Design of induction heating lines using ELTA program

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Introduction

In metallurgical and tube industries the induction lines are widely used for heating a variety of long products (rods, billets, tubes, slabs, strips) for heat treating or before hot deformation (rolling, forging, pressing). Design of such lines is a rather challenging task. It may be divided in two phases. The first phase is determination of the line length, power distribution along the line and optimal frequencies for different parts of the line. The second phase is a detailed determination of individual coil parameters and their optimization as well as proper selection of the power supply and matching circuitry.

Main features of ELTA program

ELTA is based on a combination of one-dimensional numerical (Finite Difference) approach and analytical account for finite lengths of the part and induction coil. Because of that simulation is very fast while providing good accuracy for systems of simple geometry typical for induction lines. ELTA 6.0 program has an option for 2D FD simulation of heating bodies with rectangular cross-section.

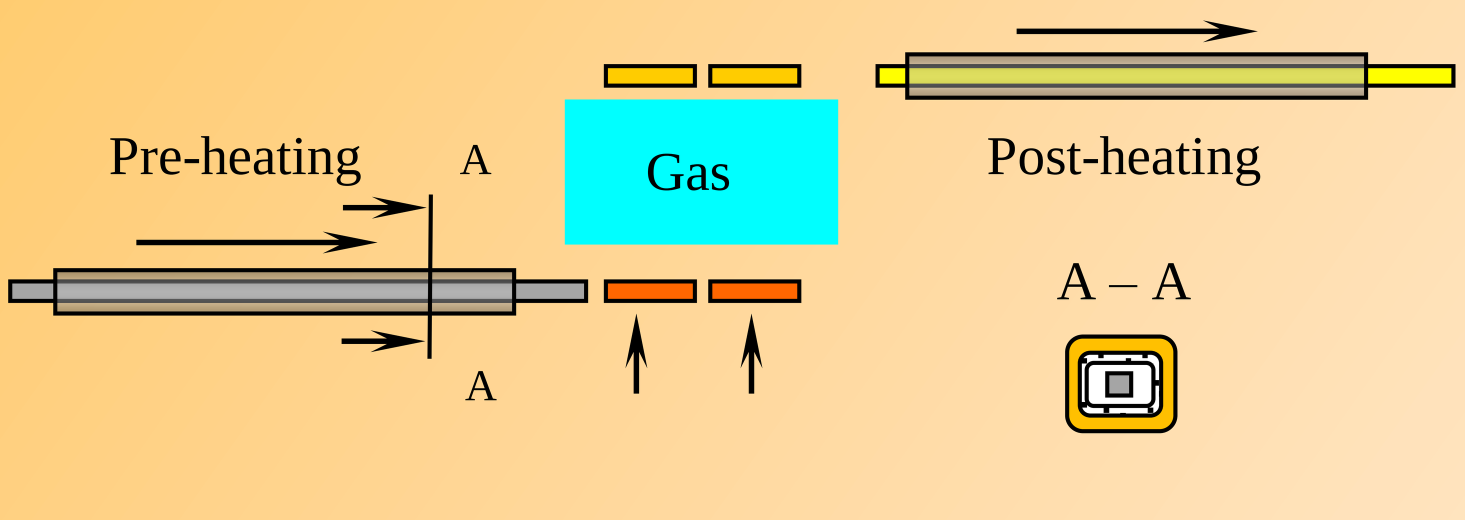
Programs provide the great opportunities for visualization of output parameters in the form of graphs and tables, i.e. the advanced post processing.

