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NON-STATIONARY HEATING OF SHELL MOULDS IN THE PROCESS OF MANUFACTURE OF ARTIFICIAL LEATHERS

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Abstract: *Efficient manufacture of artificial leathers of extensive and complicated shapes in the company Magna Exteriors & Interiors (Bohemia), s.r.o., used for example in sandwich switchboards in cars, is a very complex engineering problem. To achieve satisfactory precision and stability of a production process of artificial leathers, it is necessary to apply special methods and procedures. Considering heating is realized by means of a large number of infra-red emitters, both the heating of the moulds and finally their abrupt cooling are very dynamic thermal processes. The paper deals with a possible prediction of non-stationary thermal processes in the shell moulds by means of finite element method. The discussed problems are part of innovation activities realized within the project MPO TIP 2009 registered under the registration number FR-TI1/266.*

Keywords: ***Non-stationary thermal process, artificial leather, finite element method.***

1. Introduction

It is well known, that innovations in a technology of production of new products demand a complex approach and participation of a number of specialists. The main aim of the processes during development or innovation, respectively, of the technology in question is to increase its efficiency and decrease the product price. This approach was chosen by the company Magna Interiors & Interiors Bohemia, s.r.o. (hereafter Magna), which uses so called "slush technology" to produce artificial leathers in one of its plants in the Czech Republic (plant in Libáň). These are then used for fabrication of softened interior elements in vehicles. One representative of such a product is, for example, a switchboard, which is a complicated product from the point of view of design, complexity of design shapes, dimensions and energy exigency of its fabrication.

2. Methods

The procedure of artificial leather production is as follows: a powder of thermoplastic polymer based on PU or PVC is applied on a hot metal 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 imprints appropriate desirable shape on the artificial leather and at the same time a precise mark of the mould surface, 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.

As early as during the determination of the concept of evidently non-stationary heating of the shell moulds it turned out that technical preparation of the mould heating and its realisation demand application of virtual prediction of heating. This was intensified by the fact that from the efficiency viewpoint, heating by infra-radiators had been chosen. At present, dozens of infra-radiators are used for the mould heating, depending on the external dimensions and shape complexity of a mould. The largest number of infra-radiators applied in the procedure of mould heating was less than two hundred. Infra-radiators of various types and performances are applied.

It is evident from the above-stated description that the basis of technical preparation of heating

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technology is spacing of a large number of infra-radiators over the back side surface of the shell mould. First attempts of infra-radiators spacing into special holders on a frame of a so called "heating back" using an ad-hoc method did not lead to a satisfactory result. That is why experts of the company LENAM, s.r.o. developed methodology of infra-radiators spacing using environment of software tools of simulation systems CAD (computer aided design) and FEM (finite element method) in a suitable combination (Potěšil et al., 2010).

In order that utilization of the above-mentioned method was users-friendly and accessible for the staff of technical preparation of heating, it was decided to realise the method of radiator positioning in several steps with possible optimisation loops, see Fig. 1.

At the same time it was decided to replace originally used licensed software product CAD (ProE) by a completely new tool, more friendly to technicians, which would have simultaneously more special functions necessary for preparation and satisfactory optimisation of the mould heating. The development of this tool with a working name IREview is one of the main activities of the solved project MPO TIP 2009, registration number FR-TI1/266.

2.1. IREview Function

On the basis of the executed analyses, acquired theoretical and practical experience with the "Slush" technology in the company Magna and creative visions of development experts of the company LENAM, s.r.o., a conception of a SW toll has been designed, which, having been completed, will perform the following functions:

- Imports of objects and data structures into the complete configuration of the mould heating (moulds, infra-radiators including their performance characteristics, relevant subsidiary constructions…)
- Control of visualisation and/or suppression of objects, definition of their identifications
- Manipulation with objects (displacements, rotation, transformation, suppression or visualisation of objects, …)
- Check-up of intersections and collisions of objects
- Acquisition of geometrical information on objects in required systems of coordinates
- Creation and modification of meshes of moulds for radiation calculations
- Computational procedures for radiation of moulds
- Further and other functions (statistics, lists of materials, values of mould radiation, deviations from criterion values, …)
- Data export for further sophisticated applications (physical spacing of radiators and thermocouples by a robot, initial conditions for non-stationary thermal structural FEM simulations, …)

The realized study of feasibility for the software IREview (Živný, 2009) development realised in the first stages of solution within the above-mentioned MPO project, directed the researches of this part of the project towards utilisation of the open source graphical environment Blender. It appeared, among others, that for the considered purposes, a number of sophisticated graphical options of the development environment Blender can be exploited immediately.

