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Casting Technologies of Manufacturing of Metallic Foams and Possibilities of Their Use as a Heat Exchanger

Slévárenské technologie výroby kovových pěn a možnosti jejich využití coby výměníku tepla

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Metallic foams are materials with broad applicability in many different areas (e.g. automotive industry, civil engineering industry, medicine, etc.). These metallic materials have artificially created pores in their structure. These pores give them specific properties, such as large rigidity at low density, high thermal conductivity, capability to absorb energy, etc. Since the discovery of porous metallic materials numerous methods of production have been developed. Porous metallic materials can be made from liquid metal, from powdered metal, metal vapors, or from metal ions. The aim of the paper is to introduce casting methods for manufacturing of metallic foams with irregular and regular cell structure. All these manufacturing methods of metallic foams are based on conventional foundry technologies and materials. The aim of the paper is also to show a possibility of using metallic foam as a heat exchanger.

Key words*: casting; metallic foam; 3D modelling*

Kovové pěny jsou materiálem s širokým uplatněním v mnoha oborech lidské činnosti (např. automobilový průmysl, stavebnictví, medicína, aj.). Tyto materiály obsahují ve své struktuře uměle vytvořené póry. Tyto póry jim pak dávají mnoho výjimečných vlastností, jako je např. vysoká tuhost při nízké měrné hmotnosti, vysoká tepelná vodivost, schopnost absorpce energie atd. První zmínky o kovových pěnách pocházejí již z počátku 20. století, kdy se tyto pórovité kovové materiály začaly používat pro strojírenské účely. Ve dvacátých letech minulého století se začaly vyrábět a komerčně využívat pěny vyhotovené spékáním kovových prášků, které se používaly pro výrobu filtrů, baterií a samomazných ložisek. Ve francouzském patentu z roku 1925 nalezneme zmínky o kovových pěnách vyrobených vzpěněním materiálu, o třicet let později v USA začíná jejích komerční použití. Ale rozsáhlá výzkumná a vývojová činnost začala až v 90. letech a pokračuje dodnes. V současné době probíhá na VŠB – Technické univerzitě Ostrava výzkum zabývající se optimalizací výroby tohoto unikátního materiálu slévárenskou cestou. Od objevu porézních kovových materiálů bylo vyvinuto mnoho metod jejich výroby. Porézní kovové materiály mohou být vyrobeny z tekutého kovu, kovového prášku, kovových par či ionizovaného kovu. Cílem tohoto příspěvku je představit slévárenské metody výroby kovových pěn, a to jak pěn s pravidelnou, tak i s nepravidelnou buňkovou strukturou. Tyto metody jsou založeny na konvenčních slévárenských technologiích a ve slévárnách běžně používaných materiálech. Principem níže uvedených technologií výroby kovových pěn je infiltrace tekutého kovu do dutiny formy vyplněné prekurzory/preformou nebo použití odpařitelného modelu. Cílem příspěvku je rovněž ukázat možné aplikace odlitků kovových pěn s pravidelnou vnitřní strukturou coby výměníků tepla – využití velkého vnitřního povrchu těchto složitých odlitků.

Klíčová slova: *odlitek; kovová pěna, 3D modelování*

Metallic foams are materials, which are still under development with wide application possibilities in many fields of human activities (e.g. automotive industry, civil engineering industry, medicine, etc.). These interesting materials contain artificially created pores in their structure. These pores give them many exceptional characteristics, such as: high rigidity at low density, high thermal conductivity, absorption of energy and others. These materials offer interesting perspectives due to the combination of properties (Fig. 1). The aim of this paper is to explore the possibility of manufacturing of various structures of metallic foams and using cast metallic foam with divided inner cavity as a heat exchanger. As an instrument of the investigation the method of computer simulation was first chosen, which can compare the metallic foam with classic tube exchanger [1].

The term ‘‘foam’’ is not always properly used and shall therefore need to be defined. According to Fig. 2 which lists the designations for all possible dispersions of one phase in a second one (where each phase can be in one of the three states of matter), foams are uniform dispersions of a gaseous phase in either a liquid or a solid. The single gas inclusions are separated from each other by portions of the liquid or solid, respectively. Thus the cells are entirely enclosed by the liquid or solid and are not interconnected. The term “foam” in its original sense is reserved for a dispersion of gas bubbles in a liquid. The morphology of such foams, however, can be preserved by letting the liquid solidify, thus obtaining what is called a “solid foam”. When speaking of “metallic foams” one generally means a solid foam. [1].

