USING FREEFEM++ TO SOLVE AN INDUSTRIAL PROBLEM:

HEAT TREATING OF A STEEL HELICAL GEAR

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In this presentation we describe the industrial procedure of the heat treating of a steel helical gear by induction. A simple model is used, involving the electromagnetic variables, the temperature and two phase fractions of steel, namely, austenite and martensite.

Though at first sight the 3D geometry of a helical gear may appear rather complex, we show how one can manage to fully describe it with Freefem++, without needing other commercial packages. This steel workpiece is surrounded by a coil, made of copper. Then, these two conductors are included in a big domain (box) where the magnetic induction is defined. Finally, we use the capabilities of Freefem++ in order to build up a tetrahedralization of the whole setting: gear + coil + box.

Some Freefem++ numerical simulations of this industrial procedure are also shown.

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Bibliography

[1] N. Barka, A. Chebak, A. El Ouafi, *Simulation of Helical Gear Heated by Induction Process Using 3D Model*, Advanced Materials Research, **658**, 266–270, 2013.

[2] N. Bugliarello, BĠeorge, D. Giessel, D. McCurdy, R. Perkins, S. Richardson, C. Zimmerman, *Heat treat processes for gears*, Gear Solutions 38–51, July 2010.

[3] J. M. Díaz Moreno, M. T. González Montesinos, C. García Vázquez, F. Ortegón Gallego & G. Viglialoro, *Some Basic Mathematical Elements On Steel Heat Treating: Modeling, Freeware Packages And Numerical Simulation,* Thermal Processing for Gear Solutions, 2014-Fall, 42–47.

[4] J. Fuhrmann, D. Hömberg and M. Uhle, *Numerical simulation of induction hardening of steel,* COMPEL, **18**, No. 3, 482–493, 1999.

[5] Hecht, F. *New development in FreeFem++.* J. Numer. Math. **20** (2012), no. 3-4, 251–265, 65Y15.

[6] M. T. González Montesinos, F. Ortegón Gallego, *On an induction?conduction PDEs system in the harmonic regime.* Nonlinear Analysis: Real World Applications, **15**, 58–66, 2014.

[7] D. Hömberg, *A mathematical model for induction hardening including mechanical effects*, Nonlinear Analysis: Real World Applications, **5**, 55–90, 2004.

[8] V. Rudnev, D. Loveless, R. Cook, M. Black, *Induction Hardening of Gears: a Review*, Heat Treatment of Metals, **4**, 97–103, 2003.