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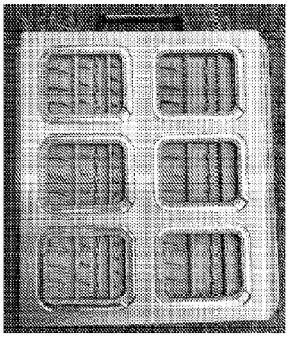
(54) Title: TESTING MOULD TO TEST MICRO- AND NANO-COATINGS ON AL AND FE MATERIALS



[Fig. 1]

(57) Abstract: The invention relates to a testing mould to test micro- and nano-coatings on Al and Fe materials during product pressing, particularly in a vulcanisation mould. The testing mould comprises at least three Al-alloy testing inserts and three Al-alloy testing inserts with Fe fins having the same composition as the moulds for pressing the finished products themselves, wherein at least two Al-alloy testing inserts and at least two Al-alloy testing inserts with Fe fins are provided with coatings. The testing inserts correspond to moulds for pressing finished products selected from the groups of tyres, shoe soles, and mats.

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Title of Invention: Testing mould to test micro- and nano-coatings on Al and Fe materials.

Technical Field

[0001] The invention relates to a testing mould to test micro- and nano-coatings on Al and Fe materials during product pressing, particularly in a vulcanisation mould.

Background Art

[0002] Currently, aluminium alloys are used to manufacture metal moulds for tyre production, especially for summer tyre moulds, or a combination of aluminium alloy and stainless-steel fins, especially for winter tyre moulds. The metal mould is composed of a certain number of segments, usually ranging from 8 to 36 depending on the size of a tyre being produced. The metal mould surface is not finished with any surface treatment technology. The moulds are used to produce tyres by vulcanising a mixture of organic substances at higher temperatures, i.e., 150°C to 170°C. After a certain number of cycles, i.e., the number of tyres produced, the individual segments of the metal mould are necessary to be cleaned. The production shutdown to clean the equipment, the metal mould is an essential part of which, takes several days. The increasing number of cleaning cycles shortens the life of the moulds, being one of the primary cost burdens in tyre production. During the cleaning cycle, a given type of tyres is not produced, affecting the productivity of the production company. Similar moulds, in terms of the material used, are also used in producing rubber soles for footwear or mats and the like.

[0003] In recent years, surface treatment operations of functional surfaces by micro- and nano-coating have been introduced into the technology of production of metal moulds made of the types of alloys mentioned above. These surface treatment operations should extend the life of the moulds, reduce the frequency of cleaning thereof required, and improve the surface quality of the resulting products. Currently, the testing of new micro- and nano-coatings is performed directly on the mould produced, during which the individual mould segments are subjected to a coating process. This testing method has several disadvantages and does not allow an uncoated mould to be tested and compared with a coated mould under the same conditions. This method is economically demanding as the price of the mould ranges from CZK 0.6 to 1.2 million. Only one mould and one type of material can be tested simultaneously, e.g., with or without Fe fins, which makes the whole process more expensive and time-consuming. Virtually, there is no so-called testing mould on the market that would eliminate these disadvantages and allow multiple surfaces and material types to be tested and

compared simultaneously.

[0004] Currently, there is no known solution for testing micro- and nano-coatings on Al and Fe materials that would allow for the operational testing of multiple new micro- and nano-coatings simultaneously. Testing and checking are carried out directly on the produced Al mould or Al mould with Fe fins intended for finished production. This is highly cost-ineffective as the coating has to be done on all segments, i.e., 8 to 36 pieces, and only one variant is tested. With the testing mould, 6 variants are possible to be tested simultaneously, meaning 6 times lower testing costs, especially in terms of energy and labour, and material consumption. The test price for the testing mould for 2,400 pieces of mouldings is CZK 85,000; when testing directly on finished moulds, the price is CZK 510,000, i.e., 6 times more. The price of one finished mould for production is CZK 0.7 to 1.2 million; the price of the testing mould is only CZK 292,000.