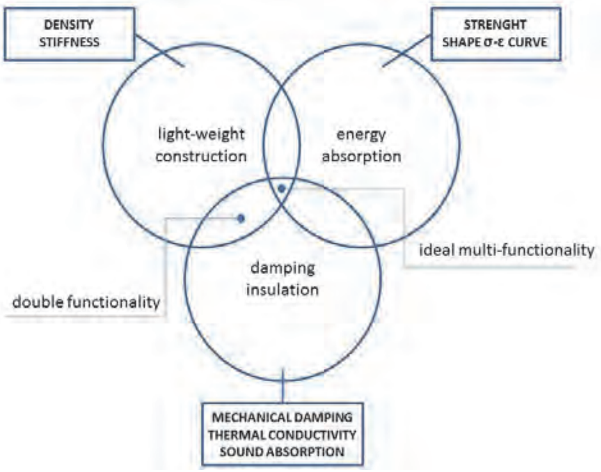

Fig. 1 Combination of properties of metallic foams
Obr. 1 Kombinace vlastností kovových pěn

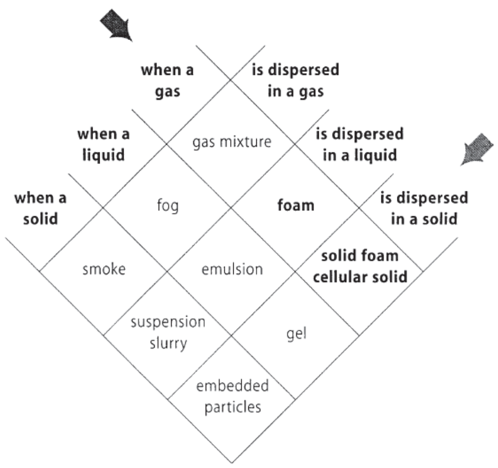

Fig. 2 Dispersions of one phase into a second one. Each phase can be in one of the three states of matter [1]
Obr. 2 Disperze jedné fáze ve fázi druhé. Každá z fází může být v jednom ze tří skupenství [1]

1. Possibilities for manufacturing of metallic foams

Since the discovery of porous metallic materials numerous methods of production have been developed. Some technologies are similar to those for polymer foaming, others are developed with regard to the characteristic properties of metallic materials, such as their ability to sintering or the fact that they can be deposited electrolytically [2].

According to the state, in which the metal is processed, the manufacturing processes can be divided into four groups. Porous metallic materials can be made from [3, 4]:

- liquid metal (eg. direct foaming with gas, blowing agents, powder compact melting, casting [5], spray forming)
- powdered metal (eg. sintering of powders, fibres or hollow spheres, extrusion of polymer/metal mixtures, reaction sintering)
- metal vapours (vapour deposition)
- metal ions (electrochemical deposition)

Porosity may achieve 30% to 93% depending on the method of production and material used. By changing the process parameters it is possible to obtain porous structure with various sizes and shapes of pores and with different types of arrangement (regular or irregular - stochastic) [3].

By manipulation of the process parameters, the pore structure can assume continuous or discontinuous geometries, a range of pore sizes, pore fractions, and a controllable shape of the final product. The continuous pores are connected together and to the surfaces of the component to allow fluid flow from one side to the other [6].

Within the production of cast metallic foams, we were verified by the infiltration of the molten metal into the mould cavity filled with precursors/preform and an investment casting process using an evaporable pattern.

2. Experiment – casting technologies of manufacturing of metallic foams

Casting technologies of metallic foam production referred to in this paper are based on the use of existing materials and process procedures, which are commonly used in foundries. Precise definition and subsequent implementation of these manufacturing technologies could enable further expansion of these materials and using their full application potential.

2.1 Infiltration of molten metal into mould filled with precursors/preform

Inner pores of metallic foams can be achieved by using „particles“ – precursors or preform, which fill the mould cavity. These particles, which have given shape and size, are placed into the mould cavity and the molten metal is poured over them. Precursors and preform must meet certain criteria. Particularly, they must be made of material, which preserves its shape during impact of the molten metal (sufficient strength, low abrasion, refractoriness) and they must allow also good disintegration after casting.

