Maximising Output in High-Frequency Tube and Pipe Welding

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Abstract

The authors evaluate the parameters that influence welder performance and scrap production during changeover in the high-frequency tube and pipe welding process. The paper focuses on the welder system's features during changeover. The parameters involved are welder recipes, energy consumption monitoring, and matching capabilities.

Introduction

Maximum throughput in a high-frequency tube and pipe mill is achieved by a welder that features:

- High uptime
- Consistently high weld quality (to minimise scrap)
- Flexibility
- High total electrical efficiency

High uptime is a prerequisite for high throughput and was addressed in the paper *Maximising Uptime in High-Frequency Tube & Pipe Welding*[1]. Key design features for maximising uptime are:

- The welder must withstand short circuits
- The welder must work with high ambient and cooling water temperatures
- The welder should not feature continuously operating mechanical parts in order to avoid problems caused by fatigue, wear and jamming
- The welder should be based on IGBT transistors, the most rugged inverter switch available

Flexibility means a welder that can:

- Perform over a wide product (tube/pipe/profile) range
- Weld different materials

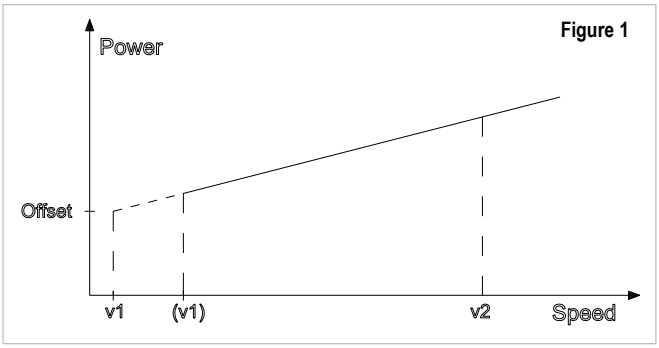

Figure 1

- Ensure short changeover times, with minimal operator intervention
- Contribute to easy start up of new products, with minimal scrap production

The topic of achieving consistent high weld quality was covered in the paper *Maximising Output in High-Frequency Tube and Pipe Welding*[2]. This document is a continuation of that paper, and focuses on how to achieve consistently high weld quality and welder flexibility during changeover.

Important features during changeover

Minimising scrap requires that the least possible amount of steel strip is consumed during a changeover. This means that the mill and welder parameters from previous successful production runs should be available as a recipe for the next product. The recipe should be downloadable to the welder's control system, and should be used to automatically preset the required settings for automatic power/speed control for the product to be welded. These settings are:

- Adjustable mill speed at which weld power is turned on, to minimise scrap
- Start weld power offset
- Weld power-speed gain slope

Where temperature monitoring is in use, the weld temperature set-point and acceptable temperature tolerances must be included in the recipe. The use of recipes relieves the operator from performing test runs to find the correct power input and weld quality for the next product.

It must be emphasised that successful changeovers do not rely solely on the use of recipes for the welder parameters. Experience shows that the mill (weld) set-up is extremely important for weld quality and power consumption. The mill set-up parameters should definitely be defined in a mill set-up recipe and, together with the welder recipe, should be available for the overall mill quality system. Recipes for existing products can also be used as good starting points when new products are to be welded. This minimises scrap, and reduces start-up times for new products – thereby maximising mill throughput.

At the end of changeover it is important that the operator can quickly see whether the mill is properly adjusted or not. He should also see that coil and impeder size and position, as well as impeder cooling, are correct. If these parameters are within reasonable limits and the correct welder recipe is downloaded, energy consumption will be

roughly equal to that achieved in a previous successful production run. This indicates that the set-up is within specified limits. Therefore, the welder system should include the possibility to display the energy consumption factor and the accepted tolerances from the previous reference run. The tolerance values should be available as part of the welder's recipes.

