

APARATURA

BADAWCZA I DYDAKTYCZNA

Analysis of quality of cold plastic for road surface marking

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ABSTRACT:

This article presents the assessment of the product quality on the example of cold plastic. To describe the product characteristics, its performance was used. In addition, an approach to the description of the quality structure was discussed.

Analiza jakości masy chemoutwardzalnej do poziomego oznakowania dróg

Słowa kluczowe: jakość wyrobu, masa chemoutwardzalna

STRESZCZENIE:

Prezentowany artykuł przedstawia ocenę jakości wyrobu na przykładzie masy chemoutwardzalnej. Do opisu cech wyrobu wykorzystano jego właściwości użytkowe. Dodatkowo przedyskutowano podejście do opisu struktury jakości.

1. INTRODUCTION AND PURPOSE OF THE STUDY

For road surface marking, paints (water-borne or solvent-borne), compounds (thermoplastic or cold plastic), reflective tapes or retroreflectors are used [1]. This article presents the structure of the quality analysis of cold plastic used for road surface marking. The product's performance, its role for the user and characteristic stages of the production process were identified.

2. PRODUCT DEFINITION AND ITS CHARACTERISTICS

Road surface marking as one of the forms of traffic organization has a great impact on the safety of users, performing the functions of guiding, directing and informing on the authorized and safe driving direction or the need to stop [2]. The marking should ensure good visibility at daytime and nighttime as well as during harsh weather conditions. It must be characterized by appropriate roughness, durability and resistance to abrasion and dirt, and provide appropriate retro-reflection parameters throughout its service life. Moreover, the road surface marking should also meet certain legal requirements [3-6], technical requirements (e.g. technical specifications [7]) and, which is currently particularly important, ecological requirements [8].

Cold plastics for road surface marking are not covered by a harmonized standard setting out the requirements for e.g. technical and service properties. For this purpose, technical approvals were issued until the end of 2016. As of 1/01/2017, the Act of 25/06/2015 on amendment of the Act on construction products, the Construction Law and the Act on amendment of the Act on construction products and the Act on the conformity assessment system (Journal of Laws of 2015, item 1165) entered into force and repealed the applicable regulations concerning technical approvals, replacing them with the provisions concerning national technical assessments. Due to the 5-year period of validity of technical approvals, the documents which currently define the performance of specific cold plastics for road surface marking may include both technical approvals and national technical assessments.

Due to their properties, cold plastics may be used on urban and country roads, places with intense

vehicle traffic, including heavy vehicles (e.g. for marking pedestrian passages, lines of obligatory and conditional stops, segregation or edge lines, symbols) [9].

The main components of cold plastics are appropriate resins, fillers (fine or coarse stiffening additives, glass balls), pigments and auxiliary substances. Cold plastics may include two or more components. The components are mixed in appropriate proportions, resulting in a chemical reaction causing the mixture to cure. The plastic may be applied mechanically (e.g. segregation lines) or manually (e.g. symbols). The retroreflective properties of the markings are ensured by glass microballs scattered around the compound directly after its application onto the substrate [9, 10].

Cold plastics may be applied in layers with different thicknesses and structures:

- smooth linear marking, approx. 3 mm (lines separating traffic, edge lines, pedestrian crossings, symbols);
- ribbons, approx. 5 mm (acoustic marking, profiled);
- structural marking, 3-3.5 mm (with improved retroreflection in wet conditions and during rainfall).

The road marking is ready to use after 15-20 minutes. The durability of cold plastic markings ranges from 2 to 5 years [10].

3. PRODUCTION PROCESS

The cold plastic production process consists in mixing, for a specified period of time, the components indicated in the recipes, dosing them to the mixer in specified quantities and in a specified sequence.

The components may be fed manually or automatically and mixing may take place in different devices (dissolvers, mixers). The process is controlled at individual stages. The production process flow diagram is shown in Figure 1.

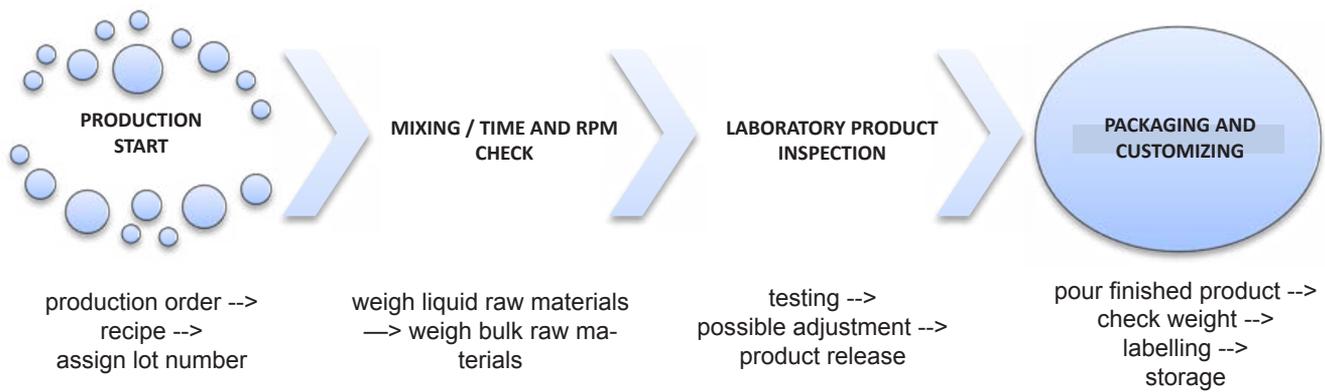


Figure 1 Cold plastic production process (source: own study)

4. PRODUCT QUALITY STRUCTURE

The structure of the cold plastic quality model should include elements concerning several aspects presented in Figure 2.

