# Successful upgrading of old induction melting furnaces – a contribution to saving energy and increasing melting rates

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The upgrading and extension of existing equipment offer a great potential for saving energy, increasing output and reducing downtimes. In light of the fact that the costs are considerably lower than for new investments and erection times shorter, it is worthwhile to take a closer look at this alternative.

In times of ever increasing energy prices, users should reap the benefits of upgrading existing equipment with a view to cutting costs and increasing output, especially with regard to melting operations which represent more than 60 % of a foundry's total energy consumption.

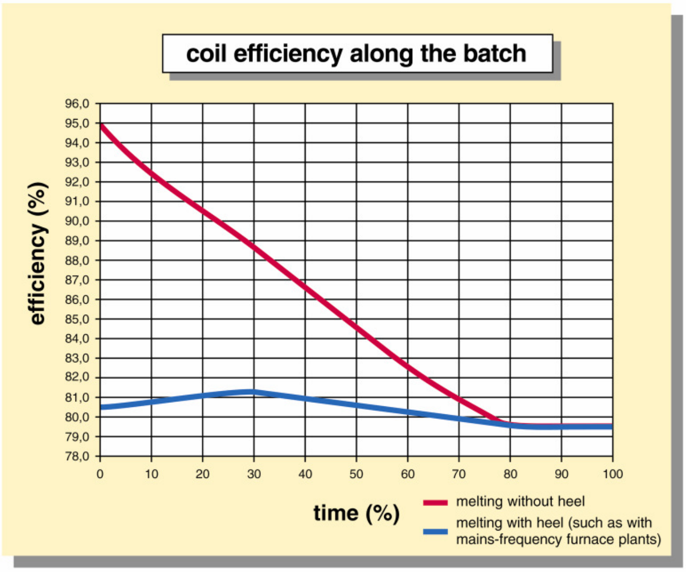
The state of the art in inductive melting technology is the coreless medium-frequency induction furnace, a flexible and powerful melting tool which due to its many advantages has largely superseded the mains frequency furnace. These furnaces are powered through reliable low-loss frequency converters providing operating frequencies in the 60 to 3,000 Hz range. Initially, these systems relied on rotary and magnetic converter technology (e.g. quintuplers) which were characterised by significant power losses. The most recent development by OTTO JUNKER in the medium power range are IGBT converters which use the latest transistor technology in the inverter instead of thyristors.

## Basic solutions

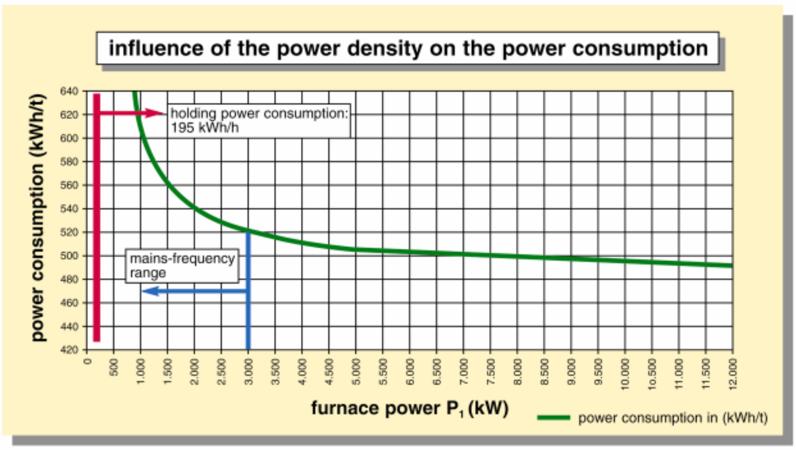
The advanced medium-frequency converter technology in conjunction with today's sophisticated process control systems offer following major avenues to cutting energy costs and increasing melting rates of old equipment:

1. The efficiency of modern converters is between 96 and 97.5 %, whereas older converter systems (e.g. quintuplers) are hard-pressed to reach values of up to 88 %.

2. The conversion of mains frequency furnaces to medium frequency technology enables you to melt without heel, meaning that you can start the furnace in batch operation with solid charge materials. For the melting of iron materials this provides improved electro-magnetic coupling, resulting in energy savings of about 8 %.




