Experimentální Analýza Napětí 2011 Experimental Stress Analysis

Experimental Measurement of Performance Characteristics of Infra-Red Emitters

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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 great 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 identification of performance characteristics of infra-red emitters utilized in the above-described manufacture process. Created database of these characteristics is one of the data sources of the software tool IREview, being developed for emitters positioning and for simulation of initial conditions during non-stationary mould heating. The discussed problems are part of innovation activities realized within the project MPO TIP 2009 registered under the registration number FR-TI1/266.

Keywords: Experimental, Thermal, Heat flow measurements, Transient thermal analysis

1. Introduction

It is well known fact, that innovations in a technology of production of new products demand a complex approach and coordinated 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) together with its development partners (LENAM, s.r.o. and Technical University of Liberec), which uses so called “slush technology” to produce artificial leathers in one of its plants in the Czech Republic (plant in Libáň). The artificial leathers are then used for fabrication of softened interior elements in vehicles. A typical 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. Briefly about the “Slush technology” and its needs

The procedure of artificial leather production is as follows: thermoplastic polymer powder 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 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

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possible. The procedure of high-quality sintering of artificial leathers, however, necessitates keeping rather a narrow interval of sintering temperatures – 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-Red Emitters had been chosen. At present, dozens of infra-red emitters are used for the mould heating, depending on the external dimensions and shape complexity of a mould. The largest number of infra-red emitters applied in the procedure of mould heating was less than two hundred. Infra-red emitters of various types and performances are applied.

It is evident from the above-stated description that the basis of technical preparation of the heating technology is spacing of a large number of infra-red emitters over the back side surface of the shell mould. First attempts of infra-red emitters 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-red emitters spacing using environment of software tools of simulation systems CAD (computer aided design) and FEM (finite element method) in a suitable combination [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 the working name IREview is one of the main activities of the solved project MPO TIP 2009, registration number FR-TI1/266. Description of the functions, which this tool enables to use, is given for example in [2].

This requirement resulted in a necessity to realize a great number of experimental measurements of heat flux densities of the used infra-red emitters and eventually of their special lay-out. Therefore a conception, design, fabrication, assembly and finally putting into operation of the "Measuring IRE workplace" were realized, see further.

3. Measuring IRE workplace

The basis of the measuring workplace is a framework made of aluminium profiles, a so called test desk. The identified infra-red emitters or groups of emitters are placed in required positions in its upper portal part, in the lower part the movable components are mounted, bearing special inclinable head with a heat flux sensor Hukseflux SBG01-50 [3]. Individual parts of the workplace are obvious from the Fig. 1; the real lay-out of the workplace is illustrated in the Fig. 2.

The movable frames allow movements in longitudinal and cross directions while the whole size of the test desk is designed in such a way that sufficient range was achieved considering the need of measuring at least one quadrant of the infra-emitter characteristics. An unassuming mounting by means of a slide way has been chosen for motion, applicable in the Al profiles MyTec. As for the drive, the movement is realized by means of small step motors. This solution does not require application of gear boxes and within the developed SW application they can be controlled by means of a logger together with measured quantities reading.

