Reactive power compensation of EAF is one of the most demanding tasks, that only limited number of companies is able to perform successfuly. Avalon Partners had successfuly implemented an innovative solution for increasing capacity and loses reduction of an 3 MW/10 kV Electric Arc Furnace. Hereby described approach had not been implemented before and surely it is a new method in controlling reactive power flow.

Problem description: EAF is one of the most demanding loads in industry, due to high current dynamics and stohastic nature of electrical arc. EAF working current is highly distorted which induces additional losses and is injecting significant disturbances into to grid. Additionaly due to high ampacity there is a large voltage drop which reduces power and capacity of the EAF itself.

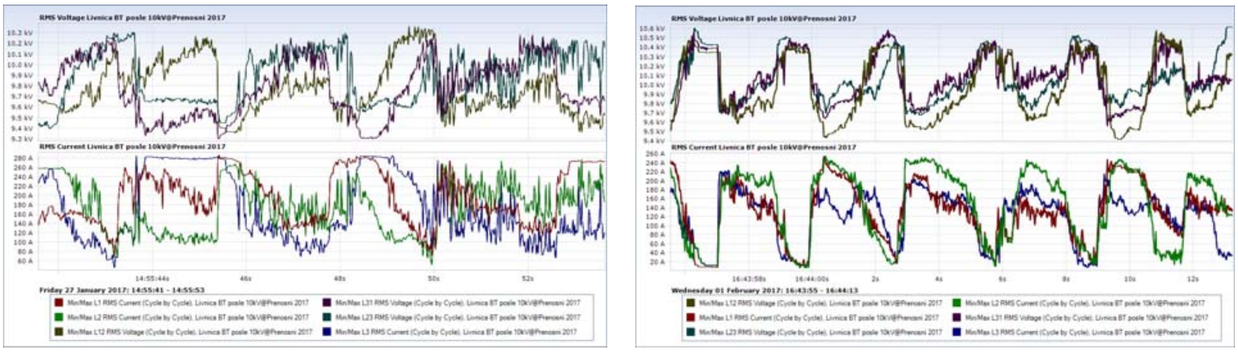
A renowned producer of cast iron parts is using 5 t, 3 MVA/10 kV Electric Arc Furnace. This is a small power furnace and classical solutions are not financially viable (STATCOM, SVC,...). Therefore, Avalon Parnters engineering team had come up with an innovative solution that is economical and technically capable to reduce disturbance injection and voltage drop.

Our team performed detailed measurement of electrical parameters during EAF operation. Based on these results a detailed model of EAF and electrical grid was built in on a professional platform for modeling electrical networks. The model was used to test and verify seferal potential technical solutions. Finally our engineering team designed a solution that is both financialy viable and technically capable to reduce disturbance injection and voltage drop. The voltage rms stabilisation yields an increased energy input into the furnace, which reduces tap to tap time increasing EAF efficiency. This case study proved excellent results in all segments of furnace opreation.

The implemented solution has a responce time that is fast enough to follow dynamics of arc current and on the other side the total power of the device is sufficient to reach desired final results. The control algorithm was developed in-house and it represents a unique result without correspondence in existing engineering practice. An algorithm was tested using latest software simulation tools for transient analysis, as well as in our lab using previously recorded EAF working data. The device for EAF power factor correction of total power 2 MVAr/10 kV was assembled, delivered and commissioned by Avalon Partners engineerign team. This case study presents final results.

Photo of the final setup

Figures 1 and 1a present EAF voltage and current rms with and without compensation. In Fig. 1 a fast changing nature of the EAF current is visible, as well as its impact on working voltage. In Fig. 1a it is visible that due to operation of PFC device an EAF current is stabilised and voltage assymetry had been dramaticaly reduced. Average EAF voltage had stabilised at 7% higher level than before, which for the same working current increased energy input into the furnace.



Figures 1 i 1a: Voltage and current rms before and after PFC

In Fig. 2 and 2a there are active and reactive power of EAF in regimes before and after compensation. In the figure before compensation there is a clear view of active power droops due to high voltage drop. Voltage stabilisation and voltage drop reduction increases energy input into the furnace and reduces tap to tap time.

