Practice of Computer-Assisted Design of induction installations

V. Vologdin[1], Vl. Vologdin Jr. [1], V. Bukanin[2], A. Ivanov[2]

[1]FREAL Ltd., Shvetsova str., 23b, St. Petersburg, Russian Federation;
[2]St. Petersburg State Electrotechnical University, prof. Popova str., 5. 197376, St. Petersburg, Russian Federation.

Introduction

Designing of induction heaters is very interesting and creative process.
ELTA 6.0 and 2DELTA programs open wide opportunities for the specialists employed in design and production of induction heating installations. Many types of cylindrical and flat shaped parts are used in industry and they have to be heated by induction method with different technologies. Above mentioned programs are effectively used in practice of work and Computer-Assisted Design process of FREAL-Ltd research-and-production company.

Features of ELTA and 2DELTA

• ELTA and 2DELTA programs have very friendly user interface;
• They are relatively simple programs for understanding and realization; the boundary conditions in the problem of calculating the electrical and thermal parameters can be set automatically;
• Many typical technological heating lines with simultaneous, non-stationary semi-continuous and continuous processes can be simulated from start to stationary finish;
• Programs provide the great opportunities for visualization of output parameters in the form of graphs and tables, i.e. the advanced post processing.
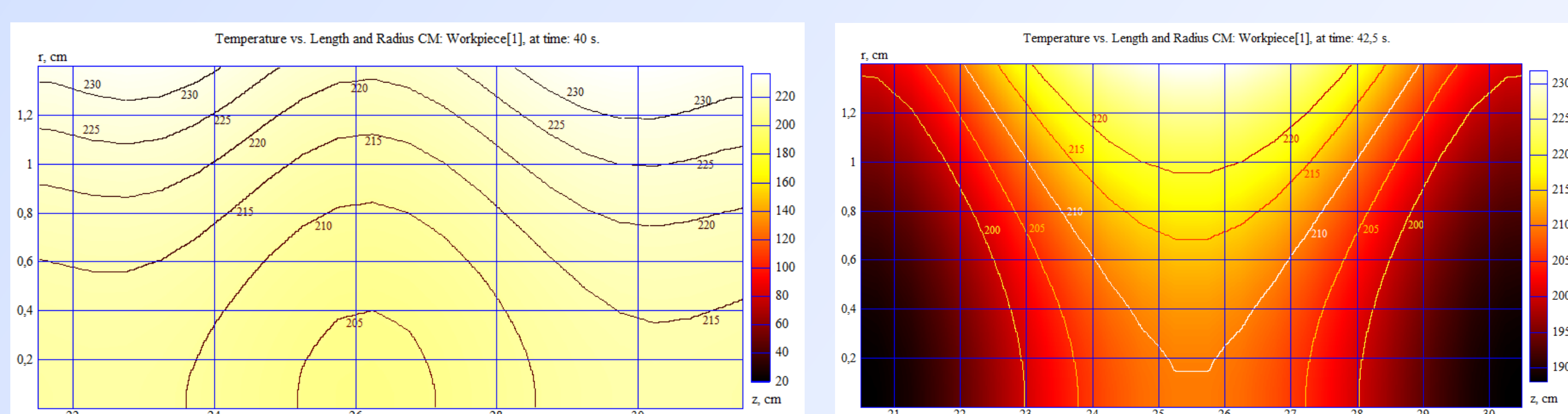
Induction heating of workpieces for specific tests