2.2. Figures

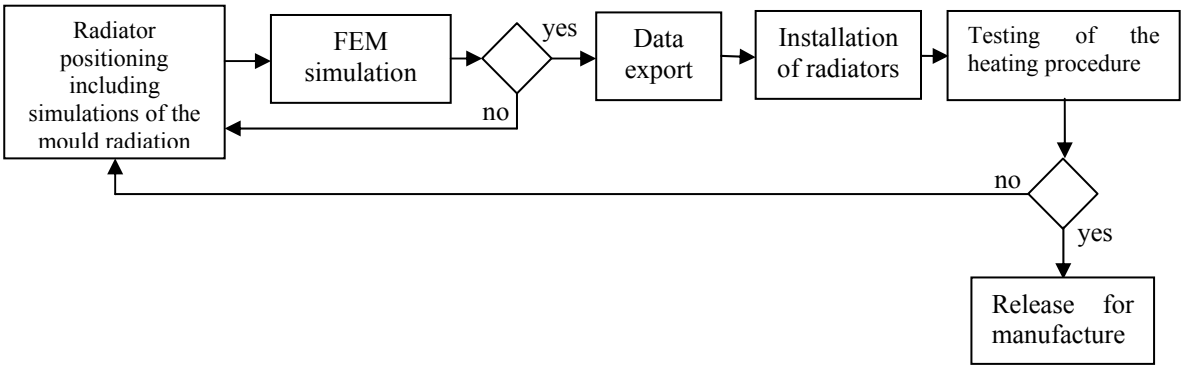

Fig. 1: Scheme of procedure of virtual non-stationary mould heating design.

The following illustrations present the up-to-date stage of development of the IREview software according to the activities planned in the project

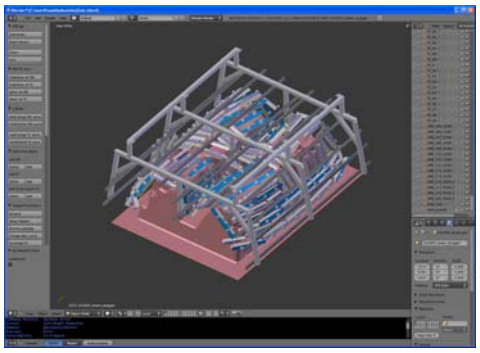

Fig. 2: Import and visualization of objects.

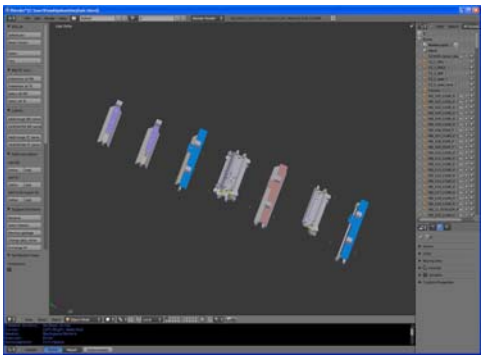

Fig. 3: Database of radiators with their characteristics.

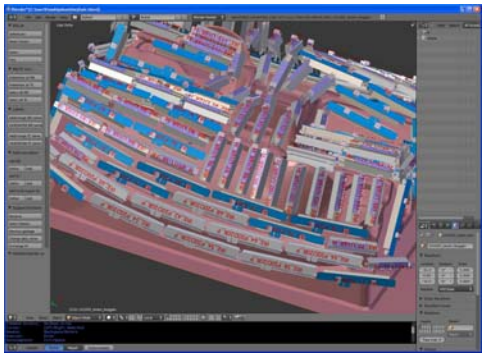

Fig. 4: Identification of radiators.

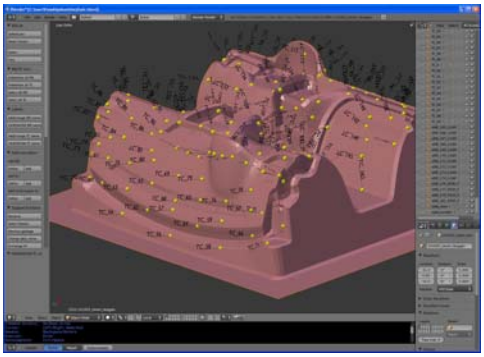

Fig. 5: Identification of thermocouples.

