18th International Conference
ENGINEERING MECHANICS 2012
Svratka, Czech Republic, May 14 – 17, 2012

pp. 477–482
Paper #9

SOFTWARE PREDICTION OF NON-STATIONARY HEATING OF SHELL MOULDS FOR MANUFACTURE OF ARTIFICIAL LEATHERS

M. Hušek*, A. Potěšil**

Abstract: *In the design of non-stationary heating of shell moulds for the production of artificial leathers for vehicle interiors using infrared emitters, virtual simulations are of great importance. Virtual heating was used in a number of practically solved problems and has become irreplaceable in the complex process of technical preparation of the artificial leathers manufacture. It is based on combination of suitable informatics tools complemented by specific functions. Optimal temperature distribution on the styling mould surface is achieved only by suitable positioning of infra-red emitters, correct identification of positions of control thermocouples on the heated mould surface and setup of corresponding parameters of the regulation system. Development of the technology of virtual heating has been supported by the project MPO TIP 2009 under the registration number FR-TI1/266.*

Keywords: ***Artificial leather, shell mould, non-stationary heating, radiation heating, finite element method.***

1. Introduction

In the last few years, the company Magna Exteriors & Interiors Bohemia, s.r.o (hereafter Magna) has been dealing with an innovation project " Innovation of technology of artificial leathers manufacture". The artificial leathers are major styling elements of softened interior components in vehicles. An example of such a product is a dashboard, which represents a complicated part in terms of design, complexity of styling shapes, dimensions and process energy.

Within the innovation of the so called “Slush technology”, workers of the company Magna acknowledge necessity of a complex approach with participation of a number of experts from the Technical University of Liberec and the company LENAM, s.r.o. This synergy resulted in acceleration of preparation of the technology in question and increased efficiency in batch production.

The issue of virtual heating in the final stages of the above-mentioned project is mainly implementation of software application IREviewBlender in the preparatory stages of the artificial leather manufacture. This process would not be possible without prior knowledge of everyday realities and technical complications in the production itself. That is why the individual functionalities of the developed application were optimized and confronted with the experienced workers responsible for the technical preparation of production as early as at the project start.

2. Methodology

The procedure of artificial leather manufacture is as follows: a sufficient amount of powder of thermoplastic polymer based on PU or PVC is applied on a hot metal shell mould face. The powder melts and sinters into a thin compact layer. Having cooled the mould, the finished product is stripped from the mould. The mould gives the artificial leather appropriate desirable shape and precise impression of the mould surface at the same time, which is usually a fine embossed design. With the view of productivity it is desirable that the heating and cooling of the mould were as fast as possible. The procedure of high-quality sintering of artificial leathers, however, necessitates keeping rather a narrow interval of sintering temperature – approximately 20°C.

*Ing. Martin Hušek, Technická univerzita v Liberci, Studentská 2, Liberec 1, CZ, e-mail: martin.husek@tul.cz

** Doc. Ing. Antonín Potěšil, CSc.: LENAM, s.r.o., Klostermannova 690/15; 460 01, Liberec; CZ, e-mail: antonin.potesil@lenam.cz

2.1. Procedure of Design of Non-stationary Mould Heating

Preparation of heating is divided into two basic stages, as illustrated in fig. 1.