Summary of Invention

[0005] The drawbacks mentioned above are eliminated by the testing mould to test micro- and nano-coatings on Al and Fe materials during product pressing, particularly in a vulcanisation mould according to the invention. Summary of this invention consists in that the testing mould comprises at least three Al-alloy testing inserts and three Al-alloy testing inserts with Fe fins having the same composition as the moulds for pressing the finished products themselves, wherein at least two Al-alloy testing inserts and at least two Al-alloy testing inserts with Fe fins are coated, i.e., six different variants in total.

[0006] The testing inserts correspond to moulds for pressing finished products selected from the groups of tyres, shoe soles, and mats.

[0007] The present invention introduces a so-called testing mould into the process of micro- and nano-coating; this mould is made of segments of the same composition as the moulds produced for the technology of manufacturing the finished products themselves, i.e., tyres, shoe soles, mats, etc. The advantage of the testing mould consists in those three different coatings on the inserts or two inserts with coating and one insert without coating are possible to be tested at the same time for comparison purposes, and this can be done in combination on the Al mould only or the Al mould with Fe fins. The complete assembled testing mould usually comprises three Al-alloy testing inserts and three Al-alloy testing inserts with Fe fins. Therefore, the mould allows six different combinations to be tested at the same time within a single process, effectively reducing the financial cost of testing and examining multiple micro- and nano-coatings at the same time and comparing them to each other but also testing under the same conditions and shortening the overall process time.

[0008] In addition to the already mentioned economic advantage, i.e., 6 times lower costs of testing itself and low cost of the testing equipment compared to the form used in production, the testing equipment's low maintenance and cleaning requirements are also a great advantage. The ability to test and compare six variants simultaneously under exactly the same technical conditions also represents a great benefit. Also, the cost of the produced testing mould is 3 to 7 times lower compared to the production of one mould for the finished production, wherein testing directly on the production mould is moreover impractical in terms of the exclusion thereof from the production process for a certain period, generating losses in production.

Brief Description of Drawings

[0009] The testing mould to test micro- and nano-coatings on Al and Fe materials during product pressing, in particular in the vulcanisation mould, according to the present invention will be described in more detail in a particular exemplary embodiment referring to the accompanying drawings. [Fig.1] is an outline of the complete testing mould consisting of six testing inserts ready to test. [Fig.2] is an outline of one of the testing inserts after coating. [Fig.3] is an outline of moulding from the test of the testing mould. [Fig.4a] shows the mould in elevation and Fig. 4b in the side elevation.

[0010] All drawing documentation is included in the appendices. Two images are also included in the appendix, showing the produced testing mould without testing tread pattern inserts and the complete testing mould with 6 testing tread inserts that can be changed to fit the changing tread pattern shape.

Examples of the Invention Embodiments

[0011] An exemplary testing mould to test micro- and nano-coatings on Al and Fe materials during product pressing in a vulcanisation mould comprises three Al-alloy testing inserts and three Al-alloy testing inserts with Fe fins, which have the same composition as the moulds for pressing the finished products themselves, wherein two Al-alloy testing inserts and two Al-alloy testing inserts with Fe fins are provided with nano-coatings. The testing inserts correspond to moulds used for pressing the finished products, i.e., tyres.

[0012] The overall description and procedure of the vulcanisation mould production technology, including the materials used for testing the micro- and nano-coatings, are specified in Table 1. The base plate for fitting the individual inserts is made by AlSi10Mg material casting, followed by machining of the functional surfaces, particularly milling, turning, and drilling, to achieve the required surface quality and dimensional accuracy. The inserts, six pieces in total, were produced by the low-pressure casting of AlMg4.5Mn material, subjected to heat treatment by hardening and mechanically machined by blasting before coating. The fin material is made of an alloy

based on 1.4301, and the handles on the base plate are made of steel of grade 11.

