Advantages of MAG-STT Welding Process for Root Pass Welding in the Oil and Gas Industry

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Abstract: **This paper describesthe basics of modern MAG-STT welding process and its advantages for root pass welding of construction steels in oil and gas industry. MAG-STT welding process was compared with competitive arc welding processes (SMAW and TIG), which are also used for root pass welding on pipes and plates. After experimental tests, the obtained results are analyzed and presented in this paper.**

Keywords: **MAG, STT, welding, root pass.**

1. Introduction

In the oil and gas industry, engineers and welders are faced with very complex problems during welding, which requires well-trained team of welders and engineers [1]. The most commonly used welding processes are: SMAW, MIG/MAG and TIG. Each of these processes has its advantages and disadvantages, so welding can be performed by combination of these to achieve the required quality, and it depends of the type of base material (BM), the thickness, etc. [2]. Root pass welding requires a "great" quality, because root pass is most common place for errors in weld, and also represents a major challenge for the welders.

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Today, for pipes welding with large diameter and thickness of BM, most commonly used processes for root pass are SMAW with cellulose electrode or TIG, and filling passes can be performed with other arc welding processes.When to use TIG or SMAW process, it depends on the required quality and the welding time. In order to increase efficiency and competitiveness, on the market we can find many various modifications and improvements of conventional welding processes. This is the case with MAG-STT (Surface Tension Transfer) welding process from Lincoln Electric company [2].

2. Characteristics of MAG-STT welding process

MAG-STT is a modern welding process that represent a significant innovation in the field of metal arc welding processes. Because of "great" quality of root pass welds on pipes and welding thin plates, which are similar to the weld quality obtained by TIG, we can see increasing application of MAG-STT process in practice [2].

MAG-STT is a modern, high efficient and high quality welding process for welding of thin wall materials and root pass on thick materials [3]. STT process is based on short arc metal transfer, and the separating of droplet is performed by surface tension transfer [1]. The key to STT technology is in its ability to control the current independent of wire feed speed. This means that we can use more or less current without adding more wire. The Surface Tension Transfer – STT process was named by the way this technology monitors and controls the surface tension of the weld droplet as it adheres to the weld puddle. It does this through a high-speed inverter that precisely adjusts the output current waveform during the entire shorting cycle. This unique high frequency inverter technology is known as the Waveform Control Technology [4]. The main difference between MAG-STT and the conventional MAG-MIG welding process is in the way how it creates droplets of molten metal from the electrode and transfer them to the weld puddle, showed in Figure 1.and Figure 2.

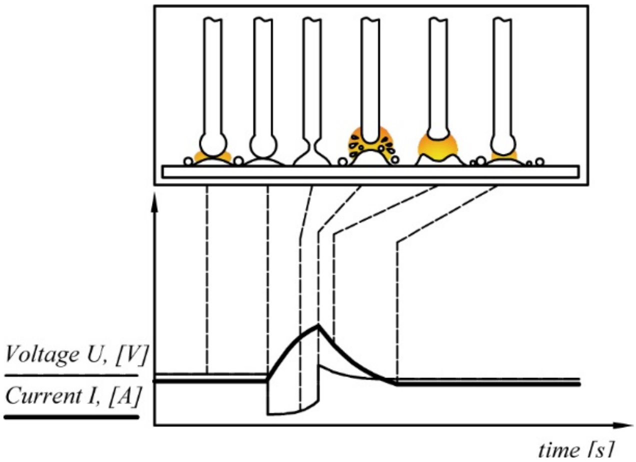

Figure 1.Conventional MAG-MIG welding process-creation and transfer of droplet

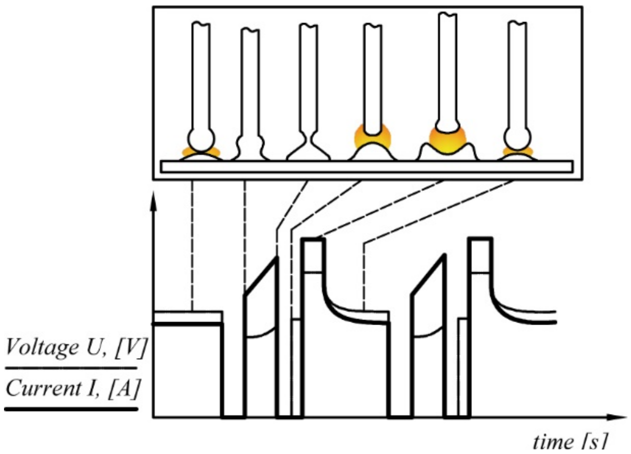

Figure 2.MAG-STT welding process- creation and transfer of droplet

To illustrate how this waveform technology works, Figure 2.shows six steps of the STT welding process.

The first step is characterized by a background current. This is the current level of the arc prior to the shorting to the weld pool. It is a steady-state current level, between 50 and 100 amperes. The wire approaches the base material.