The main parameters of induction system are:
length of inductor – 11.8 cm;
turn number – 10;
internal diameter of coil – 7 cm;
frequency of power source – 71.8 kHz;
length of workpiece – 10 cm;
external diameter of workpiece – 2.8 cm;
cylinder material – steel 40.
Technology requirements:
final temperature – 220 ± 15 °C;
temperature difference on the length of surface – 5 °C;
required speed of heating – 5 °C/s.
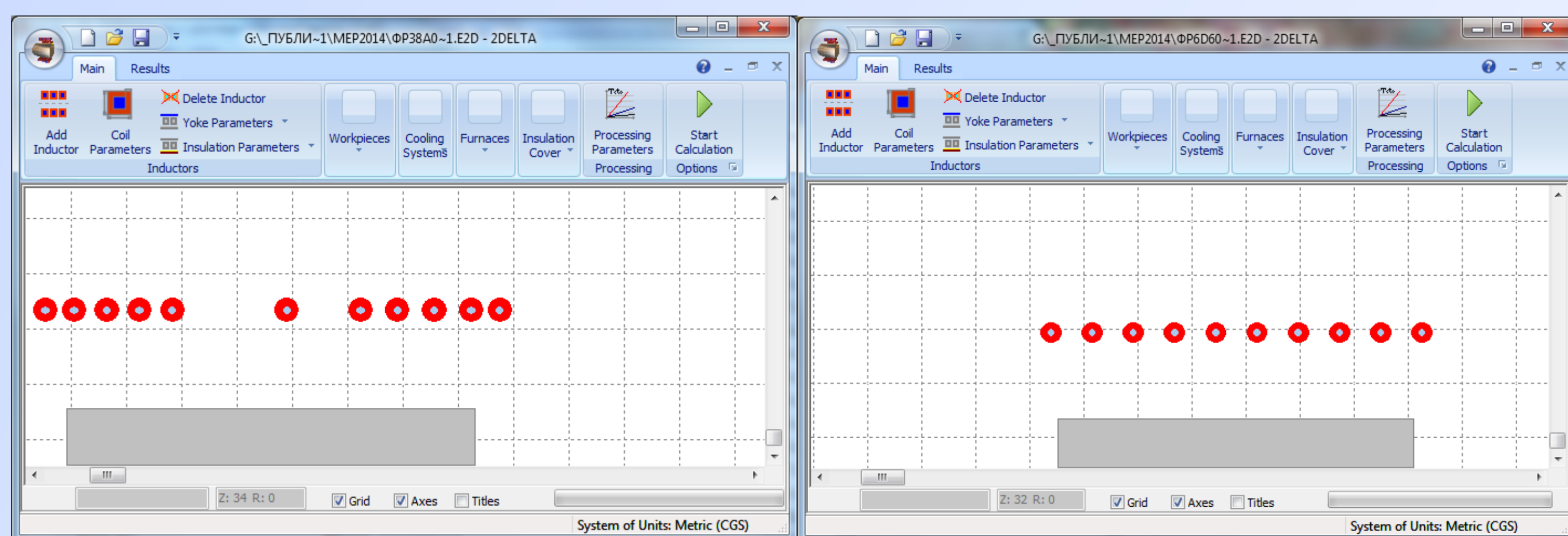
Variants of induction coils with non-uniform (left) and uniform (right) winding

Temperature distribution along the cross-section of workpiece with non-uniform (left) and uniform (right) winding

Installation for heating of cylindrical parts for forming

The main parameters of induction system are:
length of inductor – 15.5 cm;
internal diameter of coil – 7 cm;
turn number – 12;
frequency of power source – 21.0 kHz;
length of workpiece – 12.5 cm;
external diameter of workpiece – 2.8 cm;
material of workpiece – steel 40;
material of magnet yoke: ferrite;
permeability: 600;
thickness: 1 cm;
length: 5 cm;
interior radius: 4.8 cm.
Material of thermal insulation: ceramics (α=0.02 W/(cm·°C); ε=0.7).
Inductor insulation:
Length: 15.5 cm;
Thickness: 1 cm;
End covers:
Height or radius: 4 cm;
Thickness: 2 cm.
Technology requirements:
final temperature – 1200 ± 30 °C;
temperature difference on the length of surface – ± 35 °C.