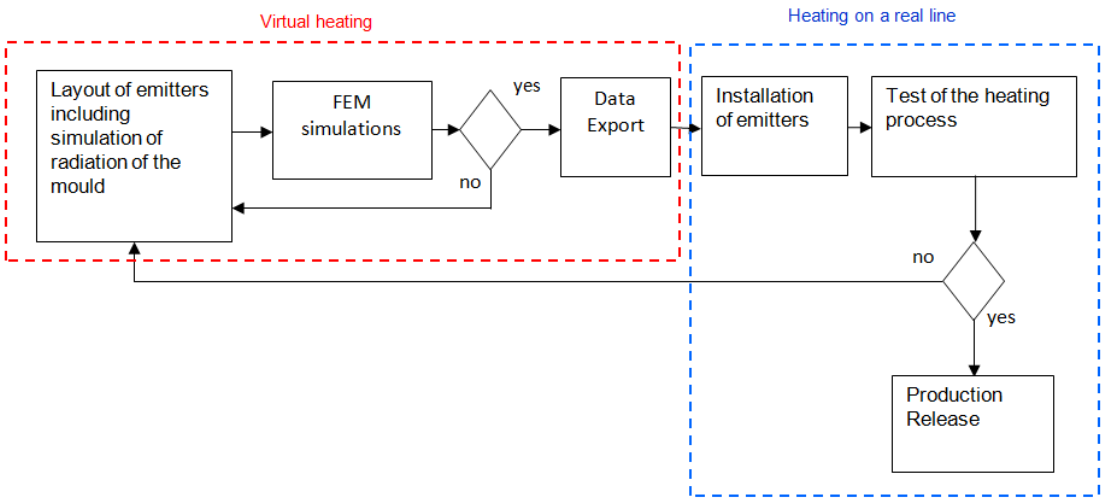

Fig. 1: Flowchart of the procedure of heating layout

The first working stage is the design of virtual heating. It is based on the first estimation of positions of infra-red emitters according to the needed amount of heat necessary for heating the given amount of material. These efforts result in simulation of the heat flux density distribution. This is followed by finite element computation of temperatures in the selected time steps. In this stage of determination of heating, virtual experimentation with simulation of the regulated heating of the model of the system in question begins. The desired result is a satisfactory uniform temperature distribution over the whole mould surface. In case of reaching an optimal result, the data for manual or robotic placement of holders of infra-red emitters around the mould are exported. Further tests of heating are realized on the test or batch line. In that case heating is already evaluated according to the quality of the manufactured leather. The leather is thoroughly examined and imperfections caused by over-heating or insufficient heating of the given area are looked for. These problems are solved by changing the position of the concrete emitter directly on the line or by intervention in the regulation parameters. Having completed these procedures, heating is released for the batch production.

2.2. IREviewBlender

IREviewBlender is an application based on extension of freeware environment Blender by functionalities that enable positioning of emitters over the mould relief. The main tasks of the application are:

1) Building a virtual model of a real module of shell mould heating, consisting of relevant components of a flow line (frames for shell mould fixation, frame for emitters clamping and other special structures), see fig.2.
2) Application of various types of infra-red emitters as needed and within the technical limitations (emitters of various shapes, numbers, layout and power properties), see fig. 3.
3) Simulation of the heat flux distribution on the surface of a shell mould and optimization of the positions of infra-red emitters above the mould and their control thermocouples on the shell mould, which is necessary for successful control of non-stationary temperature field, see fig.4.
4) Export of the results into a suitable format for the needs of control temperature-structural FEM analyses in CAE systems, see fig.5.
5) Export of the topological data (coordinates) for emitters and thermocouples for safe and non-collision placement of emitters on the real supporting structure and placement of corresponding thermocouples on the mould (output image files or files with transformation matrixes for positioning by a robotic arm).