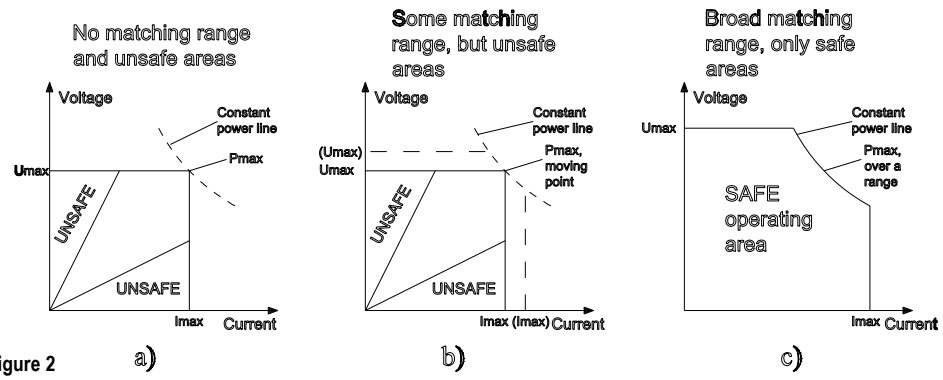

Figure 2

Changeover and welder flexibility

The mill operator has many tasks to perform during a changeover. In this situation, it is beneficial if the operator does not have to perform several adjustments to the welder or coil in order to achieve safe and reliable welder operation. Different welder designs influence this part of the operator's workload. Some welder manufacturers offer welders with matching capabilities, while also offering cheaper versions that lack this important feature. In other words, the welder does not have any means of matching the load to the power supply. Other manufacturers such as EFD Induction ensure that all their welders are equipped with a matching range.

A welder with some means of matching – ie featuring a matching range – is a welder with the capability to match the different loads' electrical characteristics (impedances) to the power supply of the welder, in order to deliver nominal (maximum) output power. The impedance is influenced by the tube dimensions, mill weld setup and induction coil size and position. For a welder without matching range the coils must be specially designed to match the load (coil and steel strip) to the welder's power supply.

These welders have only one operating point at which nominal power is available. It is not feasible to reach this single point for more than a few tube dimensions through coil design alone. This means that the welder's available output power and weld speed is extremely sensitive to weld set-up variations. If the single optimal coil is damaged, a replacement coil, originally designed for a larger size tube, will reduce available power and throughput. In a situation like this, the number of test runs and the amount of scrap will increase. Moreover, to obtain nominal power through coil design can also lead to a coil that does not optimise the weld process. The end result compromises throughput in steady state operation, not only during changeover.

A welder with some means of matching may not be straightforward to use during changeovers. Whether or not this is the case depends on how the matching feature is implemented. Welders are available with and without some matching range, where parts of the total operating area are unsafe (Figure 2a and 2b). In these cases the operator is responsible for running the welder within the safe area. The welder (inverter part) is likely to be damaged if operated in unsafe areas. Welders with such implementation of matching are better than welders without matching range, but they clearly place more demands on the operator, and require more test runs at changeover, thereby increasing scrap. The best overall solution is a welder with a broad matching range to cope with unexpected operating conditions and the practical tolerances required and given by the total weld process. A welder offering a total operating area, completely without any unsafe areas is, without doubt the best choice (Figure 2c). The EFD Induction Weldac offers this feature, thereby ensuring easy operation during changeover. This in turn minimises scrap and changeover time.

Conclusions

Maximum throughput in a high-frequency tube and pipe mill requires a welder that contributes to consistent quality and minimum scrap production. The evaluation of the parameters influencing quality and scrap production, conducted both in this and a preceding paper[2], has led to the following conclusions:

- Stable weld temperature requires a weld output power without low frequency ripple. A welder with a passive diode rectifier, some smoothing circuitry and rapid power regulation in the inverter is the best overall solution. This is particularly true in order to meet the strict requirements of high speed mills and mills producing stainless steel tubes.
- Recovery after short circuits in the load is optimised by welders with ultra-fast power regulation in the inverter.
- The use of welder recipes, including energy consumption monitoring, minimises scrap during changeovers. It also ensures fast changeovers and repeatable quality and production.
- EFD Induction strongly recommends welders with automatic matching, without any unsafe or restricted operating areas.

References

[1] "*Maximising Uptime in High-Frequency Tube & Pipe Welding*"; B Grande, JK Langelid, O Waerstad, *Tube & Pipe Technology*, March 2011
[2] "*Maximising Output in High-Frequency Tube & Pipe Welding*"; B Grande, O Waerstad, *Tube & Pipe Technology*, September 2011

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