Design of induction line for Heating square billets

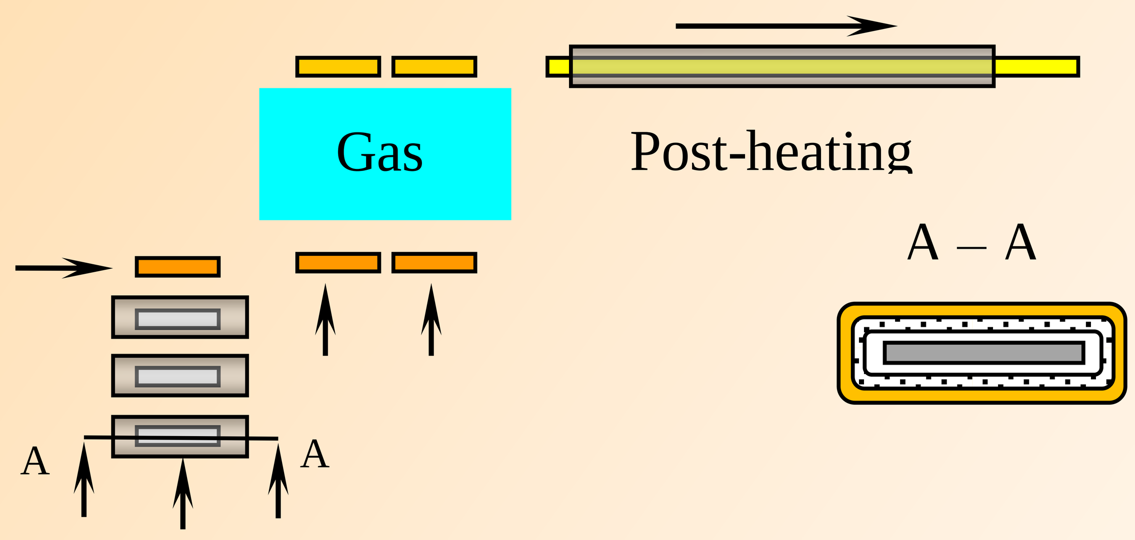
Technology requirements: Material: Cracking sensitive steel. Final temperature – 1250 ± 15 °C. Productivity: 10 t/hr. Billet dimensions: square cross-section 8.3×8.3 cm, length 91 – 112 cm. Required speed of heating – 1,5 K/sec.

First variant. A continuous heater with induction coils of square configuration. Billets are moving through the inductors in longitudinal direction on a rolling system. Post-heating induction line may be of the same type as a pre-heating one.
Inductor dimensions: the "window" is $2X_1 \times b_1$ =13.0×13.0 cm, length l_1 = 29 cm, coils turn number 12, tubing $A \times T \times d$ = 2×1×0.2 cm.
Thermal insulation – Portland cement concrete 2 cm thickness.
Calculations showed that heating with speed 1.45 K/sec requires 45 induction coils and total length of line 19.5 m.