3. Converting mains frequency furnaces to medium-frequency technology also enables them to realise a higher power density. Increased power densities cut the melting times and reduce thermal losses, which also translates into energy savings.




4. Advanced converters with digital control systems are characterised by a largely automatic operation of the switchgear and enhanced control and monitoring of all sequences of operations. Any faults which may occur are reported and diagnosed in timely manner. Also, the installation of a modem permits remote monitoring and instant troubleshooting from the manufacturer's site.

5. The elimination of all mechanical switches implies a significant reduction in maintenance and the possibility of infinitely variable power control.

The starting point for all considerations should always be an analysis of the condition and weak points of the existing equipment. The objectives of the upgrade should also be clearly formulated. It makes little sense to install a new converter on an obsolete furnace and accept a number of inevitable drawbacks if it means that a new furnace needs to be purchased in two years from then. On the other hand, an overhaul of older equipment components may often be conducive to achieving significant service life extensions and cutting downtimes. Factors to be taken into account in such an evaluation are the maintenance and repair efforts for the existing equipment as well as the availability of spare parts.
All this means that the decision as to which actions make sense can only be taken on a case-to-case basis for every specific furnace.

With regard to upgrades and extensions of existing coreless induction furnaces, following possibilities are available more specifically for the units which determine the furnace capacity:

- Conversion of mains frequency furnaces to medium-frequency technology
- Replacement of old converter systems (quintuplers etc.) by advanced medium frequency switchgear
- Conversion of a monomelt system into a tandem system (installation of a second furnace)
- Use of a more powerful converter system
- Conversion to advanced PLC-based process control systems with JOKS melting processor
- Use of advanced monitoring and control systems (crucible monitoring with *OCP*, by way of example)

## Implemented projects

In the following we will present the achievable results on the example of some completed upgrading and extension projects.

### Conversion of mains frequency melting furnaces to advanced IGBT converter technology

By way of example we would like to shortly present the successful conversion of two coreless mains frequency furnaces in the anode rodding shop of Soer-Norge Aluminium AS in Husnes, Norway.
The objective of upgrading the more than 20 years old furnaces with a capacity of 2 tonnes of cast iron was to improve their availability and increase their throughput capacity. The upgrade was to be focused only on absolutely mandatory equipment items in order to limit costs and erection times.

*View of the existing furnaces at Soer-Norge*

Only five days were available for installation work on each furnace, commissioning and performance tests were carried out on the sixth day.

The upgrade essentially comprised the supply of the rectifier-transformers, two advanced IGBT converter units with capacitor module, an additional water recooler for the two converters, the installation of weighing systems, the "JOKS" melting processor and a set of new coils. A modern type S 7-300 Siemens control system and the visualisation of all functions and operating sequences on a type 670 Siemens PC round off the scope of supply. The photo shows one of the new IGBT power packs designed for a power rating of 750 kW and a frequency of 100 Hz. The frequency was selected on the assertion that charges can be molten without heel, giving a major advantage over the old mains frequency systems. The conversion to melting without heel and the new converter technology cut the energy consumption for melting by about 10 %.

*New frequency converter system at Soer-Norge*

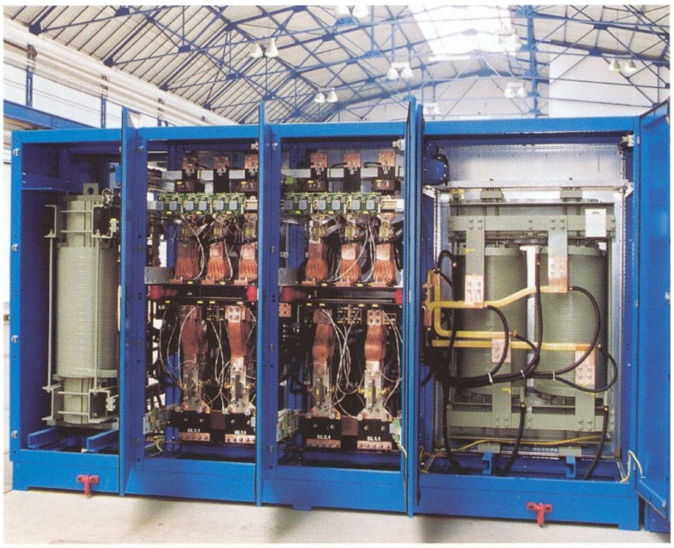
## Replacement of quintuplers with new converter technologies