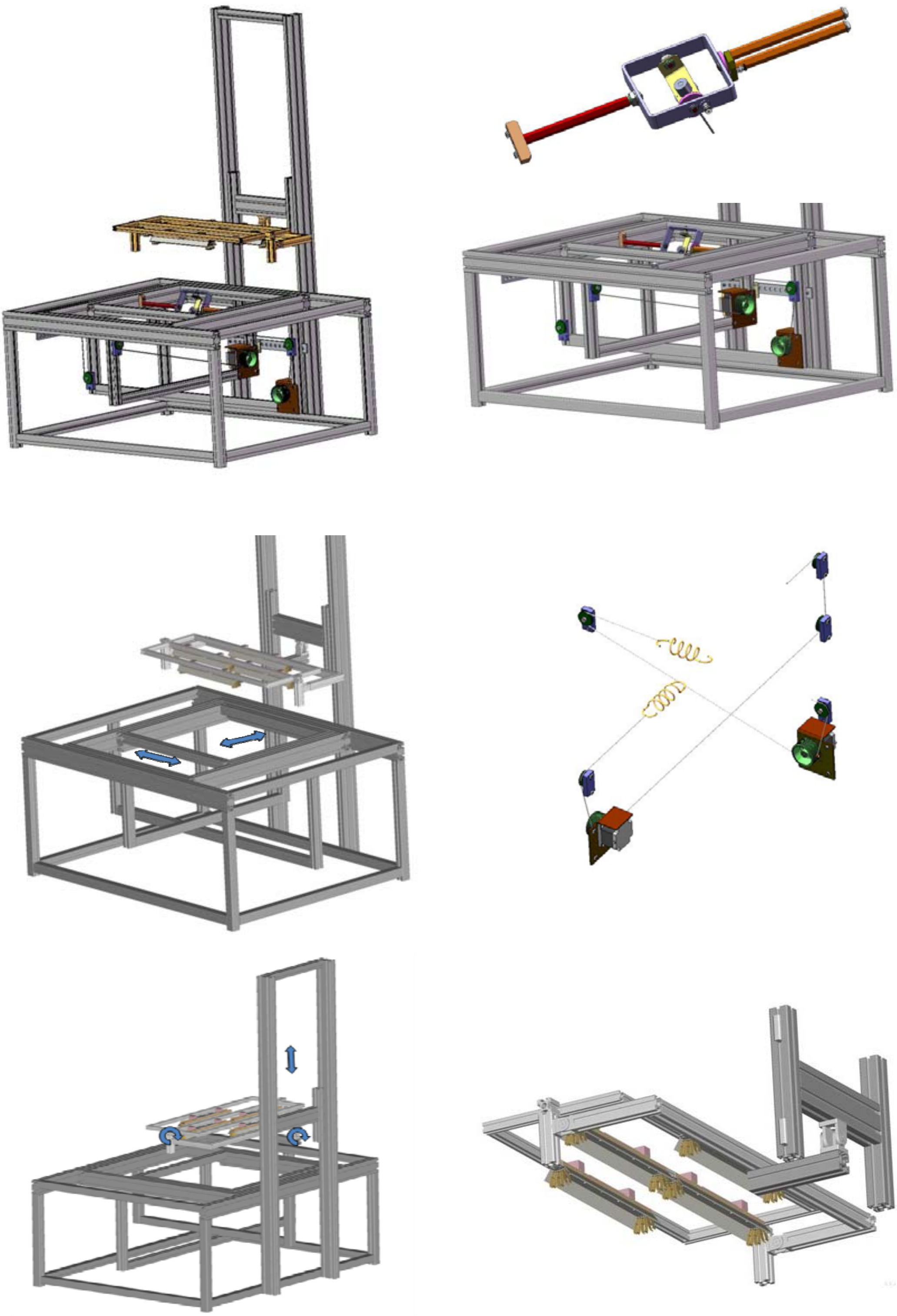

Fig. 1. Constructional Parts of the Measurement Workplace

Fig. 2. Operation Lay-out of the Measurement Workplace

4. Methodology of Measurement of Infra-Red Emitters Performance Characteristics

Identification of the power characteristics of infra-red emitters used in the process of fabrication of artificial leathers requires measurement of heat flux density of the given configuration of an infra-emitter or group of emitters depending on their distance from the radiation exposed mould surface and on the inclination angle of the normal line of this surface vis-a-vis the normal line of the radiator. Let us note that in the heating processes infra-red emitters with straight tubular lamps of various lengths, wattage, with or without reflectors are used. An example of the emitters lay-out in the so called heating back of a slush mould is obvious from the Fig. 3.

Fig. 3. Example of Real Infra-Red Emitters Lay-out

Measurement of the power characteristic is on principle realised as follows: under the lay-out of "alight" radiators in question, a density heat flux sensor is controllably shifted, for example according to the scheme in the Fig. 4. Information from the sensor is continually recorded by means of a logger Dewetron.

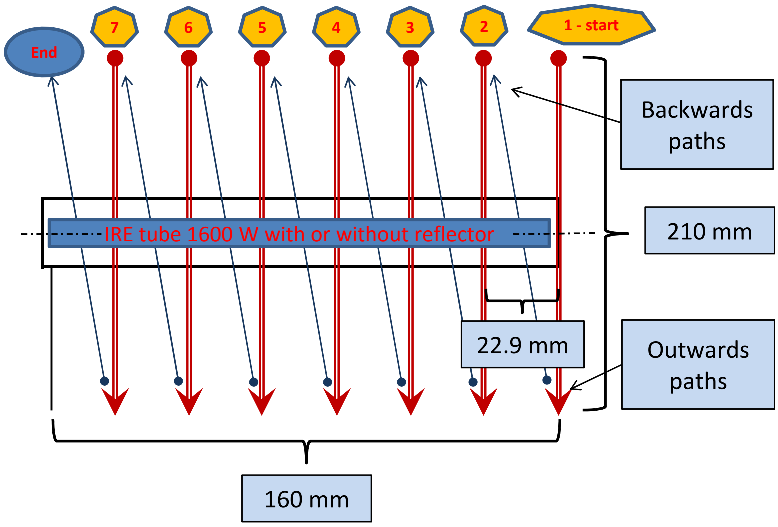

Fig. 4. Scheme of Measurement of the Heat Flux under the Infra-Emitter

5. Measurement Results

Relevant segments are taken out from the recorded heat flux behaviour, see Fig.5, for individual measured trajectories, see e.g. Fig. 6, from which discrete values are read and arranged into a suitable table, see Table 1 and Fig. 7.