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Irregular arrangement of inner pores can be achieved by using precursors. Regular arrangement of the pores may be achieved by using preforms (special kinds of cores) of different shapes, which fill the mould cavity.

Principle of the method (using precursors) is shown in Fig. 3.

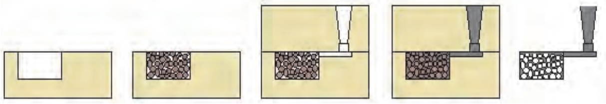

Fig. 3 Principle of infiltration of molten metal into mould filled with precursors, from left: mould, mould cavity filled with precursors, composite foundry mould, pouring molten metal into the mould cavity, cast metallic foam after removing precursors.
Obr. 3 Princip infiltrace tekutého kovu do dutiny formy vyplněné prekursory, zleva: forma, dutina formy vyplněná prekursory, složená forma, odlévání kovu do dutiny formy, odlitek kovové pěny po odstranění prekursorů.

2.1.1 Irregular cell structure

In the experiment we made castings with irregular cell structure with use of precursors based on conventional moulding mixtures (organic types). There were two types of precursors:

Precursors – Croning process

Core particles were manufactured from a moulding mixture (or from the rejected cores made by the Croning process). Final globular shape of core precursors was achieved by splitting them in to small pieces (10 – 30 mm) and subsequent tumbling. A mould cavity was filled with these precursors. Mould was made from the commonly used green sand (i.e. bentonite bonded moulding mixture). The disadvantage of these precursors is their irregular shape (Fig. 4), which is determined by uneven tumbling of the cullet due to non-uniform hardening of the default core mixture. Therefore, new technology of precursors manufacturing has been proposed – use of moulding mixture bonded by furan resin. This way of manufacturing of precursors should ensure the achievement of the same size, shape and the resulting characteristics of precursors.

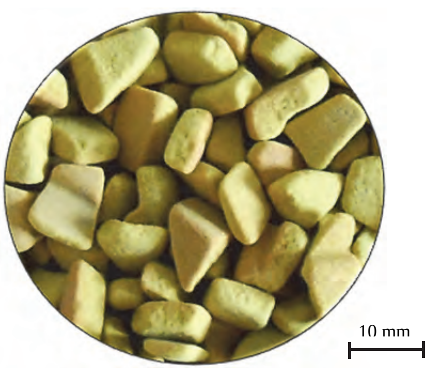

Fig. 4 Precursors – Croning process (irregular shape and size)
Obr. 4 Prekursory – technologie Croning (nepravidelný tvar a velikost)

Precursors – Furan moulding mixture

For creating these precursors were used a plastic grille as a core box. By using this core box we created cubes with a side of 25 mm. These cubes were then subjected to tumbling. The proposed technology ensures production of precursors of the same size, shape and properties (Fig. 5).

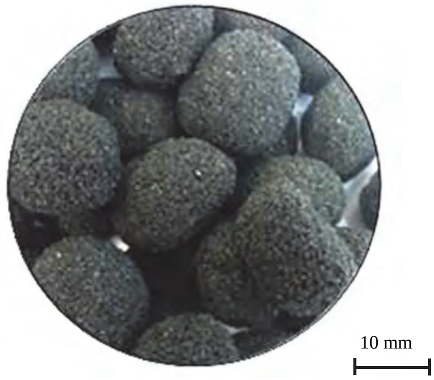

Fig. 5 Precursors – Furan moulding mixture (regular shape and size)
Obr. 5 Prekursory– furanová ST-směs (pravidelný tvar a velikost)

2.1.2 Regular inner structure

Preforms (cores) for manufacturing of metallic foams with regular inner structure were made with the use of the polyurethane cold box technology, which is based on a two-component binder system and constitutes a suitable method for the production of thus geometrically complex shape preforms. Gradually produced cores were subsequently assembled into one unit to form the preform (Fig. 6), which is the negative of regular internal cavities of the casting (metallic foam).