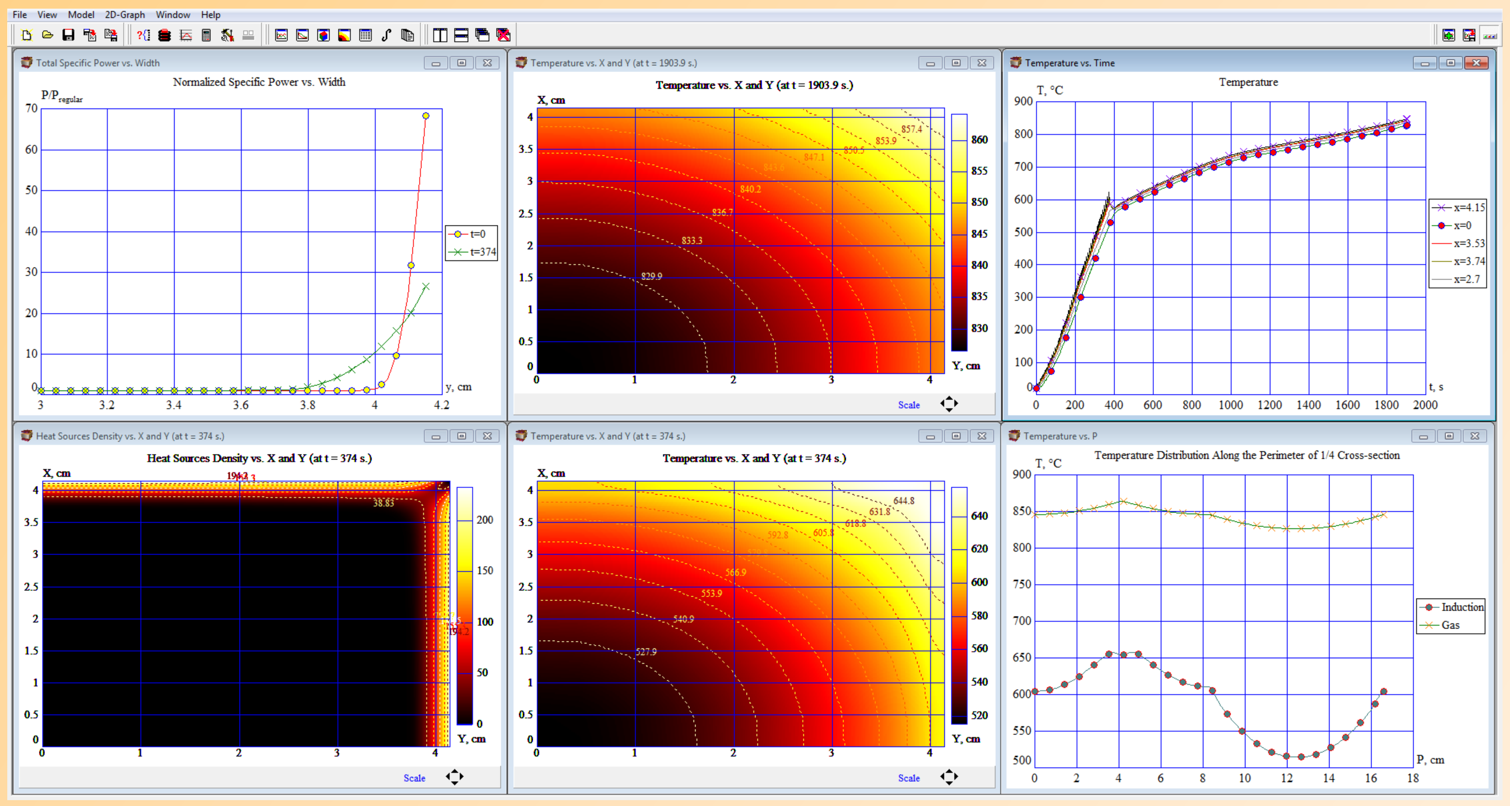
Second variant. In order to reduce the line length, it was decided to use 3 oval inductors for pre-heating line. All billets are moving through the inductors semi-continuously in transversal direction by using a pusher. It is more convenient than in the first case. There are 14 billets in each inductor, i.e. total length of the load is 14×8.3 = 116 cm.
Inductor dimensions: the "window" is $2X_1 \times b_1$ =13.0×125 cm, length l_1 = 120 cm, coil turn number 26, tubing $A \times T \times d$ = 4×2×0.2 cm.
Thermal insulation – Portland cement concrete 2 cm thickness.



First variant.
Sketch of longitudinal pre-heating induction line + gas furnace + post-heating induction line