The second step represents "ball time". It is the time interval needed to make the ball of melted material at the top of the wire. Just before the wire is about to complete the short, the voltage-sensing clip reads a decrease in voltage and the machine drops the amperage. In conventional short circuit welding, the short circuit would occur and amperage would rise dramatically. The background current is further reduced to 10 amperes for approximately 0,75 milliseconds.

The third step in one STT cycle is presented by the pinch mode. The wire is still being fed; therefore, fusion occurs between the wire and the base material. In order to transfer the molten drop, amperage must be increased. A high current is applied to the shorted wire in a controlled manner. This accelerates the transfer of molten metal from the electrode to the weld pool by applying electronic pinch forces. The electrode-to-work voltage is not zero during this period. This is due to the high resistance of iron at its melting point of 1560 ^{o}C. And wire begins to "neck" down or melt from the outside in.

The fourth step is characterized by the dv/dt calculation. This calculation indicates the moment before the wire completely detaches. When this calculation indicates that a specific dv/dt value has been attained, indicating that fuse separation is about to occur, the current is reduced again to 50 amperes in a few microseconds. This is to prevent a violent separation and explosion that would create spatter. Step four indicates that the separation has occurred, but at a low current.

The fifth step is characterized by plasma boost. Amperage is again increased and a controlleduniform separation takes place and creates the weld bead with little spatters. It is at this period of high arc current that the electrode is quickly "melted back".

The sixth step represents the period of the cycle where the arc current is reduced from plasma boost to the background current level. In this "tail-out" period, the current goes from this higher level down to its initial background level. The cycle then repeats itself, with the time required for one waveform taking between 25-35 milliseconds [4].

MAG-STT welding process has a number advantages and improvements compared to conventional MAG-MIG, SMAW and TIG welding process [2], [5] ,[6], [7]:

- controlled penetration and outstanding heat input control,
- excellent welding process for open root pass,
- lower spattering and shorter cleaning of welding joint,
- high welding speed and higher productivity compared with other processes (especially with TIG),
- reduced welding time,
- lightweight and compact design of welding device, which provides maximum flexibility in the workshop and on site,
- lower heat input (J/mm^2) and base metal deformation,
- satisfactory welding pool control during the welding,
- easy welding process automatization,
- higher root gap welding possibility,
- reduced training time.

3. Experiment

In order to determine the advantages of MAG-STT process for root pass welding, we made comparison with the conventional welding processes SMAW and TIG, which are also used for root pass welding in the oil and gas industry.The experiment consisted of two parts, i.e.welding of three pipe samples (88,9x3,2x150 mm, St 35.8/1) and three samples on plate (250x125 mm, S235JR). A butt joint, with two layers, is used to join plate and pipe samples, and welded in workshop conditions. Pipes and plates' samples are welded as shown in Figure 3.

During the experiment the measurement of the welding time is performed. Then the welding speed is calculated for each sample. After that, from the plate samples, specimens are prepared and root pass weld dimensions were measured. At the end, from the pipe samples, the testspecimens were prepared for tensile and bend testing.

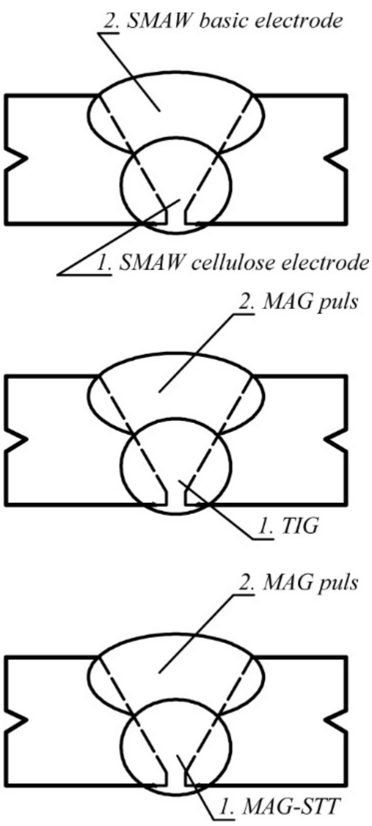

Figure 3. Welded pipes and plates- example of welding methods

4. Results and discussion

After analyzing the collected data, welding speeds for root pass on pipe samplesare showed in Figure 3.

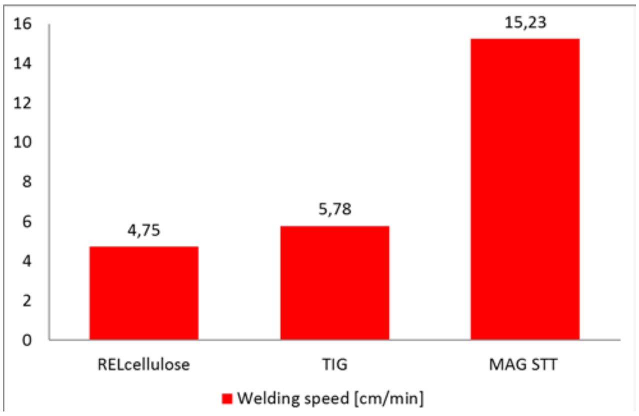

Figure 4. Pipe samples- root pass welding speeds

Figure 4.is showing that welding speed of root pass with MAG-STT process is up to three times greater than SMAW or TIG process, and weld quality is in range with TIG process.With the known values of welding speed and other necessary parameters, heat input [kJ/mm] was calculated (Figure 4.). Heat input is responsible for amount of heat input during welding and which may cause deformation of the base material.

