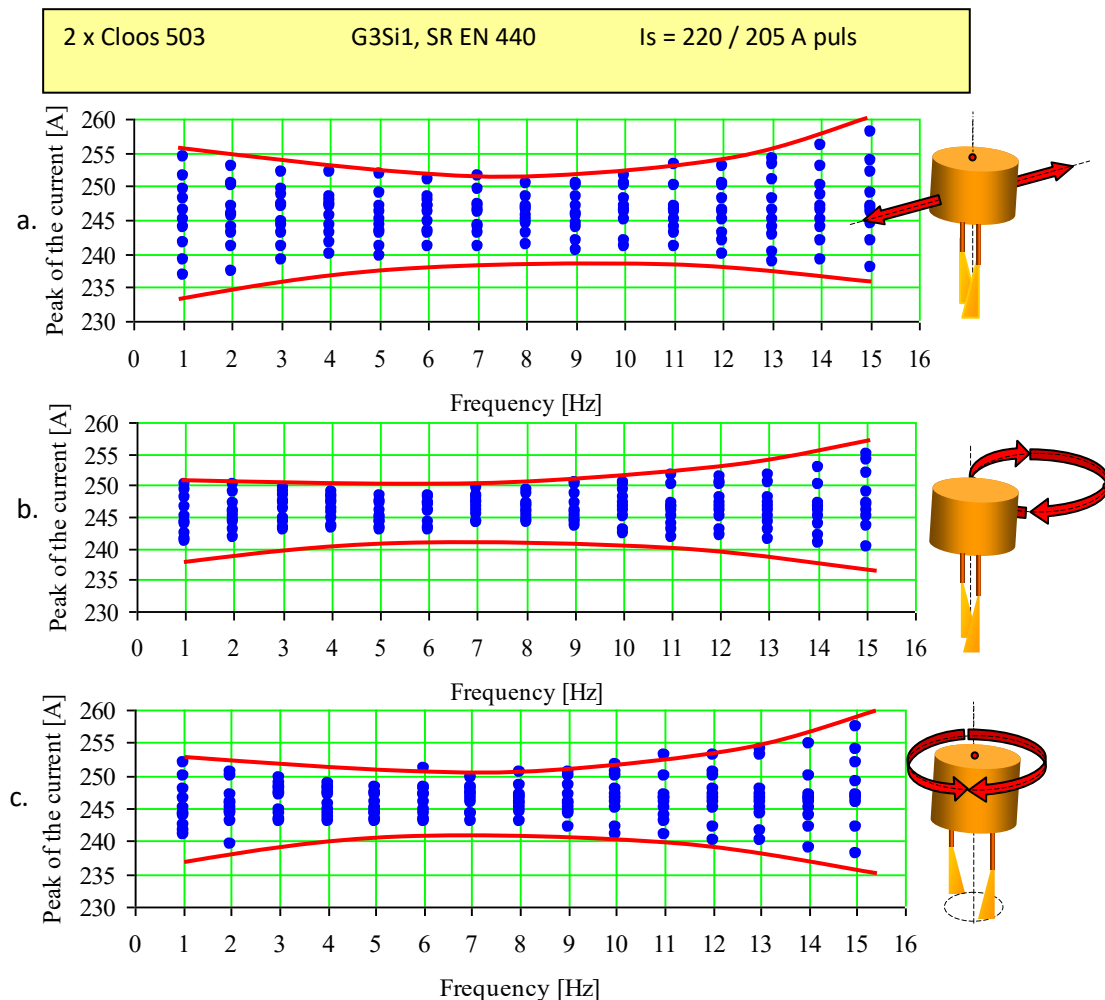


Fig. 8. Range of the peaks for the three types of movement

Another important observation that comes from the experimental analysis is that the frequency of the oscillation influences the difference between a maximum and a minimum that are successive. For a good function of the through-the-arc sensor the difference should be as large as possible. Being large it can be easily detected and interpreted by low performance data acquisition systems also, not only by the top performance systems. If the difference between a maximum and a minimum that are successive is low, errors in interpretation of the torch position could be involved. The experiments that were conducted on steels and on aluminium alloys, with different frequencies, revealed that the level of the welding current influences the difference between a maximum and a minimum, also.