[0013] The testing mould assembled in such a way was successfully tested in producing specific rubber-compound semifinished products for the needs of individual moulds by pressing and the final product, i.e., the moulding, shown in [Fig.3]. The products produced in such a way can be compared with each other and subjected to further qualitative examination.

[0014] Table 1. Overall description of the technology for the vulcanisation mould production to test the micro- and nano-coatings

Production technology for the experimental vulcanisation mould		
Ref. no.	Part of the mould	Description
1.	Model and production fins – drawings H_036-110_LAMELA 1_MODELOVKA H_036-111_LAMELA 2_MODELOVKA H_036-110_LAMELA 1 H_036-111_LAMELA 2	– Fin material 1.4301 – Laser cutting in 2D profile – Finishing in a tumbling barrel, chamfering
2.	Model drawing H_036-109	– Model material: PUR, density: 750 $kg \cdot m^{-3}$ – Modelling a 3D model for programming – Machining on a 5-axis milling centre – Manual finishing of models, including assembly of model fins into the model
3.	Casting – tread pattern insert drawing H_036-105	– Model impression using silicone of 20 Shore hardness – The casting of gypsum cores, including production fins using the Bendix method – Drying of gypsum cores, 230°C, 24-hour cycle – Casting material AlSi10Mg, CSN EN 43000 – Casting into water-cooled steel permanent mould using the LPC technology – Refining with FDU including salt spiked

		with strontium – Gasification index 0.8% – Casting temperature 730°C, mould filling time 20 sec, holding pressure time 1080 sec, de-pressurisation time 120 sec, mould cooling between 60–1000 sec – Melt filtration using 10 ppi ceramic foam filters
4.	Finishing	– Water jet cleaning – Cutting the technological allowances off
5.	Rough machining the tread pattern inserts	– Machining of castings on a 3-axis milling machine
6.	Heat treatment of T6 tread pattern inserts	– Dissolution annealing – see Annex for temperature curve – Cooling in preheated cooling medium (water) at 45°C, time: 3 min. – Artificial ageing, ramp: 30 min. at 170°C, endurance: at 170°C, 150 min. – Hardness 122 and 123 HBW
7.	Slashing the tread pattern inserts	– Machining to final dimensions on a 3-axis milling machine
8.	Machining the mould parts: Baseplate drawing H_036-103 Mould drawing H_036-104	– Mat.: AlMg4,5Mn in the hardened state – Machining on a 3-axis milling machine
9.	Production of mould auxiliary parts: Handle drawing H_036-107 Tube	– Material: steel of grade 11 – Production by forming (handle) and turning (tube)

	drawing H_03-108	
10.	Assembly	– Assembly of individual parts into complete testing casting mould

[0015] An example mould size is 400 × 380 × 54 mm, and the insert size is 90 × 100 mm.