Renowned iron foundry Nippes & Schmidt in Solingen/Germany was one of the first to use coreless medium-frequency furnaces by OTTO JUNKER with quintupler technology in 1965, and in 1970 they ordered another OTTO JUNKER furnace of this design.
After 30 years of reliable operation these furnaces were upgraded to new converter technology in 2001. In this project it was possible to limit the conversion work to the bare minimum: only the converters (600 and 500 kW) with the associated transformers and control cabinets were newly installed. All the other assemblies such as the furnace units (with a capacity of 500 respectively 1000 kg), capacitor racks and water recooler could be retained without modifications. Following a short installation period the equipment was successfully commissioned and started up. The photo shows the furnace platform with the new converter system.
The achieved energy savings and increased melting rates of about 12 % resulted solely from the lower losses in the advanced converter systems, as the power source rating was not increased.

*Furnaces at Nippes & Schmidt after the upgrade*

Another successful conversion of an old melting plant with quintupler switchgear to advanced thyristor-based frequency converter technology was implemented in the iron foundry Bruzaholms Bruk in Sweden. The plant comprises two 1.5-t furnaces with a rating of 1200 kW.
In this instance it was possible to keep the complete furnace plant including yokes, hydraulics and water recooler for the furnace cooling circuit. Only the electric switchgear was renewed: the quintupler was replaced by a thyristor-based frequency converter and a new rectifier-transformer was supplied. The new converter system was based on the DUOMELT concept with infinitely variable power distribution to both furnaces.

The scope of supply was completed by a new water recooler for the converter cooling circuit.



*IGBT converter cabinet at Bruzaholms*

The investment costs were only about a quarter of the costs for a new investment. Production downtimes for the conversion work could be limited to a very short period of time.

As a result, energy consumption was cut from 630 to 535 kWh/t, corresponding to a 15 % saving with an identical rated power of 1200 kW.

For the melting of 4000 tonnes of steel per annum this amounts to energy savings of 380,000 kWh.

The melting rate was increased from 1.3 t/h to 1.85 t/h, or by more than 40 %. This improvement of the melting rate has been made possible by a lower energy consumption and more efficient use of the power source by the DUOMELT technology.
The converter system was rated and dimensioned with a spare capacity of 300 kW to allow for further increases in melting rates with a future installation of new, bigger furnaces.

## Replacement of an old Siemens converter system

The Siemens converter system of the 10 t holding furnace of the Krefeld works of iron foundry SCHMOLZ + BICKENBACH GUSS GmbH & Co. KG had been getting on a bit, and the increasing number of malfunctions, expensive repairs and the lack of spare parts all spoke in favour of a new modern switchgear.

The special challenge in this project was to interface the switchgear with a furnace of a different make and previously modernized control and operator systems while reusing the existing rectifier-transformer.

The choice fell on a thyristor-based frequency converter with a rated power of 1200 kW, a digital control system and a suitably dimensioned capacitor module.

For the interface with the existing, upgraded operator and control level the analog values of the converter were supplied as signals, and the fault alarms displayed on a separate panel in the converter cabinet and also transmitted to the operator and control system level.

This was most certainly not an every-day upgrade, but the integration of the new converter system with the existing equipment is proof of the fact that highly equipment-specific solutions can successfully be implemented.

## Use of an advanced control system

For the Turkish subsidiary of Messrs. E.G.O. Elektro-Gerätebau, the objective was to make their existing melting operations more reliable and reduce energy consumption with a limited budget.