Figure 9 a, b shows the experimental values of the difference between a maximum and a minimum for different frequencies when weld low alloyed steels.

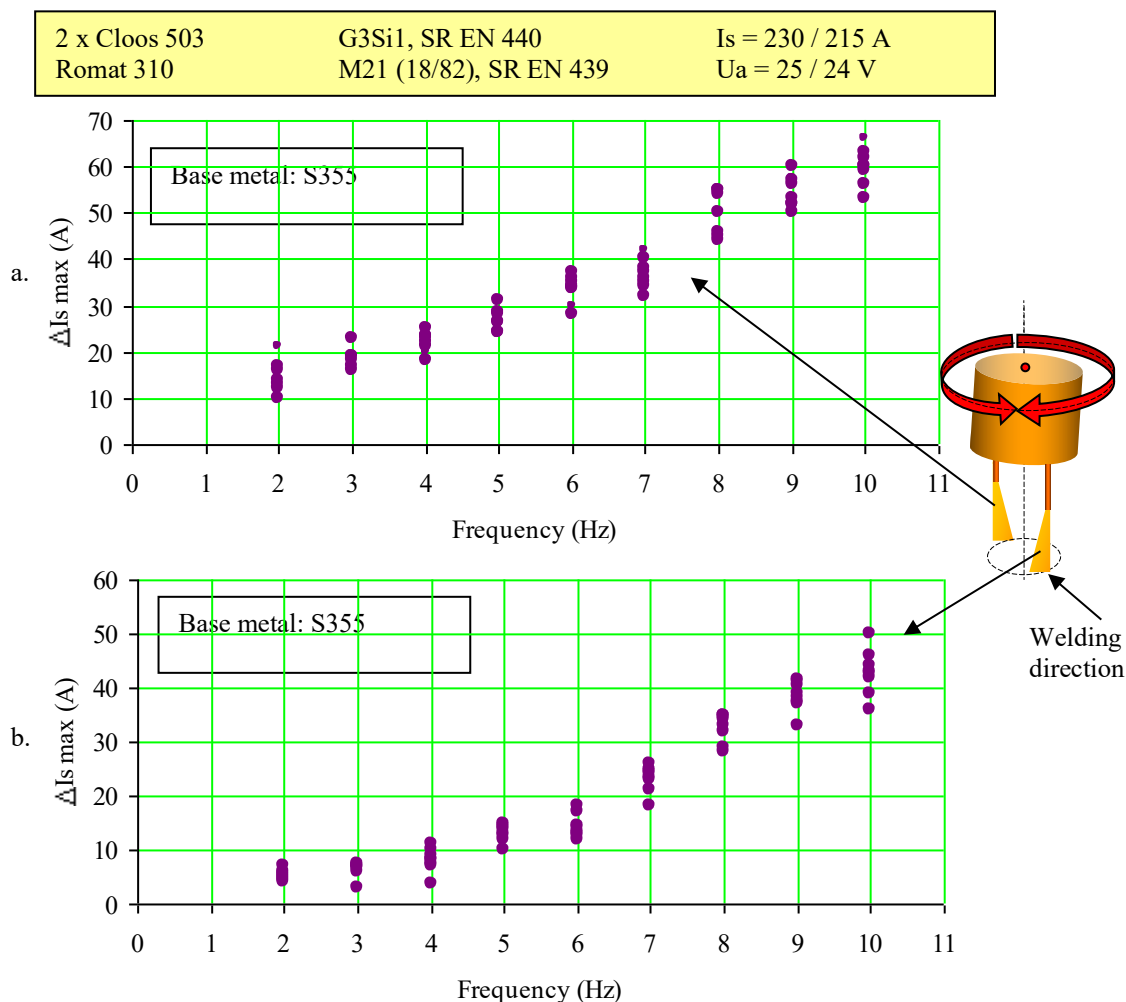


Fig. 9. Influence of the frequency on the difference between a maximum and a minimum when weld low alloyed steels

Figure 10 a, b shows the experimental values of the difference between a maximum and a minimum for different frequencies when weld low alloyed steels.