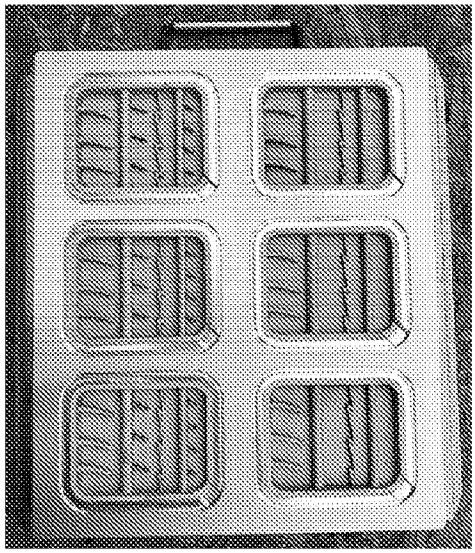
Industrial Applicability

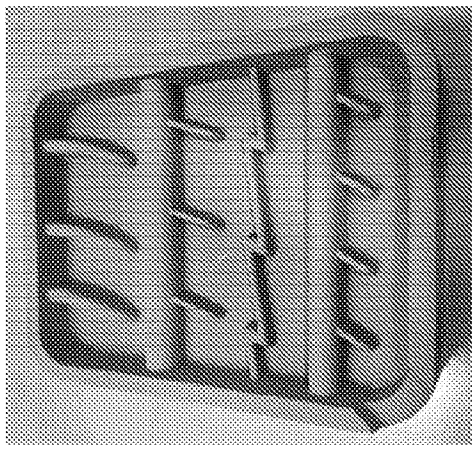
[0016] The testing mould to test micro- and nano-coatings on Al and Fe materials during product pressing, in particular in a vulcanisation mould, according to the present invention, will find the application mainly in the automotive and textile industries to test the moulds which have been coated during the manufacture of products made of vulcanisation compound, such as tyres, shoe soles, mats, etc.

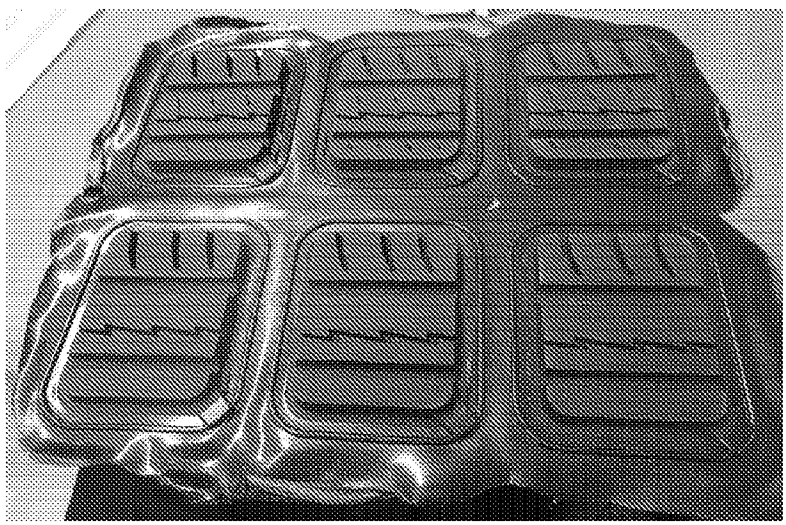
Claims

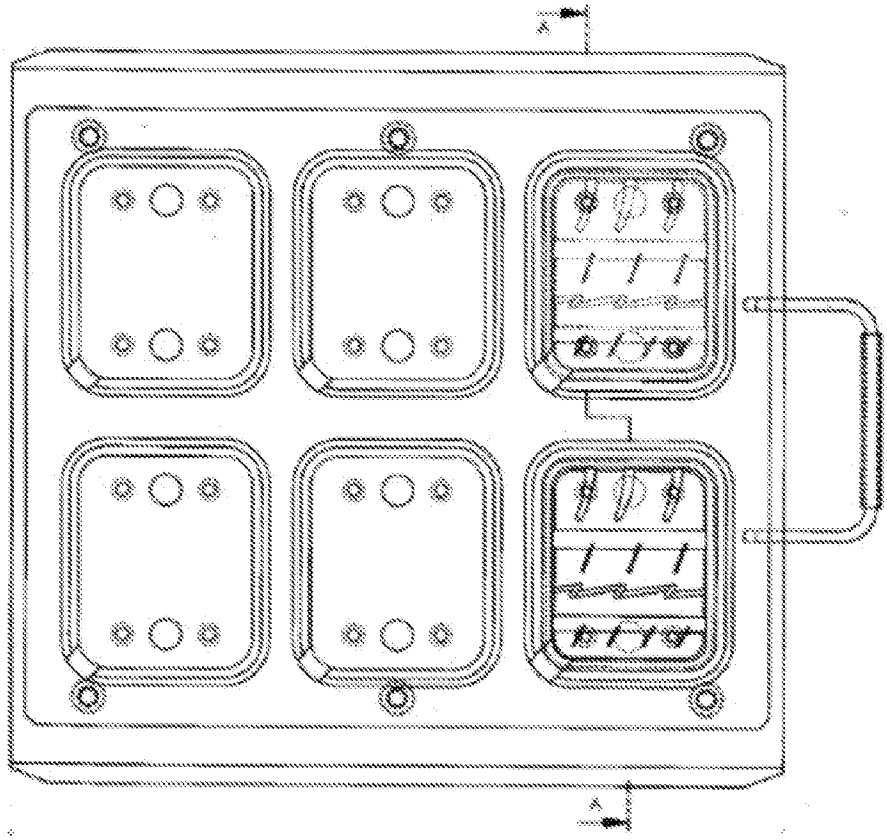
[Claim 1] A testing mould to test micro- and nano-coatings on Al and Fe materials during product pressing, in particular in a vulcanisation mould, ***characterised in that*** the testing mould comprises at least three Al-alloy testing inserts and three Al-alloy testing inserts with Fe fins, which have the same composition as the moulds for pressing the finished products themselves, wherein at least two Al-alloy testing inserts and at least two Al-alloy testing inserts with Fe fins are provided with coatings.