If possible, the product characteristics should be described in a dimensionless manner. This also applies to the weight of properties, hence both the values of characteristics and weights are mapped into a set of real numbers $[0,1] \in \mathbb{R}$. Therefore, information about characteristics and weights obtained from different sources must be unambiguously represented in the above-defined set of values.

Table 1 presents the cold plastic performance. The performance affect the primary requirements for civil structures, including the safety of use and availability of civil structures, as set out in Annex I to Regulation (EU) No 305/2011 of the European Parliament and of the Council of 9 March 2011 laying down harmonized conditions for the marketing of construction products and repealing Council Directive 89/106/EEC (OJ EU L 88 of 4/04/2011, p. 5, as amended).

5. APPROACH TO THE MATHEMATICAL DESCRIPTION

After analyzing the method of mapping the characteristics defined in Table 1 into the set of values $[0,1]$, it seems that a metrizable product quality model can be created.

This task is complex and may be performed by experts in mathematical structures, assisted by a team of specialists dealing both with the production process issues and product performance requirements. It is also very important to define the target group of its recipients and users in the product quality assessment. The aforementioned issues may constitute confidential information for each manufacturer. Secrecy may be maintained in relation to the protection of knowledge, the so-called know-how, including product recipes or unique technological solutions, both in terms of technical and economic aspects.

After analyzing the mapping of given characteristics, it is possible to proceed to the creation of a mathematical model. The mathematical model is a separate issue of the product quality analysis and therefore requires separate actions and further tests.

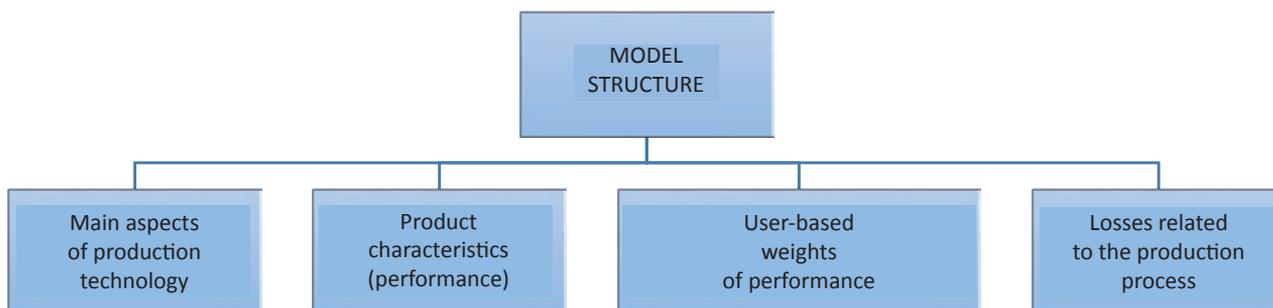


Figure 2 Structure of the quality model (source: own study)

Table 1 Cold plastic performance (own study based on [11, 12, 14])

Cold plastic characteristic (performance)	Definition/description
Nighttime visibility	The characteristic determined by the reflection coefficient R_L (the so-called retro-reflection) in the dry state as well as on wet marking. The reflection coefficient (of road marking field) is the ratio of luminance L of the road marking field along the direction of observation to the illumination E in a field perpendicular to the direction of the stream of light. $R_L = L/E$ [mcd m ⁻² lx ⁻¹]
Daytime visibility	The characteristic determined by the luminance factor β or the luminance factor in scattered light Q_d . The luminance factor (of the road marking field, in a given direction, under specified lighting conditions) β is the ratio of the luminance of the road marking field in a given direction to the luminance of a perfectly reflecting shades with identical illumination. The luminance coefficient at scattered lighting (of the road marking field) Q_d is the ratio of the luminance of the road marking field in a given direction to the luminance across the field. $Q_d = L/E$ [mcd m ⁻² lx ⁻¹]
Cold plastic color	The characteristic is determined by the coordinates (x, y) of chromaticity.
SRT roughness index	SRT is the roughness of the humid road surface measured by the frictional resistance of the foot over this surface at low speed.
Serviceability	The characteristic determining the number of car wheel passages per sign within a specified time. It is determined on the basis of tests conducted at a national experimental section.
UVB resistance	The characteristic that determines the UV resistance for the assumed service life.
Alkali resistance	The characteristic that determines whether the tested product zones show no signs of roughness and that microballs were treated with pigments.

6. FINAL REMARKS

A wider discussion and the presented study on the product quality analysis may contribute to a more advanced description of the product, whether used for marketing purposes or for innovative works, and may provide a new cognitive perspective. This becomes indispensable today, when the primary requirements for civil structures, such as load bearing capacity and stability, fire safety, health and environment, or the safety of use and availability of structures, are extended by further important characteristics, including noise protection and energy savings, in order to lead to the sustainable use of natural resources.

At the same time, the description may shed some light on features such as social and economic comfort, concerning a vast group of users. In the case of road surface marking, being an important component of traffic safety equipment, the product directly affects the protection of all road users: drivers, cyclists and pedestrians. Further discussion may be undertaken on the weight of individual properties, but all those considered in such a broad spectrum seem to have a considerable impact on the intended use of the product as envisaged by the manufacturer.

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