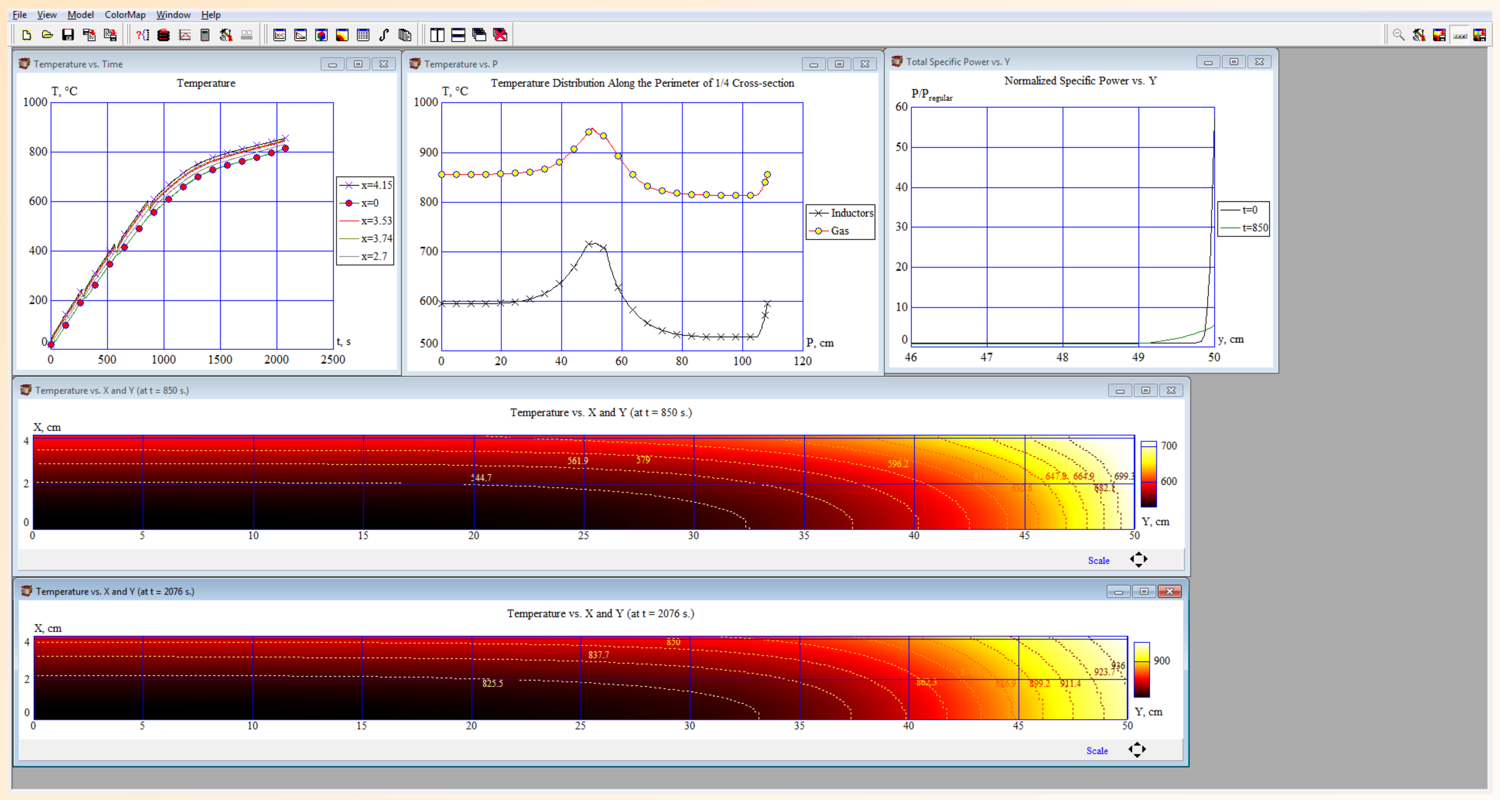


Second variant.
Sketch of transversal pre-heating induction line + gas furnace + post-heating induction line



Results presentation. First variant.

Total power and energy consumption are 1185 kW and 100.5 kWhr/t respectively. The values of electrical efficiency are 83 – 87 %. Total time of heating in induction line up to mean volume temperature of 563 °C is 374 sec.



Results presentation. Second variant.

Mean volume temperature after 860 sec of induction pre-heating is 556 °C. Total power is 1065 kW. Specific energy of induction pre-heating is 99 kWhr/t. The length of line decreases sufficiently from 19.5 to 4 m.

Main attention was paid to edge effect of load and temperature distribution in the volume of billet. Simulation of the whole heating line showed that by means of an optimal design of pre- and post-furnace induction lines it is possible to reach required temperature level of 1250 °C and uniformity of billets at the end of the whole line using both the first and second variants.

Conclusion

All complex induction-gas-induction line, including the second variant of pre-heating induction heater, was successfully designed by V. P. Vologdin Scientific Research Institute of High-Frequency Currents (St. Petersburg) for one of the metallurgical plant.

More information may be found at:

www.nsgsoft.com www.fluxtrol.com

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