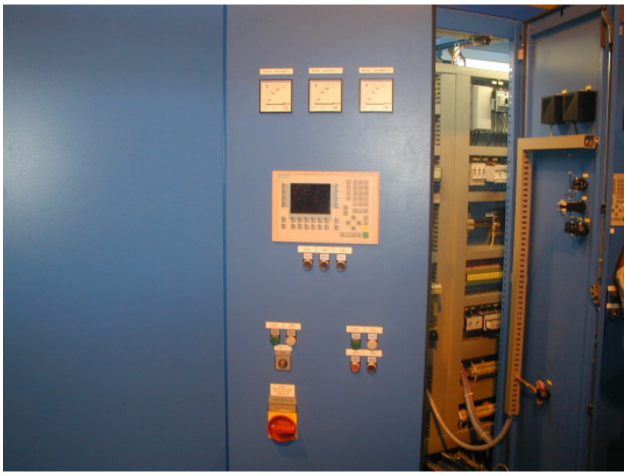
The melting operation of the foundry located near Istanbul comprised 6 coreless mains frequency furnaces with a capacity of 3 tonnes each which are fed alternately by 5 power packs rated 800 kW each.

The new installation included a modern control and operating system based on an S 7-300 PLC by Siemens with a new operator terminal with text display. The new control environment provides a high degree of automation - power factor correction is no fully automatic and the melting and holding cycles are controlled in accordance with defined power input setpoints.

The demonstrated results were energy savings and increased melting rates with a significantly improved reliability of the equipment.

The following 2 photos show the equipment control system **before** and **after** the successful upgrade.

***Before:*** *Old control system at E.G.O.*



***After:*** *New control system at E.G.O.*

## Conversion of a monomelt into a tandem system

In a first project phase, a Finnish foundry operated a monomelt system of one furnace with 8-tonne capacity on a converter with a rating of 3.800 kW for the melting of cast iron. In the course of a capacity upgrade a second furnace was installed and the computer-controlled power switch-over feature activated.

The starting point of this extension was the analysis of the idling times of the monomelt system which amounted to a total of at least 10 minutes per heat. During this time, the available converter power could not be used for melting.

The calculations made before procuring the second furnace presumed that during these 10 minutes, more then 95 % of the available converter power could already be used for melting in the second furnace. Furthermore, the other furnace can continue to run at full power during the relining operation which takes place every three weeks.

All in all, this yielded an increase in actual melting rate of 30 %, or to be more precise from 4.7 to 6.1 t/h.

The computed increase in melting rate by the installation of a second furnace and the resulting conversion to automatic tandem operation could be demonstrated after commissioning.

### Retrofit of crucible monitoring system *OCP*

The *OCP* system developed by Otto Junker in cooperation with LIOS represents a quality leap in crucible monitoring. *OCP (Optical Coil Protection System)* is a temperature measurement and monitoring system of the latest generation using fibre-optic sensors whose properties make them perfectly suited for interference-free monitoring of crucibles of induction melting furnaces. This is made possible by a direct determination of the temperature field over an extended area in the immediate proximity of the induction coil. The system includes the sensor cable as well as an evaluator and display for visualisation of the measured temperature fields.

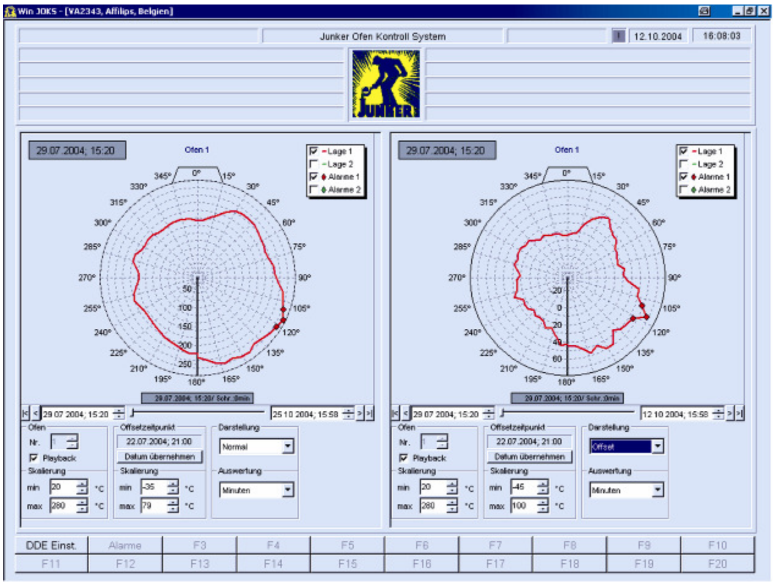
Renowned company Affilips ordered the *OCP* system for a 2.5 t vacuum induction melting furnace running in three-shift operation at their Tienen/Belgium site. This furnace is used to produce master alloys with a composition critical to the crucible material. It is operated with ready-made crucibles backfilled with a dry refractory mix.