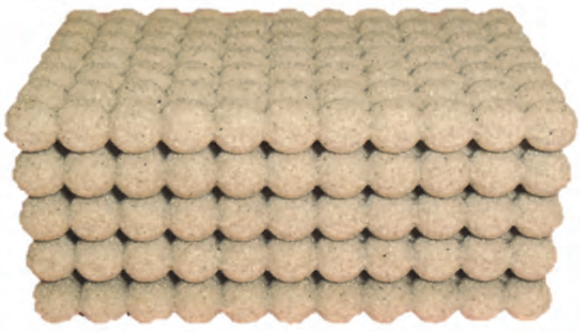

Fig. 6 Preform (core) composed of five layers of cells
Obr. 6 Preforma (jádro) složená z pěti pater

2.2 Use of evaporable pattern

One of the ways to create complex casting of metallic foam is to use an evaporable pattern (polyurethane, polystyrene).

2.2.1 Irregular cell structure

The most common foundry method for manufacture of metallic foams with open pores is a method with the use of a disposable evaporable polymeric pattern (Fig. 7) – polymeric foams (most commonly polyurethane foam – PU foams).

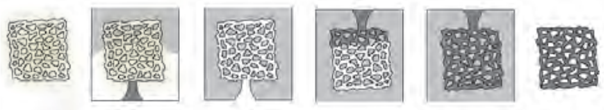

Fig. 7 The principle of use of a disposable evaporable polymeric patter, from the left – polymer foam, polymer foam infiltrated with plaster, removed polymer, infiltrated with metal, metallic foam in mould, removed mould, final metallic foam
Obr. 7 Princip využití jednorázového odpařitelného modelu, zleva – polymerní pěna, polymerní pěna zalitá sádrou, odpaření polymer, infiltrace tekutého kovu do vzniklé dutiny, kovová pěna ve formě, finální odlitek kovové pěny

One of the key steps in this production process is the choice and processing of material suitable for manufacture of a mould – plaster in this case. The material for the mould manufacture must have in particular sufficient heat resistance, the mixture must have good fluidity to be able to fill all the small pores of the PU foam.

For casting of various alloys (Cu alloys, Al alloys) it is necessary to define different annealing cycles. For casting the Cu alloys with higher melting temperature (higher casting temperature) it is necessary to anneal the plaster moulds to higher temperatures – to eliminate the thermal shock during casting, and to increase the melt fluidity into the complex mould cavity. Annealing cycles can be seen in Tab. 1.

Tab. 1 Annealing cycles of plaster moulds
Tab. 1 Žíhací cykly sádrových forem

Annealing cycle number	Temperature, increase, soak at temperature		
1	120 °C, 8 °C·min^{-1}; 8 h	320 °C, 10 °C·min^{-1}; 8 h	800 °C, 20 °C·min^{-1}; 10 h
2	120 °C, 8 °C·min^{-1}; 8 h	550 °C, 10 °C·min^{-1}; 8 h	1100 °C, 20 °C·min^{-1}; 10 h
3	120 °C, 8 °C·min^{-1}; 8 h	550 °C, 10 °C·min^{-1}; 8 h	1000 °C, 20 °C·min^{-1}; 10 h

The most commonly used is the annealing cycle No. 1 which is suitable for the subsequent casting of Al alloys (low melting temperature or low casting temperature).

However, for casting of Cu and Fe alloys it is necessary to increase the annealing temperature, i.e. to heat the moulds to higher temperatures. Therefore the annealing cycle No. 2 was recommended. This annealing cycle proved to be unsuitable – the moulds annealed to such high temperatures show an impaired collapsibility after metal casting.

A plaster sample has been subjected to differential thermal analysis, which found that at the temperatures of 1100 °C the $CaSO_4$ is disintegrated to CaO and SO_3 (degradation of the mould).

After the evaluation of the plaster DTA the annealing cycle No. 3 was designed. The moulds annealed in such a way have good collapsibility after casting, but for casting the Cu and Fe alloys the mould temperature is too low. Casting of these alloys was accompanied by metal misruns into the mould cavity due to high temperature jump. On the contrary the mould prepared in such a way for casting the Al alloys is “overheated“.

2.2.2 Regular inner structure

There is a possibility of manufacturing metallic foams with regular inner structure by using the Lost Foam Technology. The technology principle consists in leaving the polystyrene pattern in the mould when the pattern is evaporated during casting and the resulting cavity is filled with the molten metal.