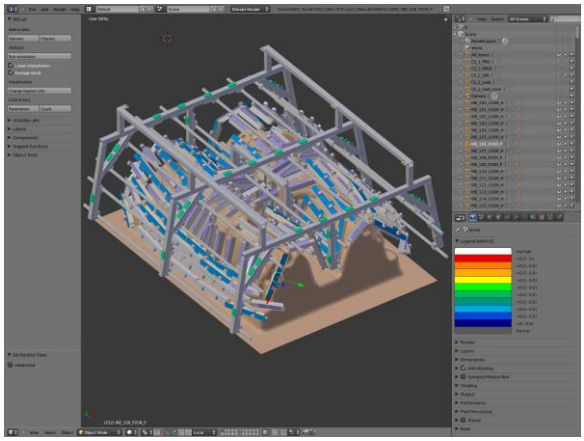

Fig. 2: Assembled model

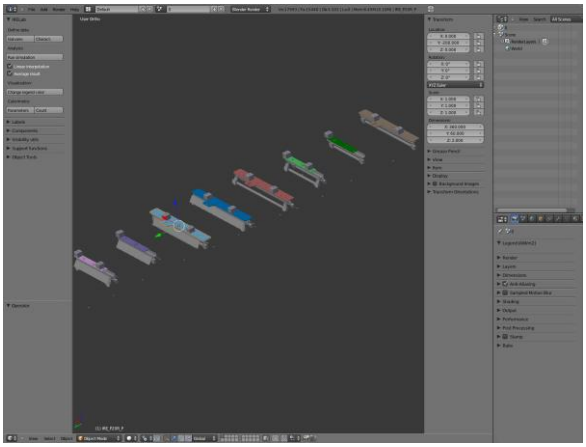

Fig. 3: Database of emitters

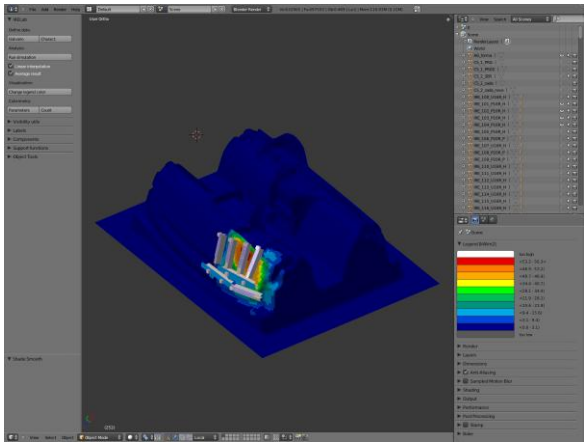

Fig. 4: Heat flux

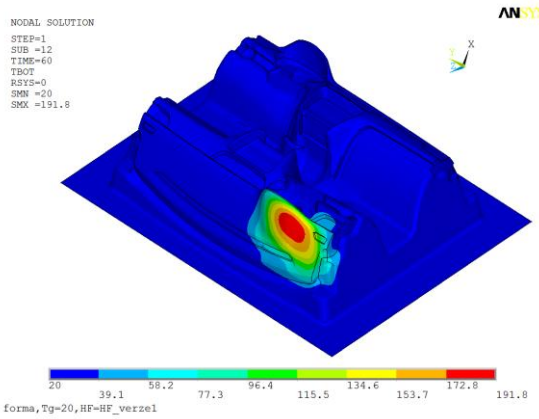

Fig. 5: Temperature calculation in sw ANSYS

3. Implementation into Manufacture

As early as during programming of the basic functions of the application IREviewBlender, a number of practical tasks had been dealt with. This was the only way of getting the feedback concerning necessity and correctness of its functionalities and adding further useful functions according to the current needs of the operators of this production technology. The following chapters present selected and resolved problem situations.

3.1. Design of Heating for Batch Production

One of many solved tasks was positioning of emitters above the mould for batch production of artificial leathers. The two situations differed considerably. The starting point was the data and experience acquired during the design of heating of a prototype mould illustrated in the previous pictures. Besides the determination of positions and types of the applied emitters it was also necessary to make design changes and to add a frame structure for fixation of special emitters in the middle of the mould – see fig. 6.

.

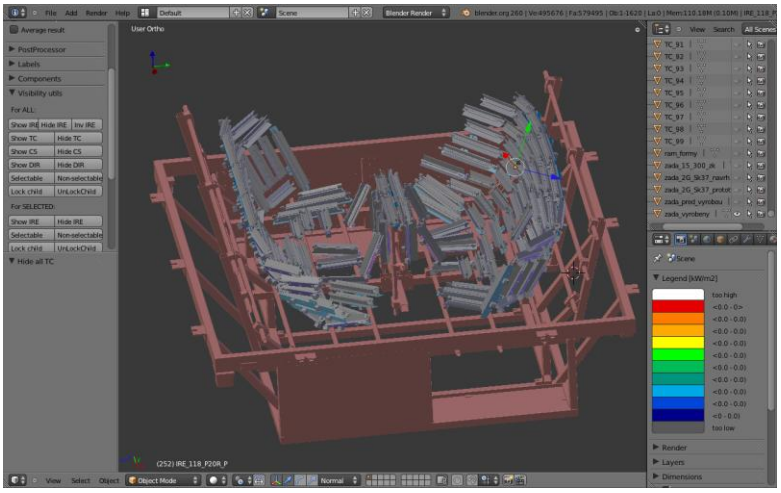

Fig. 6: Fixation of emitters

3.2. Design of Heating of the Cleaning Station

Each mould has to be cleaned up after repeated usage in the production cycle and its surface must be covered with special separation and protection preparations at precisely defined temperature range for precisely defined time.

The cleaning procedure will be run in automatic mode of a specially designed line, of a so called cleaning station, exploiting robot for application of chemicals. The workstation has to be universal for various types and shapes of moulds. Technical specifications are defined by requirements of maximum delivered and switch powers for individual emitters arranged into several sections.