[Claim 2] The testing mould according to claim 1, ***characterised in that*** the testing inserts correspond to moulds for pressing finished products selected from the group consisting of tyres, shoe soles, and mats.

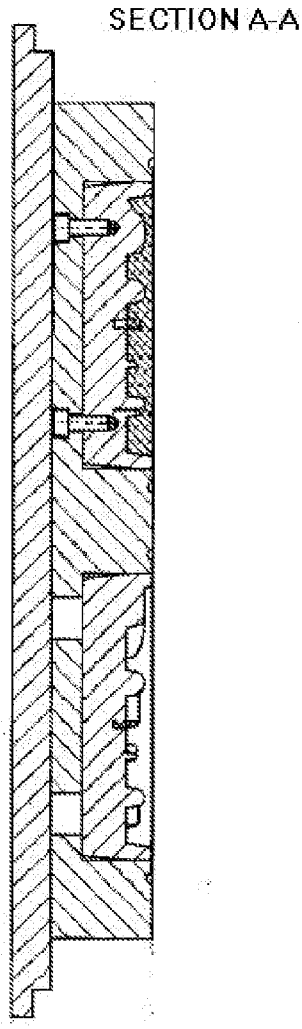
[Fig. 1] 

[Fig. 2] 

[Fig. 3] 



[Fig. 4a]



[Fig. 4b]

INTERNATIONAL SEARCH REPORT

International application No.
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A.. CLASSIFICATION OF SUBJECT MATTER

B 29 C 33/00, G 01 N 33/00, G 01 N 33/208

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B 29 C, G 01 N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

IPO CZ Database

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

ESPACENET, EPOQUENET (EPODOC, NPL), STN (DWPI, INPADOC, COMPENDEX, INSPEC)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2017128650 (A) (BRIDGESTONE CORP) 2017-07-27 paragraph [0009]	1 - 2
Y	CN 205009448 (U) (ANHUI ZHONGMA RUBBER & PLASTIC PRODUCTS CO LTD) 2016-02-03 the whole document, especially Figure 1	1 - 2
A	MAGHSOUDI, K. et al. Micro-nanostructured polymer surfaces using injection molding: A review. Materials Today Communications, 2017, Vol. 13, p. 126-143, ISSN 2352-4928, DOI: 10.1016/j.mtcomm.2017.09.013 the whole document	1 - 2

☒ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
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International application No.
PCT/IB2021/055826

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 3560670 (A1) (UNIVERZITA J E PURKYNE V USTI NAD LABEM) 2019-10-30 the whole document	1 - 2
A	CN 209478726 (U) (PRINX CHENGSHAN SHADONG TIRE CO LTD) 2019-10-11 the whole document	1 - 2

JP 2017128650 (A)	2017-07-27
	NONE
CN 205009448 (U)	2016-02-03
	NONE
EP 3560670 (A1)	2019-10-30
	NONE
CN 209478726 (U)	2019-10-11
	NONE