The pattern is most often prepared from expanded polystyrene (EPS) or polymethyl methaerylate (PMMA), it can be prepared by cutting, milling and subsequent gluing of individual parts or by creating a foaming mould. The pattern formed in such a way is equipped with a gating system, which can be made from the same material as the casting pattern. The entire pattern is treated with a heat resistant coating. Moulding can be done without the use of binders [7]. One of the advantages of this technology is the possibility of manufacture of castings with complex shapes and without the use of cores.

3. Utilization of metallic foam with regular inner cells

This part of the paper is devoted to designing an experiment for the possible testing of samples made of metallic foams with a regular arrangement of cells as an internal heat exchanger. Before the production of the real casting a variant for flow simulation was modeled, both for the metallic foam and the classical tubular exchanger. Subsequently both these models were subjected to comparison and evaluation of results. A powerful tool for designing an effective and adequate heat exchanger is a mathematical simulation. Simulations will be performed in ANSYS CFX software environment [8, 9].

3.1 Geometry

Figs. 8 and 9 show the initial analyzed geometries. Fig. 8 shows ball cores inside the metallic foam within two rows. The total number of the balls is 120. The left side of the figure shows the internal domain of the flowing medium, the right side shows a domain of the metallic foam with input intakes for attaching hoses for entering a medium.

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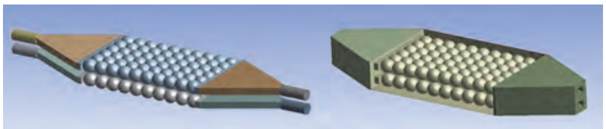

Fig. 8 Analyzed geometry of the metallic foam
Obr. 8 Zkoumaná geometrie kovové pěny

Fig. 9 shows the classic two-row tubular heat exchanger, which is used in many applications. The total number of tubes is 12. The inner diameter of the pipes is equal to the diameter of balls in a metallic foam.

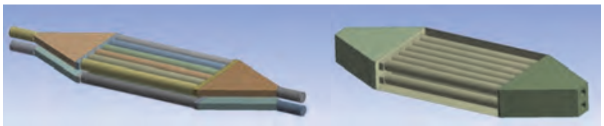

Fig. 9 Analyzed geometry of the tubular heat exchanger
Obr. 9 Zkoumaná geometrie trubkového výměníku tepla

3.2 Mesh

Tube heat exchanger includes a total number of 1.1 million cells. Heat exchanger created with metallic foam contains a total number of 2.1 million cells. Cell size was set at 1.5 mm in both cases. The boundary layer at the surfaces is formed by five cells with a thickness of one millimeter.

3.3 Boundary conditions

Calculation of both geometries was divided into two main domains. The first domain was set as a liquid representing a flowing air. The second domain was set as a solid body representing the metal exchanger. Material properties of both domains are summarized in Tab. 2. The roughness of the walls is not included in the calculation [10]. Adiabatic walls were set up on all outer walls of solid bodies. Boundary conditions of the heat exchanger are defined on both floors.

Tab. 2 Physical properties of used material
Tab. 2 Fyzikální vlastnosti použitého materiálu

	Domain	
	Ideal Gas	Aluminum
Thermal conductivity (W·m·K^{-1})	0.0261	237
Specific Heat Capacity-cp (kg·J·K^{-1})	1004.4	903
Density by 20 °C (kg·m^{-3})	1.204	2702
Dynamic viscosity (kg·m^{-1}·s^{-1})	1.831E-5	-

3.4. Results

Calculation of the tube heat exchanger ran approximately for two hours and the accuracy of the convergence is given below 1E-6. Calculation of the metallic foam heat exchanger ran approximately for 2.5 hours and the accuracy of the convergence is given below 1E-6. Tab. 2 summarizes the mean values of the output areas of both heat exchangers.

Tab. 3 Average values at the output of heat exchanger
Tab. 3 Průměrné hodnoty na výstupu z výměníku

		Metallic foam	Pipe
Temperature – hot side	(°C)	55.9	62.1
Temperature – cold side		55.5	50.2
Velocity – hot side	(m·s^{-1})	0.88	0.89
Velocity – cold side		1.12	1.1
Pressure – hot side	(Pa)	4.533E-3	4.548E-3
Pressure – cold side		6.42E-3	7.431E-3

Figs. 10 and 11 show values of the observed waveforms dependent on coordinates.