It was evident from the beginning that some automatic movements of whole groups of emitters should be applied. This is the only way of adapting the positions of emitters to various types and shapes of moulds. Fig. 7 illustrates three configurations of emitters layout. For better lucidity only the fixing elements – so called holders are depicted.

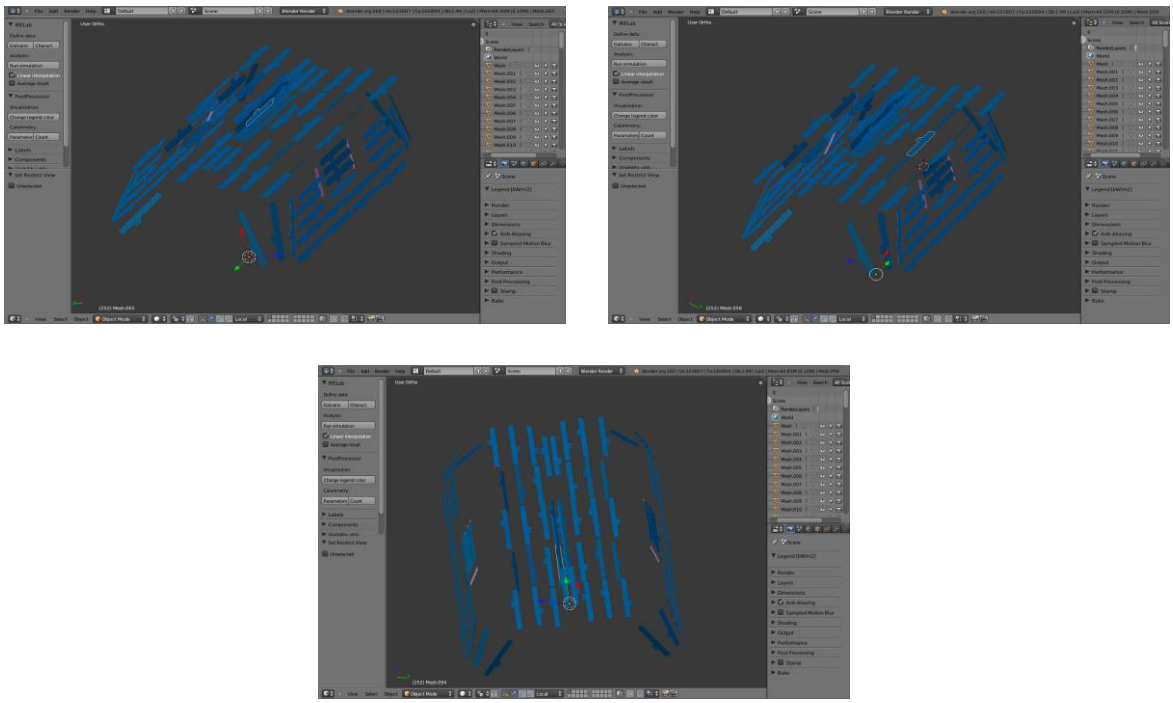

Fig. 7: Three group positions of the emitters

3.3. Test Mould Design

Another requirement of workers of technical preparation of artificial leather manufacture, which has been successfully resolved, was design of a so called test mould and its heating. Prior to launching a new product on the basis of PVC or PU it is essential to realize a number of tests with powder mixture on test moulds so that the prototype or batch production of leathers was not restricted. These moulds are usually equipped with dividing grooves of various shapes and areas with several styling reliefs.

For this purpose, a test mould has been designed for the test line, see fig. 8. Its undulated shape serves for testing the functionalities of virtual heating and for searching important criteria for optimal positioning of emitters in IREviewBlender. Further application of this mould is in testing genetic algorithms for optimization of the emitters layout, which is dealt with by experts of the Technical University of Liberec.