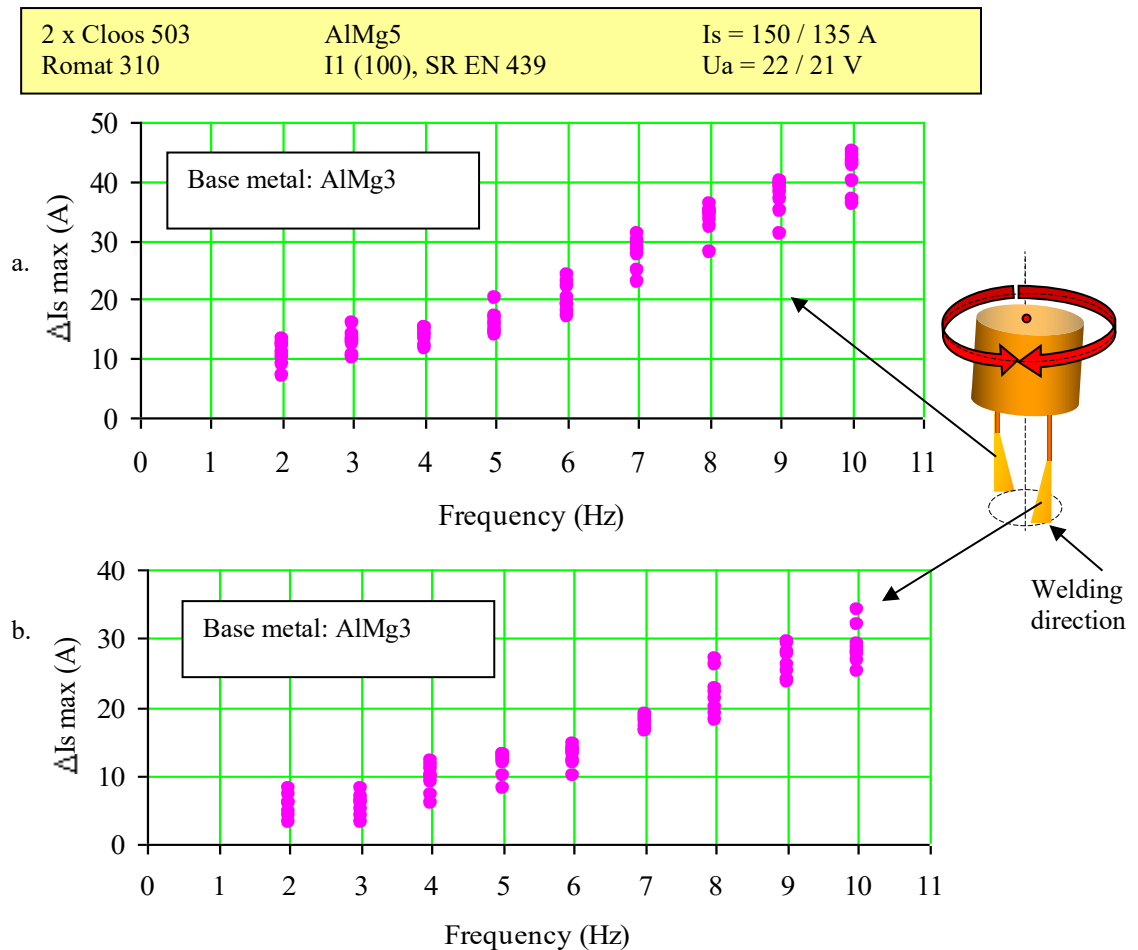


Fig. 10. The influence of the frequency on the difference between a maximum and a minimum when weld Al-Mg alloys

4. DISCUSSIONS AND CONCLUSIONS

The configuration of the two-wires welding system permits a few types of oscillating movements when the torch is acting as component of a through-the-arc sensor. Three of those types have been studied from the quality of the signal point of view. The first type of the oscillation, a perpendicularly on the axis of the groove alternating translation, offers a signal that has not very clear peaks. The range of the maximum values of the current is large even if the groove is constant in shape and dimensions. The large range is coming from a short vibration of the torch when the direction of the movement is changed (figure 11). That vibration is usually in connection with a delay of the start in the opposite direction. That means that the movement is not continuous and because of that the signal of the current it cannot be considered as periodical function. The vibration is determined by the fast turn requested by the frequency of the movement. Short and low amplitude vibrations have been obtained for low frequency of the oscillating movement (0.5-2 Hz). When the frequency was higher than 2 Hz the

amplitude of the vibration was high enough to give 15-30 A range of the peaks existence. That means errors in the interpretation process of the torch position and the correction becomes not possible.