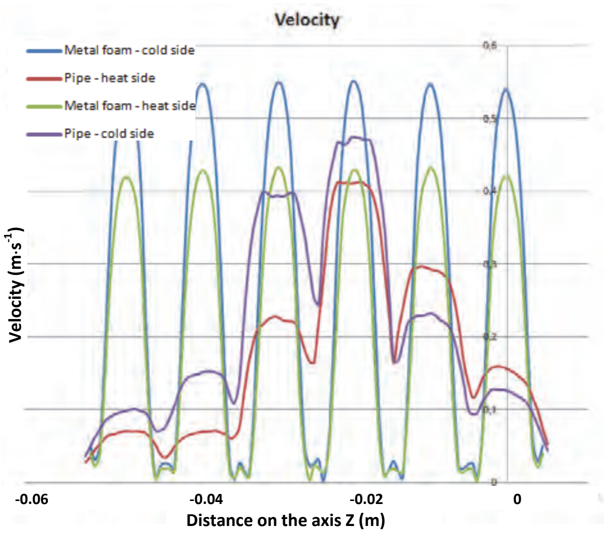

Fig. 10 Velocity profile of the heat exchangers
Obr. 10 Rychlostní profil ve výměnících tepla

From Fig. 10 it is clear that the heat exchanger of the metallic foam has a uniform distribution of the velocity field around the analysis section. Temperature variation of a conventional tubular heat exchanger has the maximum velocity in the centre of the region. The colder side of heat exchangers has a higher rate of air flow than the hot side.

Fig. 11 shows distribution of the temperature field in two heat exchangers. The heat exchanger formed from metallic foam has a constant behavior throughout the course of the analysis cross section on both sides. In the plane of symmetry of the heat and cold sides correspond. The maximum value achieved in a tubular heat exchanger has reached the value of approx. 70 °C, with a ball exchanger this value was approx. 55 °C. The maximum difference between the hot and cold side of the metallic foam heat exchanger was approx. 1 °C, whereas classical heat exchanger had a maximum differential value of approx. 27 °C.

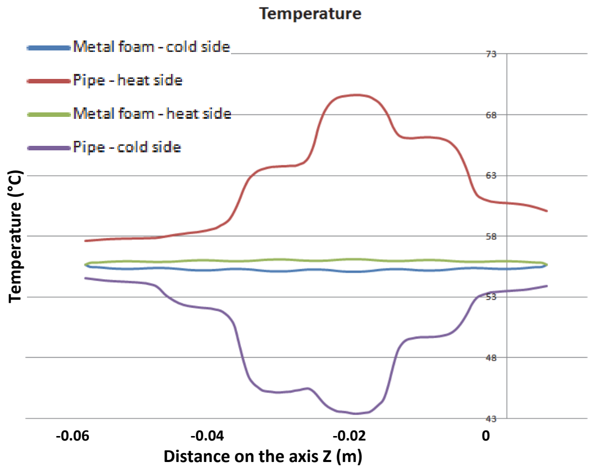

Fig. 11 Heat distribution in heat exchangers
Obr. 11 Distribuce tepla ve výměnících tepla

Figs. 12 and 13 show the color resolution of values examined in both heat exchangers. Fig. 12 shows the thermal field on the hot side and Fig. 13 shows the velocity field of both heat exchangers.

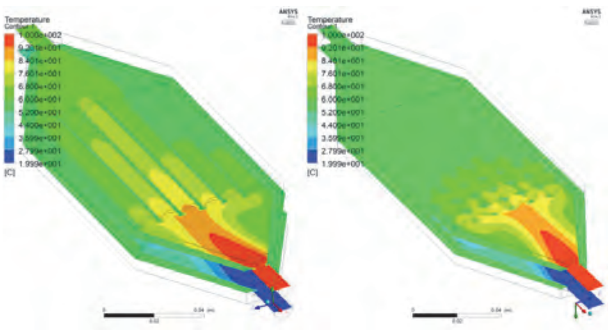

Fig. 12 Heat exchangers – the side of the hot medium flow
Obr. 12 Výměník tepla – strana průtoku teplého média