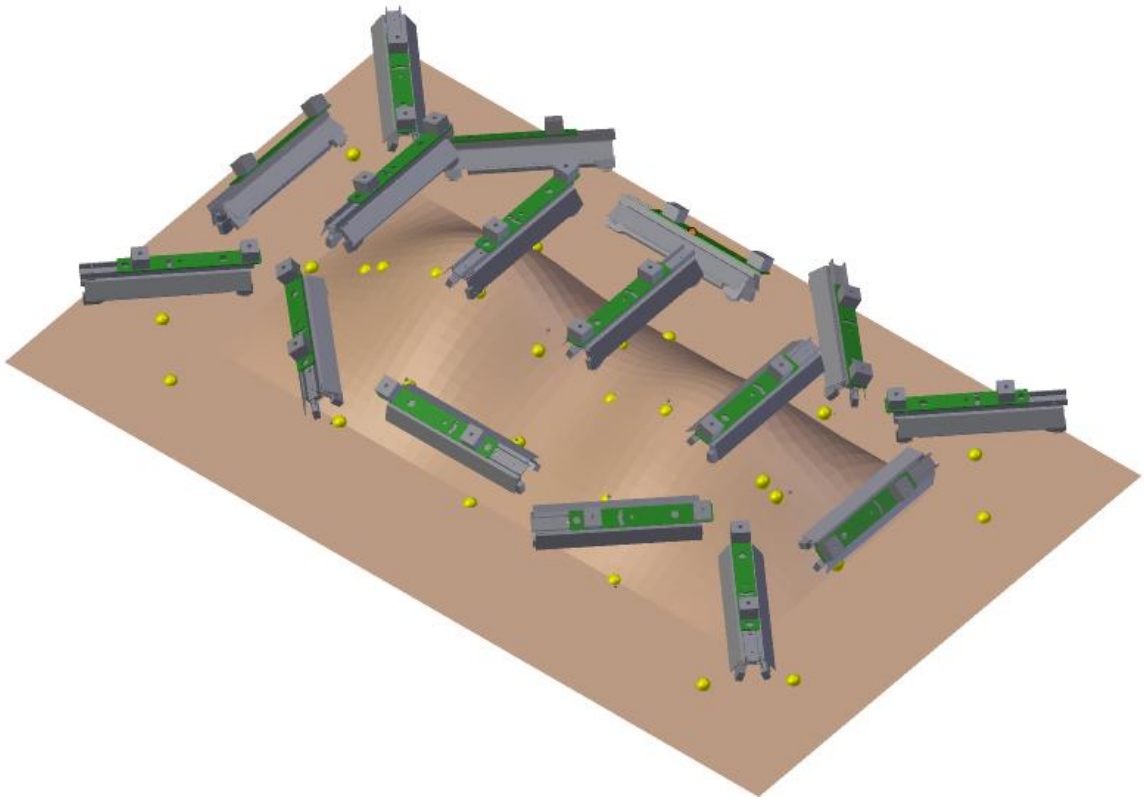

Fig. 8: Test Mould

4. Conclusions

The introduction of the paper presents problems of design of non-stationary heating of thin-walled shell moulds by a large number of infra-red emitters in the manufacture of artificial leathers. The leathers are used in production of softened interior parts mainly in cars.

In the second part, the process of design of non-stationary heating is dealt with. As having been mentioned, the whole design process begins with virtual heating. This includes design of positions of emitters above the mould surface and data preparation for temperature-structural FEM computations. The whole virtual process is completed by data export for physical installation of emitters in the flow line or test line, where further heating tests are performed.

In the last part of the paper there are mentioned some practical cases, which confirm that virtual heating of moulds is irreplaceable part of a complex technical preparation of manufacture of artificial leathers. The application of IREviewBlender allowed reaching the solution in a way more effective than using the standard CAD systems.

Acknowledgement

It is a pleasant duty of the authors of the paper to thank their team colleagues from the company LENAM, s.r.o. for their important contribution to the project solution, also to thank Mr. Jiří Hnídek from the Technical University of Liberec for consultancy support of programming in the graphical environment Blender and last but not least to thank Mr. Jaroslav Kozák from the company Magna for precious information related to the technology of manufacture of artificial leathers.

Acknowledgements belong as well to further unnamed colleagues from the partner Technical University of Liberec, faculty of Mechatronics, who work on other related topics within the project, oriented to identification of non-stationary temperature fields of moulds and regulation algorithms controlling the radiation processes of heating.

Development of the technology of virtual heating was realized within the project MPO TIP 2009 registered under the registration number FR-TI1/266.

References

Potěšil, A. (2011) Non-stationary heating of shell moulds in the process of manufacture of artificial leathers. 17th International Conference ENGINEERING MECHANICS 2011, Svratka, Czech Republic, 9 – 12 May 2011.