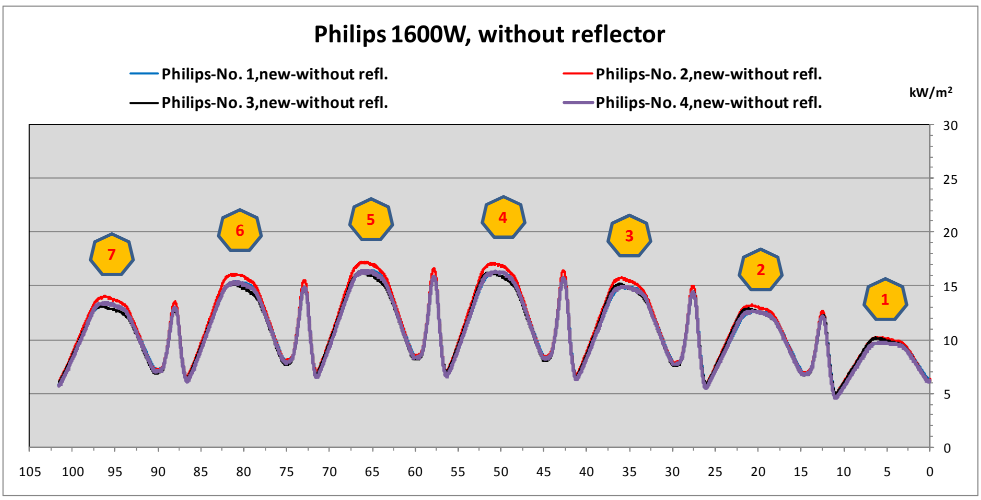

Fig. 5. Behaviour of Heat Flux Emitted by the Infra-Emitter

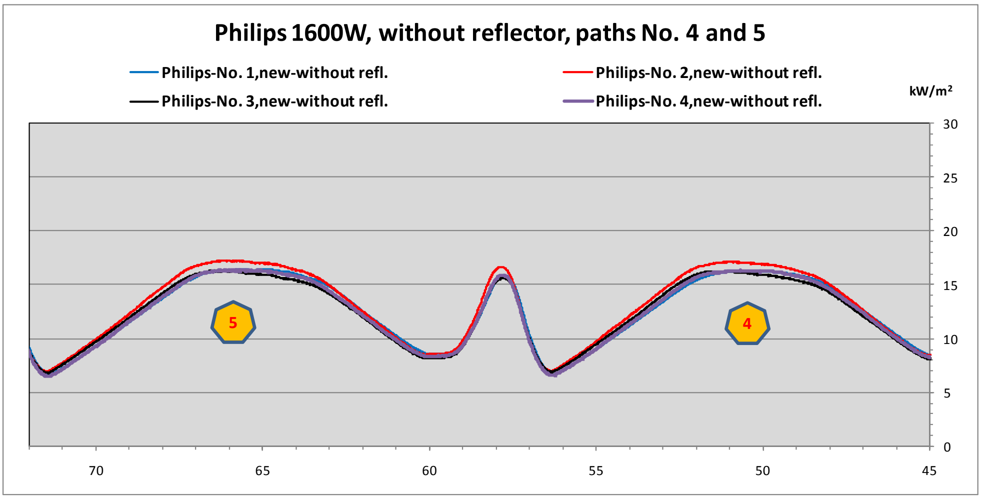

Fig. 6. Heat Flux Emitted by the Infra-Emitter along the Trajectory No. 4

Table 3. Values of the Infra-Emitter Heat Flux for a Symmetrical Quadrant of the Excited Position