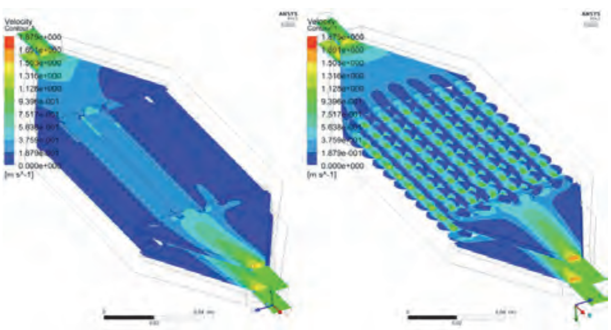

Fig. 13 Velocity field of the heat exchangers
Obr. 13 Rychlostní pole výměníku tepla

Conclusions

Metallic foams are progressive materials with continuously expanding use. Mastering of production of metallic foams with defined structure and properties using gravity casting into sand or metallic foundry moulds will contribute to an expansion of the assortment produced in foundries by completely new type of material, which has unique service properties thanks to its structure, and which fulfils the current demanding ecological requirements. Manufacture of foams with the aid of gravity casting in conventional foundry moulds is financially advantageous process, which can be industrially used in foundries without high investment demands.

The principle of the above-mentioned technologies is the infiltration of liquid metal into the foundry mould cavity the use of an evaporative pattern. These technologies enable production of shaped castings – metallic foams - with irregular or regular cell structure. For production of precursors is moreover possible to use the material, which would be otherwise wastes – rejected cores or excess moulding mixture.

One of the possible applications of metallic foam with such complicated internal cavity is a heat exchanger. We first made for the purpose of verification of effectiveness a modeling of casting of the metallic foams, with variants for simulating the flow of gaseous media in both the metallic foam and the classic tube exchanger. Computational analysis showed that the heat exchangers showed signs of different behavior under the same boundary conditions. The greatest differences can be seen in Figs. 10 and 12, when the newly designed heat exchanger made of the metallic foam exhibits stable temperature characteristics in the whole investigated cross section immediately before an outlet therefrom. Uniform distribution of heat affected overall heat transfer in the heat exchanger so that the output temperature was generally lower by 12 °C. The relative pressure at the outlet of both heat exchangers has corresponded. In the next step heat exchangers with different geometries, etc., will be modelled. Computationally the most efficient heat exchanger will be subjected to experimental measurements and compared to the reference model (tubular heat exchanger).

Acknowledgements

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Literature

[1] BANHART, J. Manufacture, Characterisation and Application of Cellular Metals and Metal Foams. *Progress in Materials Science*, 46 (2001), 559–632.

[2] LICHÝ, P., BEDNÁŘOVÁ, V. Casting routes for porous metals production, *Archives of Foundry Engineering*, 12 (2012) 1, 71–74.

[3] BANHART, J.. Manufacturing routes for metallic foams. *Journal of Minerals, Metals and Materials*, 52 (2000) 12, 22–27.

[4] BEDNÁŘOVÁ, V., LICHÝ, P., HANUS, A., ELBEL, T. Characterisation of cellular metallic materials manufactured by casting methods. *In: 21st International Conference on Metallurgy and Materials Metal 2012*, May 23rd – 25th 2012, Brno, Czech Republic. (pp. 1209-1214). Brno: Tanger Ltd., Ostrava, 2012. ISBN 978-80-87294-31-4.

[5] CHOLEWA, M., DZIUBA-KAŁUŻA, M. Closed aluminium skeleton casting, *Archives of Foundry Engineering*, 8 (2008) 1, 53–56.

[6] SHAIK DAWOOD A. K., MOHAMED NAZIRUDEEN S. S. Development of Technology for Making Porous Metal Foams Castings. *Jordan Journal of Mechanical and Industrial Engineering.* 4 (2010) 2, 292–299.

[7] ŻÓŁKIEWICZ, Z., ŻÓŁKIEWICZ, M. Lost Foam Process – the Chance for Industry. *TEKA Kom. Mot. Energ. Roln. – OL PAN*, (2009), 431–436.

[8] BLEJCHAŘ, T. *Návody do cvičení "Modelování proudění"-CFX*, 1. vyd. (učební texty) [Instruction for the exercise "Modelling of flow" – CFX, 1st edition (textbooks)] Ostrava: VŠB-TU Ostrava, 2009. 133 pp. ISBN 978-80-248-2050-7. Available at http://www.338.vsb.cz/PDF/Blejchar-CFX.pdf.