Strategy of design:
Preliminary 1D-Model & Detailed 2D-Model
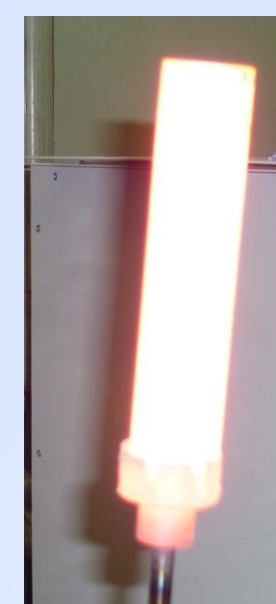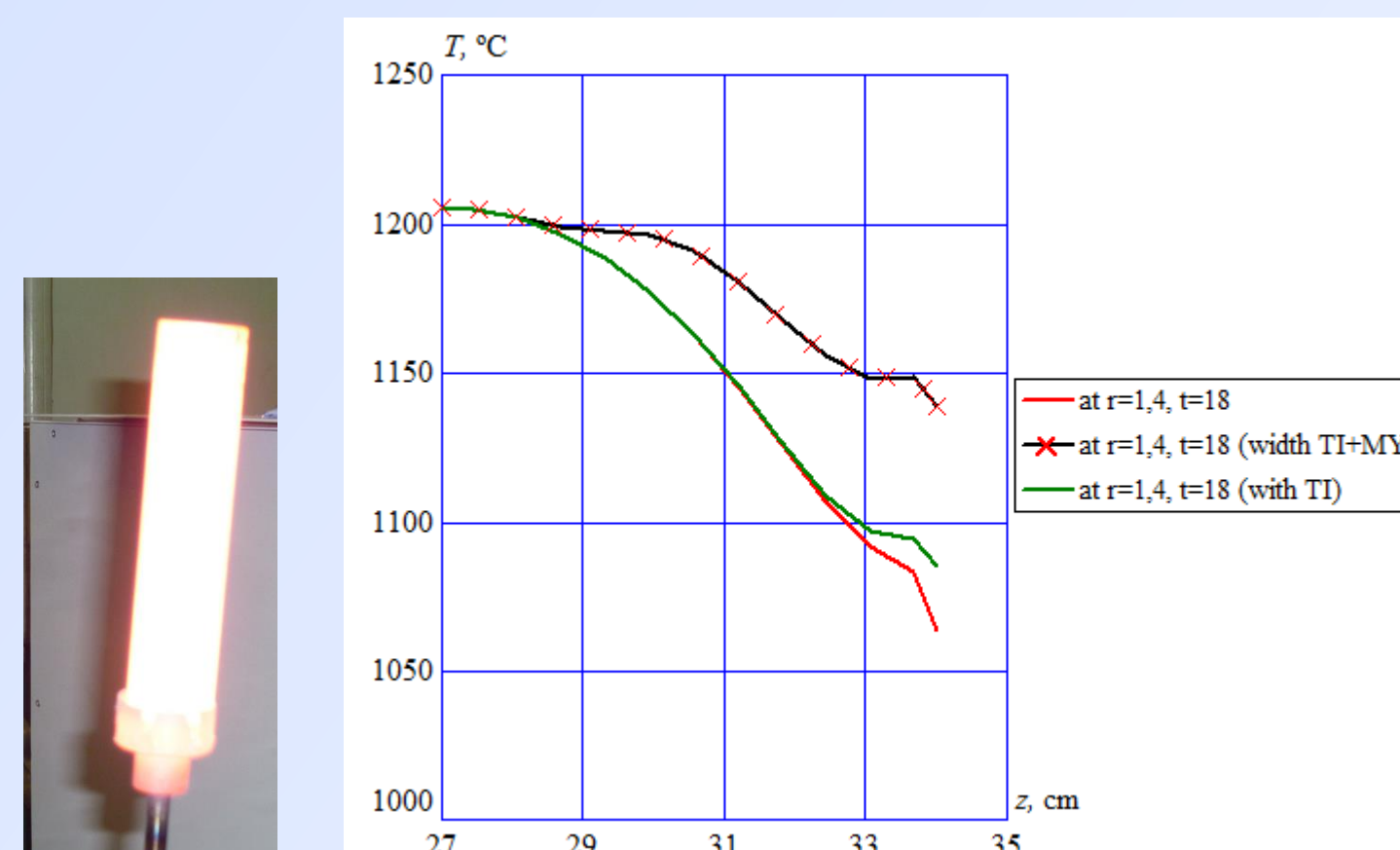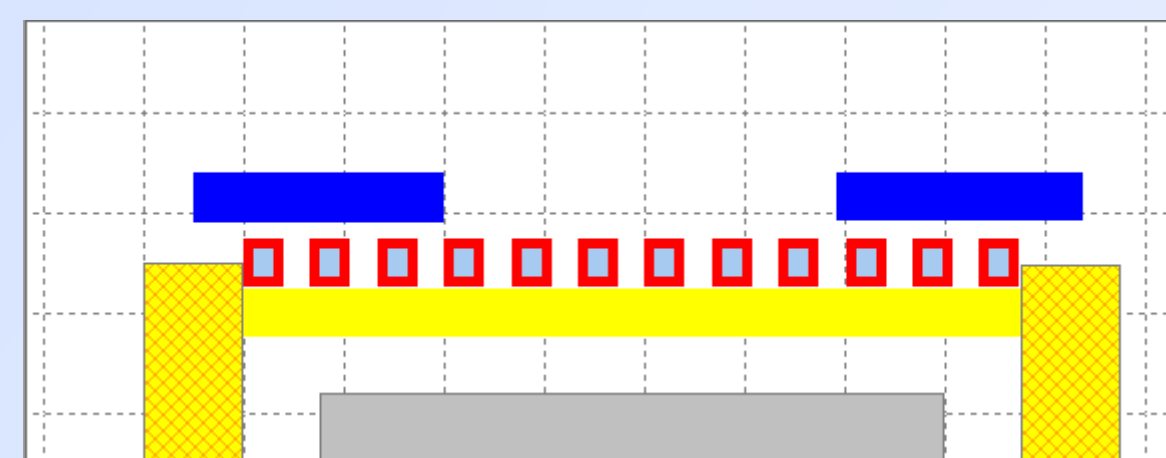
Results of optimization