		Heat flux [kW/m2]							
		coordinate x [mm]							
		0	**20.1**	**40.2**	**60.3**	**80.4**	**100.5**	**120.6**	**140.7**
coordinate y [mm]	**0**	11.0	11.0	11.0	10.4	9.7	8.7	7.5	6.2
	10	11.2	11.3	11.2	10.7	9.8	8.8	7.6	6.3
	20	11.4	11.5	11.4	10.9	10.1	9.1	7.9	6.6
	30	11.5	11.6	11.6	11.0	10.3	9.3	8.0	6.7
	40	11.2	11.4	11.4	10.8	10.1	9.1	7.9	6.6
	50	10.7	10.8	10.8	10.3	9.6	8.7	7.5	6.3
	60	9.9	10.1	10.1	9.5	8.9	8.1	7.0	5.9
	70	9.0	9.2	9.2	8.7	8.1	7.4	6.4	5.4
	80	8.2	8.3	8.3	7.8	7.4	6.7	5.8	5.0
	90	7.3	7.5	7.5	7.1	6.6	6.1	5.3	4.5
	100	6.6	6.7	6.7	6.3	6.0	5.4	4.8	4.1
	110	5.8	6.0	5.9	5.6	5.3	4.9	4.3	3.7
	120	5.2	5.3	5.3	4.9	4.7	4.3	3.8	3.2
	130	4.6	4.7	4.7	4.4	4.2	3.8	3.4	2.9
	140	4.1	4.2	4.1	3.9	3.7	3.4	3.1	2.7
	150	3.6	3.7	3.7	3.5	3.3	3.1	2.7	2.4
	160	3.3	3.3	3.3	3.2	3.0	2.7	2.5	2.2
	170	2.9	3.0	3.0	2.9	2.7	2.5	2.3	2.0
	180	2.6	2.7	2.7	2.5	2.4	2.3	2.0	1.8
	190	2.4	2.4	2.4	2.3	2.2	2.0	1.9	1.7
	200	2.1	2.2	2.2	2.1	2.0	1.9	1.7	1.5
	210	1.9	2.0	2.0	1.9	1.8	1.7	1.5	1.4
	220	1.7	1.8	1.8	1.7	1.6	1.6	1.4	1.3
	230	1.6	1.6	1.6	1.5	1.5	1.4	1.2	1.1

Discrete values of density heat flux obtained in this way represent an input into the above-mentioned software application IREview [2], which allows to simulate the density heat flux values on a complicated slush mould surface, and thus support the process of optimal spacing of a great number of infra-red emitters.

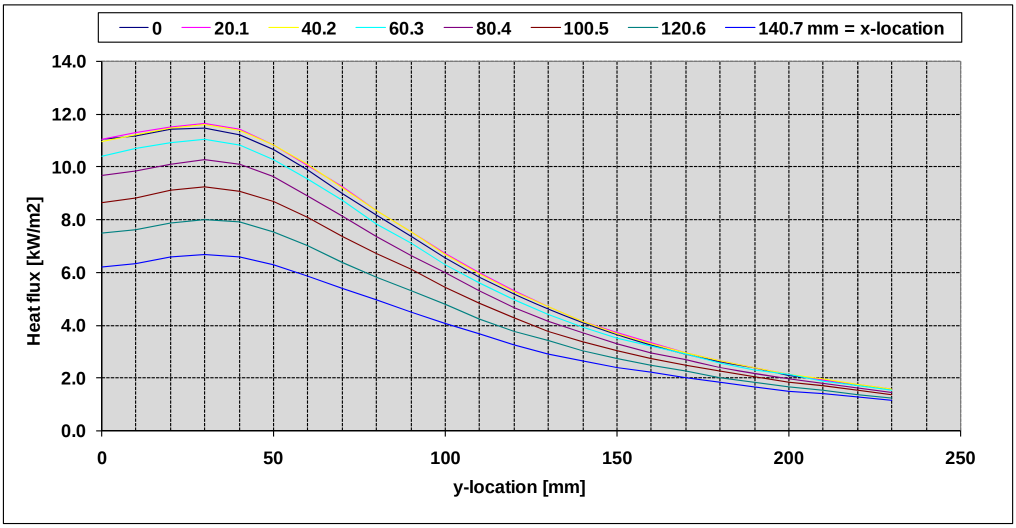

Fig. 7. Graphical Interpretation of Heat Flux Values from the Table 1

6. 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-red emitters used in fabrication of artificial leathers, which 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 moulds 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. One part is solved by development of an in-house software tool IREview by means of which 3-dimensional spacing of the infra-red emitters over a complicated and spacious metal mould is realized, with a possibility of 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, which are used for conducting a robotic hand during physical positioning of the radiators in the production facilities.

The present paper emphasizes that the developed virtual technology for optimal spacing of infra-red emitters necessitates realisation of an experimental workplace, which serves to measuring of directional radiation power characteristics of the applied infra-red emitters and their special constructions. Without these real physical measurements it would be impossible to use successfully the above stated software tools.

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 EAN 2011.

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