No modifications had to be made on the furnace for installation of the crucible monitoring system. The *OCP* sensor cable was placed directly on the furnace coil and embedded in the cast permanent lining.

Only an opening of about 15 mm had to be made to lead out the cable for connection to the evaluator.

The *OCP* system passed the "acid test" when it reported a localized critical temperature rise after only half the usual crucible life. The below screen shot shows the corresponding temperature profile. Based on this signal, the furnace was emptied and its lining wrecked. It was found that the crucible had cracked, and metal had penetrated into the backfill exactly at the point where the anomaly had been indicated.

The timely warning to prevent a crucible breakthrough with all its consequences such as production stops and potential dangers to man and machine had worked reliably.



*Temperature curve with signal (left: temperature profile, right: differential temperature display)*


*Installation of OCP sensor cable*

## Summary

Considerable energy savings and increases in melting rates can be achieved by upgrading old coreless induction furnaces, and especially by converting them to advanced converter technology. At the same time, downtimes and maintenance and repair of the systems are reduced. As the investment costs only represent a quarter or a third of the costs of new equipment and the implementation often takes no longer than a week, there are other advantages as well.

Tables 1 and 2 show the economic and technical effects on the basis of two examples.

The upgrading projects already implemented have shown that:

- Converting mains frequency systems to medium-frequency systems brings about energy savings of 8 %, and another 10 % can be saved if a higher power density is realised.

- Replacing old converter systems (quintuplers etc.) by advanced medium-frequency switchgear cuts power consumption by 12 to 20 %.

- Converting a monomelt into a tandem system (using a second furnace) yields throughput increases of 30 %.

- Converting to a modern PLC-based control system with the JOKS melting processor reduces downtimes and cuts energy consumption.

- Using the *OCP* crucible monitoring system improves the safety and reliability of the equipment and consequently reduces downtimes.

**UPGRADE EXAMPLES** OTTO JUNKER

- **Action:** Replace quintupler by IGBT converter system
- **Result:**

| | BEFORE<br>Quintupler switchgear (QFT Ge 1.500) | AFTER<br>Converter system (MFT Ge 1.500) |
|---|---|---|
| Frequency | 250 Hz | 250 Hz |
| Furnace power | 1,000 kW | 1,000 kW |
| Melting rate * | 1.3 t/h | 1.85 t/h |
| Melting time * | 69 min | 49 min |
| Energy consumption * | 630 kWh/t | 535 kWh/t |

*) related to max. furnace power at 1,500°C / cast iron

- **Savings:**

| | | |
|---|---|---|
| Energy costs (for 4,000 t/year) | 380,000 kW/h | ➔ 30,000 € (8 Cent) |
| Labour costs (shorter melt cycle) | 4 h/day ➔ 1,000 h (250 days/16 h/day) | ➔ 30,000 € (30 €) |
| Maintenance costs | Reduced spare parts requirements | ➔ abt. 10,000 € |

*Table 1*

**UPGRADE EXAMPLES** OTTO JUNKER

- **Action:** Replace mains-frequency switchgear by converter system (120 Hz) – boosting power to 2,500 kW
- **Result:**

| | BEFORE<br>Mains-frequency switchgear (NFT Ge 8 t) | AFTER<br>Converter system (MFT Ge 8 t) |
|---|---|---|
| Frequency | 50 Hz | 120 Hz |
| Furnace power | 2.100 kW | 2.500 kW |
| Melting rate * | 3.6 t/h (with 50 % heel) | 4.7 t/h (without heel) |
| Melting time * | 134 min | 102 min |
| Energy consumption * | 580 kWh/t | 535 kWh/t |

*) related to max. furnace power at 1,500°C / cast iron

- **Savings:**

| | | |
|---|---|---|
| Energy costs (for 12,000 t/year) | 540,000 kW/h | ➔ 43,000 € (8 Cent) |
| Labour costs (shorter melt cycle) | 3.5 h/day ➔ 875 h (250 days) | ➔ 26,250 € (30 €) |
| Maintenance costs | Reduced spare parts requirements | ➔ abt. 10,000 € |

*Table 2*