The welding time could be reduced if the process is automated [8].

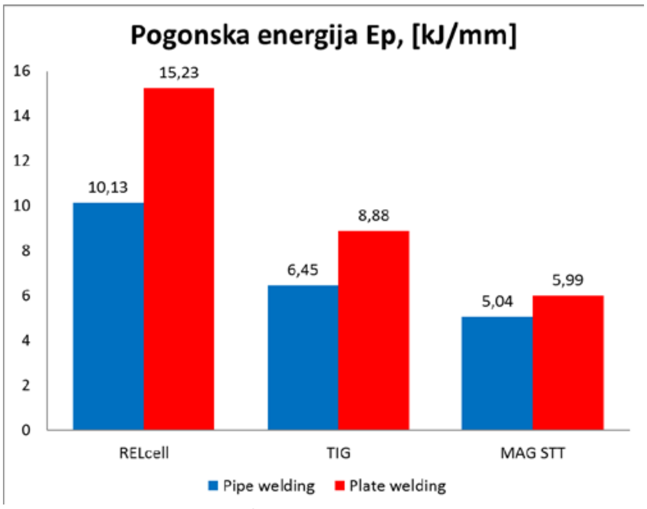

Figure 5. Amount of heat input during the root pass welding on pipes and plates

From Figure 5.it can be seen that MAG-STT welding process enables lowest heat input in base material, and this is the proof that we can use MAG-STT for welding thin base materials. After measuring the dimensions of root pass weld on plates, it can be seen that the significantly higher weld surface was achieved with MAG-STT than TIG process (Figure 6).

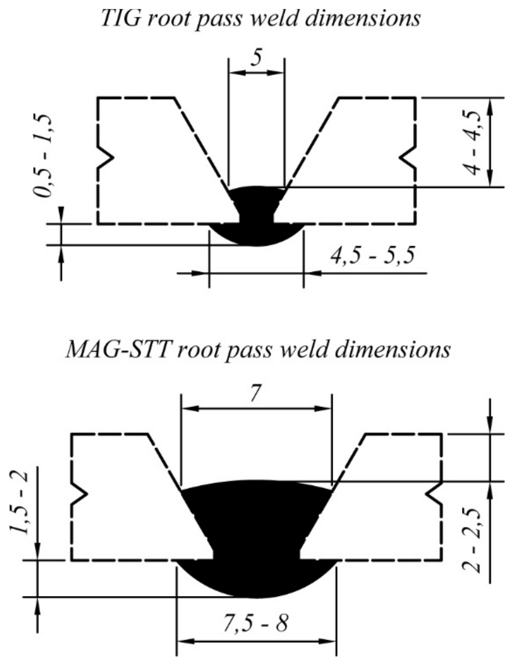

Figure 6. Root pass weld dimensions- TIG and MAG-STT process

With a large area of a root pass weld, MAG-STT process allows welding with greater root gap and slight misalignment. Based on the weld size of weld on plates and other data, deposition rate was determined and presented in Figure 7.

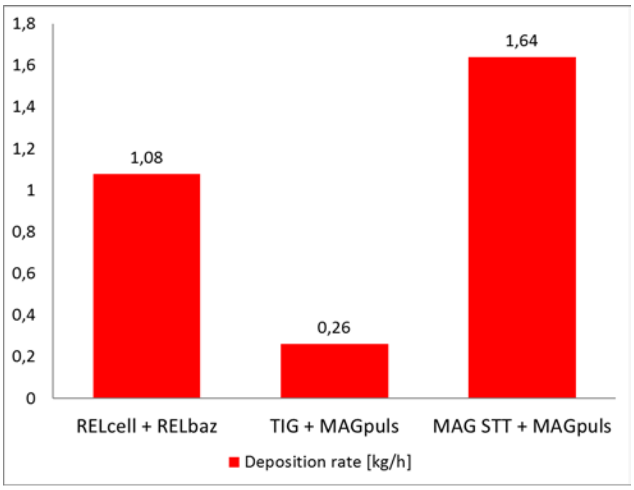

Figure 7. Deposition rate due plates welding

MAG-STT welding process achieved great deposition rate (1,64 kg/h), and it is almost two times faster than SMAW and about six times faster than TIG. This is amazing advantage for root pass welding, because with this, welding can be executed faster and in the end it means with lower cost.

Also as a result of the experiment, we have confirmed a significant reduction of spattering which also results reducing cleaning time of the weld. Except this, the amount of fumes and gases compared to conventional MAG, SMAW and TIG process is reduced, which has positive impact on the welders' health.

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