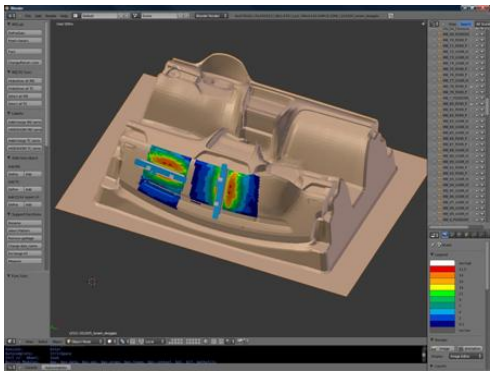

Fig. 6: Simulation of the mould radiation intensity.

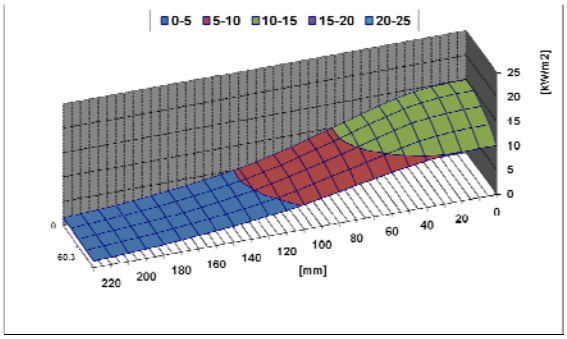

Fig. 7: Measured characteristics of the radiator.

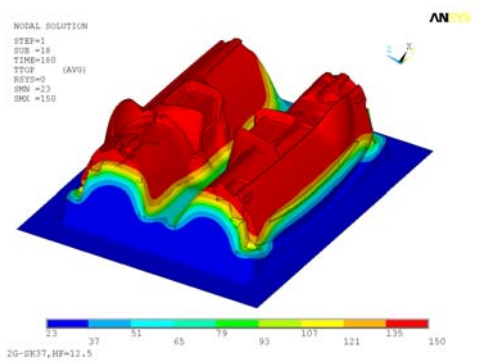

Fig. 8: Simulation of the mould temperature distribution.

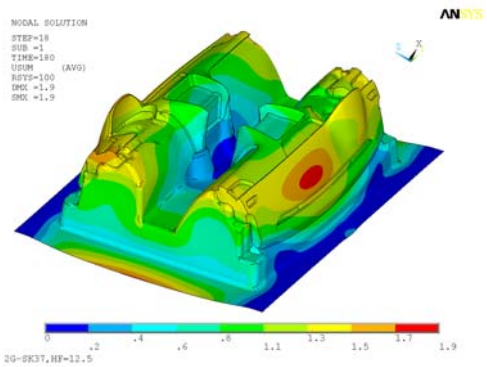

Fig. 9: Simulation of the mould deformation.

3. Conclusions

The paper introduces the reader into the problems of design of non-stationary heating of thin-walled shell moulds by means of a large number of infra-radiators used in fabrication of artificial leathers. They are applied in technologies of production of softened interior parts, mainly in personal vehicles.

The chosen conception of efficient mould heating induced a necessity of design and realisation of new sophisticated procedures so that they facilitated the process of technical preparation of the mould heating. Application of virtual information and simulation technologies proved to be correct and efficient.

The designed methodology of the mould heating combines several innovation approaches. The first one is solved by development of an in-house software tool IREview by means of which 3-dimensional spacing of the infra-radiators over a complicated and spacious metal mould is realized, with a possibility of a controlled visualisation of the mould radiation intensity including the export of the result into some FEM environment for further simulation of the non-stationary temperature field. Following an acceptable numerical optimisation of the mould heating, relevant data are exported from the environment of IREview that are used for conducting a robotic hand during physical positioning of the radiators in the production facilities.

As a conclusion it is to be mentioned that the developed virtual technology for optimal spacing of infra-radiators required designing and realisation of an experimental workplace that serves to measure directional radiation performance characteristics of used infra-radiators and their special types of construction. Without these real physical measurements the above described virtual procedures and software tools could not be successfully used.

The whole project aim can be found at http://www.lenam.cz/?action=projekty. Selected details of the project solving shall be presented to the participants of the Conference EM 2011

Acknowledgement

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