The second type of the oscillating movement gives non-uniform signal because on a point of the groove 3-5 arc passes are performed. If the frequency of the oscillation is low the number of the superposed passes is increasing. Only the first pass gives good information about the position of the torch. The next passes are done on the first deposition so the arc becomes shorter with a new pass. That means that the current is increasing with a new pass. The main advantage of this type of oscillation is that no vibration happened because the movement is continuous.

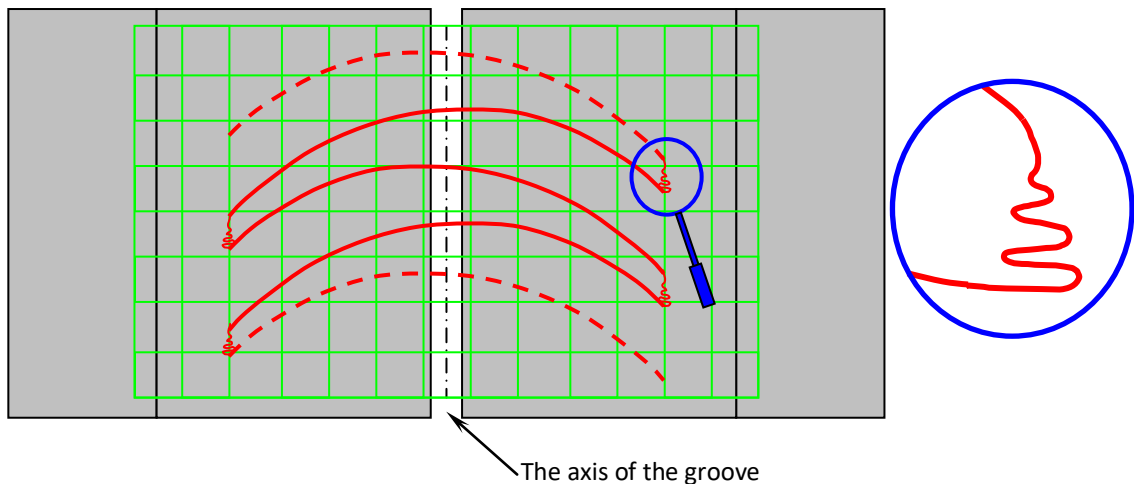


Fig. 11. The result of the vibration of the torch when change the direction

The third type of the oscillating movement gives better results than previous. The first wire is passing directly on the groove and the signal is continuous, periodical and offers real values. The second wire is acting on the deposition of the first wire, but the increasing of the current is the same on the entire weld length, so, it is facile to be corrected when perform the interpretation of the position. The vibration is low when the direction is changed, so it can be neglected. The obtained signal is easy to be processed because is very closed to a co-sinusoidal curve.

Two parameters are important for the quality of a periodical signal that is necessary to be processed: the values range of the signal peaks and the difference between a maximum and a minimum that are successive. The first parameter should have a minimum value and the second parameter should have a maximum value to have good conditions for the interpretation. The both parameters are strongly determined by the frequency of the torch movement.

For the range of the peaks, the experiments revealed that using a 4-11 Hz frequency the range of the peaks is 6-15 A. If the frequency is lower than 3-4 Hz or higher than 10-11 Hz the peaks are too different to have a precise interpretation of the torch position. Comparing the three types of movement the third offers a larger range of frequency for a low range of peaks values.

For the difference between a maximum and a minimum a higher frequency gives a higher difference between a peak and a valley of the signal. The frequency has an up limit and that is given by the mechanical system that creates the movement. The experiments revealed an optimum of the frequency: 6-9 Hz.

Combining the two ranges for the frequency value an optimum range can be obtained and this is 4-8 Hz. When used values from this range, the software of the sensor had the possibility to offer precise information about the instant position of the welding torch.

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