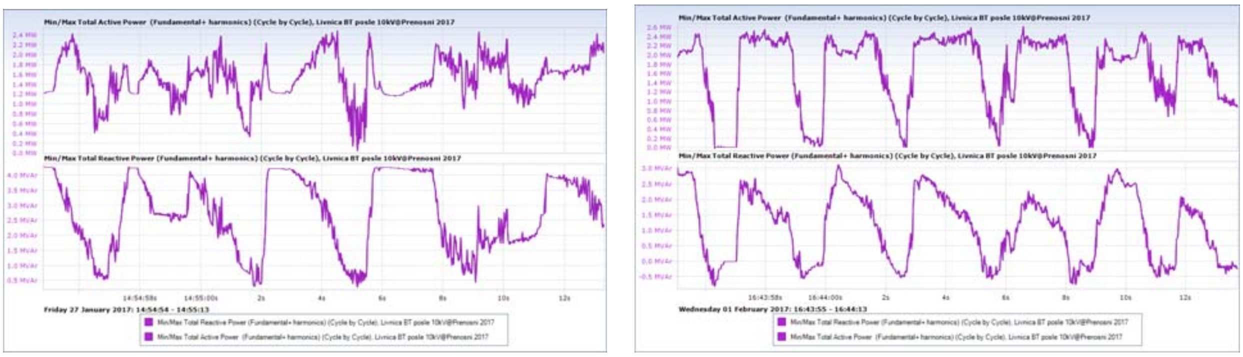


Fig. 2 and 2a: EAF active and reactive power before and after power factor correction

Figures 3 and 3a present voltage rms distribution. Comparison clearly shows that power factor correction benefited voltage stabilisation. Before, only 25% of all the samples had been above 10 kV treshold, which had rosen to 96% after compensation. That is a remarkable result that speaks in favour of excellent control algorithm of power factor correction device.

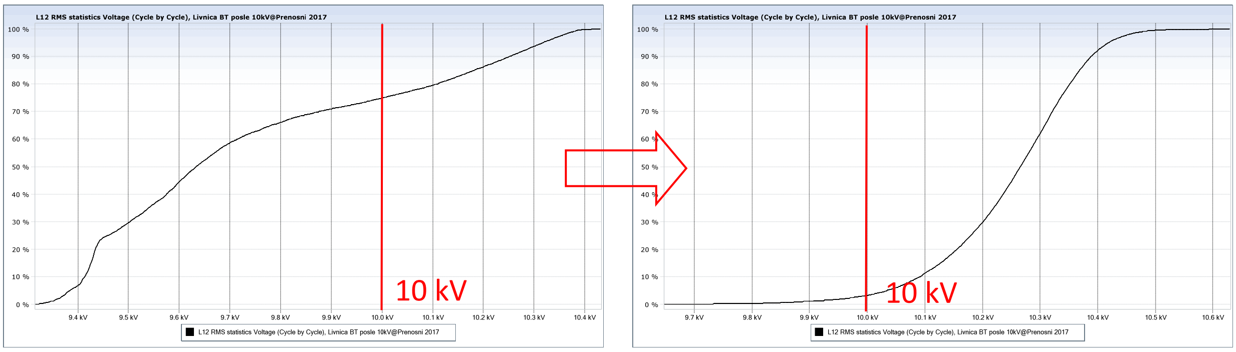


Fig 3 and 3a: Statistical distribution of voltage rms before and after compensation

Above described voltage profile stabilisation yields increase in active power input into the furnace for the same working current. Figures 4. and 4a. present statistical distribution of EAF active power. From the figures it could be concluded that after compensaton 75% of all the samples had been situated above 1.41 MW, compared to 1.18 MW before compensation. EAF maximum demand had been increased from 2.4 MW to 2.6 MW.

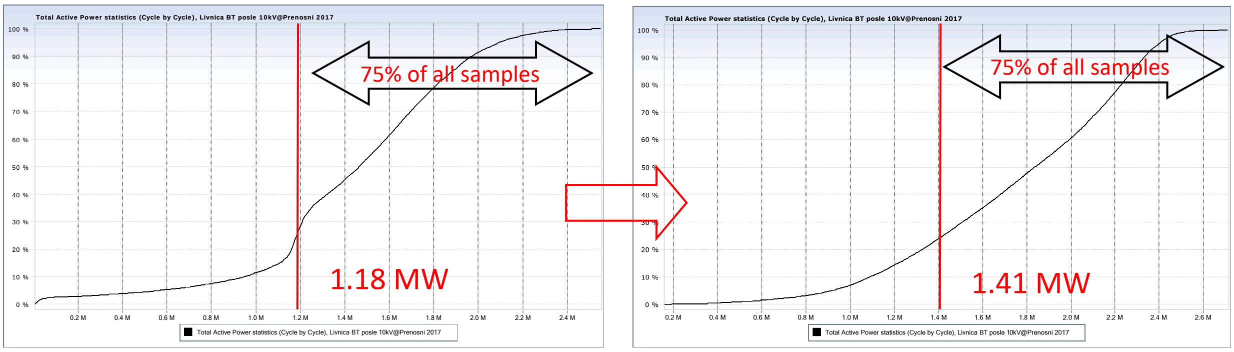


Fig 4 and 4a: Statistical distribution of EAF active power

Table: EAF electrical parameters before and after compensation

	Max. demand [MW]	Power[1) [MW]	Voltage[2) [kV]	Power factor	Nr. of taps [tap/day]
Before	2.4	>1.18	>9.37	0.78	4.5%
After	2.6	>1.41	>10.03	0.99	5.2%
Difference	+8.3%	+19.49%	+7.04%		+15.56%

1)75% of the samples 2)95% of the samples