[9] BLEJCHAŘ, T. *Turbulence Modelování proudění– CFX*, 1.vyd. (učební texty) *[Turbulence of flow modelling] CFX – 1st edition (text books)* Ostrava: VŠB-TU Ostrava, 2010. 259 s. Available at http://www.338.vsb.cz/PDF/Turbulence_ESF_v4.pdf.

[10] KADLEC, Z. *Termomechanika, návody do cvičení*, 1.vyd. [Thermomechanics, instructions for exercises], 1st edition, Ostrava: VŠB-TU Ostrava, 2002. 97 pp. ISBN 978-80-248-1736-1.

Šéfové koncernů požadují vyšší tempo u digitalizace

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Šéf ThyssenKrupp Heinrich Hiesinger požaduje více odvahy v Německu u digitalizace. První poločas byl podle Hiesingera ztracen, ale s dobře kvalifikovanými zaměstnanci by průmysl mohl ve druhém poločasu vyhrát, tvrdil Hiesinger na kolokviu na Technické univerzitě Mnichov. Produktivita prodělává díky digitalizaci přímo kvantový skok. Šéf švýcarského technologického koncernu Oerlikon Michael Süss žaluje: „V Německu dnes panuje určitá biedermeierovská nálada“. Přitom by Průmysl 4.0 mohl zastavit nebo dokonce obrátit stěhování pracovních míst do Číny a východní Evropy.

Uhlík: Roztříštěné sny

Handelsblatt *23.03.2017*

Uhlík platil jako nosič naděje, jak udělat auta lehčí. Ale ocel a hliník ho předjely. Je to právě šest let, kdy tehdejší šéf BMW Norbert Reithofer ohlásil revoluci ve stavbě karoserií. „Uhlíková vlákna jsou klíčovým materiálem pro automobilní průmysl jedenadvacátého století," řekl při příležitosti otvírání nového provozu, ve kterém se tento materiál lehkých konstrukcí měl ve spolupráci se specialisty SGL vyrábět. Černá speciální vlákna měla změnit způsob, jakým se vyvíjejí a staví automobily. Zřídkakdy se vrcholový manažer tak mýlil. Vysoce nadějné sny se rychle rozplynuly. Uhlík má výhody, to je nesporné: zázračná vlákna jsou lehčí a tvrdší než ocel, doposud nejvýznamnější materiál pro stavbu automobilů. Jenže má i velké nevýhody, a ty bohužel převažují. Z toho důvodu se masové nasazení v automobilovém průmyslu nezdařilo. Je několikanásobně dražší než hliník nebo ocel, mnohem hůř se obrábí, často jen ručně. A uhlík se téměř nedá recyklovat. BMW zůstal jako jediný stavitel aut, který černá vlákna v nezanedbatelném množství používá. Budoucnost modelů, využívajících uhlíková vlákna, je jen s otazníkem. BMW zcela zřetelně podcenilo vývoj klasických materiálů a musí se uhlíkové revoluce zříci. Nebo ji musí alespoň o celé roky odložit.

Salzgitter zvyšuje dividendu

Börsen-Zeitung *25.03.2017*

Je to právě rok, co v koncernu Salzgitter AG panoval strach o existenci. Evropu zaplavovala levná ocel z Číny, prodávaná za dumpingové ceny, které ležely dokonce pod výrobními náklady. Po zásahu EU a zavedení importních cel se situace pronikavě změnila. Koncern již před několika týdny ohlásil za rok 2016 zisk kolem 57 mil. €. Vyhlídky jsou tak dobré, jak už dlouho nebyly. Šéf představenstva Heinz Jörg Fuhrmann očekává, že v letošním roce obrat i zisk výrazně stoupnou, sanační program skončil. Firma nyní sází na růst a inovace a investuje jen v Salzgitteru a v Ilsenburgu třímístné milionové částky do nových zařízení. Cílem je moci nabídnout vyšší kvality oceli, například pro offshore průmysl. S hlavní oblastí svého obchodu (výroba oceli a trub) se podnik nachází i přes zvýšené ceny ještě stále na trzích plných stresu. Vzhledem k dosaženým výsledkům byla dividenda na akcii zvýšena o 5 centů na 0,30 €. Koncern hodlá za uplynulý rok vyplatit celkem 18 mil. €.