Heater with rectangular cross-section

The main parameters of induction system are:
length of inductor – 15,5 cm;
internal dimension of inductor window – 7 cm;
frequency of power source – 21,0 kHz;
length of workpiece – 12,5 cm;
cross-section dimension of workpiece – 2,8×2,8 cm^2;
material – aluminum.
Technology requirements:
final temperature – 500 ± 30 °C;
temperature difference – ± 30 °C.
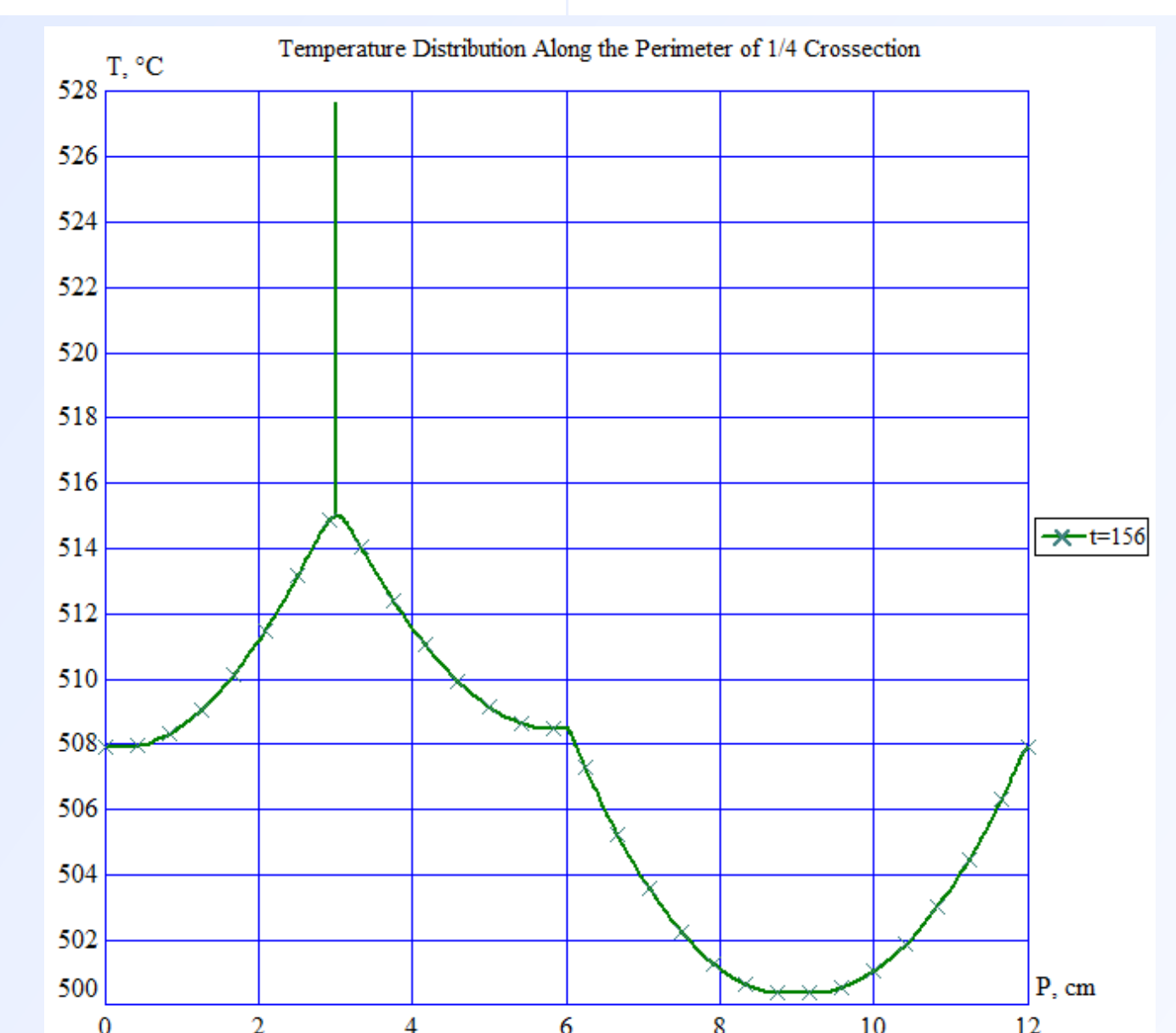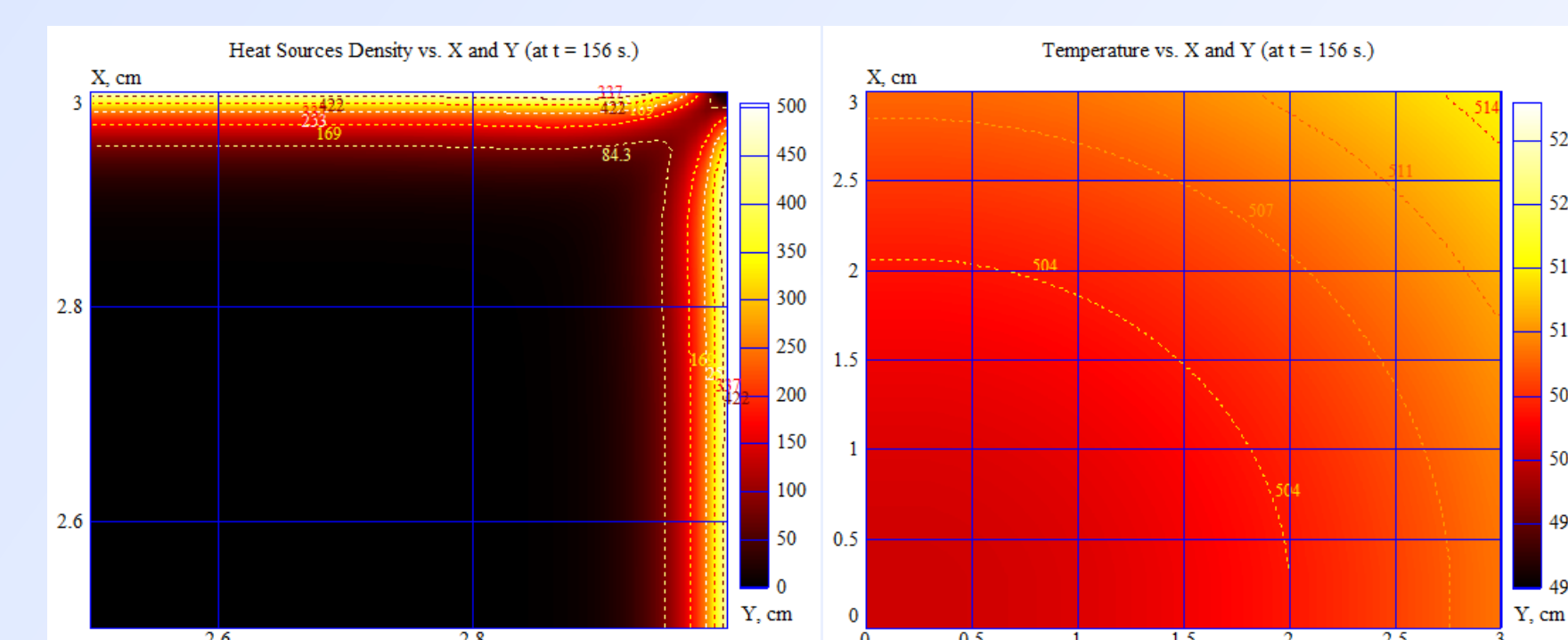
Simulation results: Distribution of Power Sources and Temperature

Installation for stamping of steel parts (left), Installation for laboratory researches of heated samples (right).

Conclusion

The subject oriented programs ELTA 6.0 and 2DELTA have been effectively used in the practice application of research-and-production company FREAL-Ltd allowing to design the wide range of electrothermal processes in the workpieces of cylindrical and rectangular cross section. Investigations of temperature for different workpieces of real technological processes have been carried out. More information may be found at:

www.nsgsoft.com   www.freal.ru

References

[1] Ivanov, A. N., Bukanin, V. A., Zenkov, A. E.: Advancements in program ELTA for calculation of induction heating systems. Proceeding of the International Conference on Heating by Electromagnetic Sources. Padua, May 21-24, 2013. pp. 345 – 351.
[2] Nemkov, V., Bukanin, V., Zenkov, A.: Learning and teaching induction heating using the program ELTA. Proceeding of the International Symposium on Heating by Electromagnetic Sources. Padua, May 18-21, 2010. pp. 99 – 106.
[3] Nemkov, V., Goldstein, R. S., Bukanin, V. , Zenkov, A.: Computer Simulation of Induction Heating and Quenching Process. The 3rd International Conference On Quenching and Control of Distortion, 24-26 March, 1999, Prague, Czech Republic, ASM International, pp. 370-377.