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APPLICATION OF TAGUCHI METHOD FOR OPTIMIZATION IN CERAMIC TILES BODY MATERIALS COMBINATION

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Abstract:

This paper presents an application of the Taguchi optimization technique in determining the optimum raw materials combination for producing green tiles of desired quality characteristics i.e. strength (MoR) and water absorption (%) required for further processing steps. Five main tile body raw materials – clay, dolomite, talc, calcite, and feldspar – were chosen as process parameters and, the performance parameters used for this study were the strength (M.O.R.) and water absorption of the resulting green tile body. An orthogonal array (OA), L27(3,5), and five controllable three level factors were adopted. Manufacturing facility setup was used to carry out experiments and explores the effect of the raw material combinations on the qualities of the final green tile body. Furthermore, the effects of the experimental factors on the selected performance parameters of the produced green tile body were investigated using the analysis of variance approach (ANOVA), thus optimizing the selected parameters. The experimental results indicate that it is possible to produce high performance green tiles by incorporating optimum raw materials combination. Especially, the Taguchi method provides a simple, systematic, and efficient methodology for optimizing raw materials combination.

Keywords: Taguchi Analysis, Design of Experiments (DoE), ANOVA, Ceramic Tile Manufacturing.

1 INRODUCTION

Ceramic tile is one of the important building materials in present days. Ceramic tile manufacturing is a rapidly growing business in India, which is one of the world's fastest developing countries. Manufacturers are always under pressure to increase performance due to the competitive market environment. Given the features of the manufacturing process for ceramic tiles, quality improvement is becoming increasingly important. The production of ceramic tiles is a flow-style process with several steps of processing. The key stages in the production of ceramic wall tiles include material preparation, shaping (pressing), pre-glaze fire (drying), glaze application, tile printing, post-glaze firing, final inspection and sorting, packaging, and storage. The quality of the finished tile is largely influenced by the quality of the raw materials used and their proper mixing at the start.

Design of experiments (DOE) is a systematic approach to solving an engineering problem in which techniques and concepts are applied during the data gathering stage to ensure the creation of valid, defensible, and supportable engineering findings. Furthermore, all of this is done with the utmost efficiency in terms of engineering runs, time, and money [1, 2, 3, 4].

The Taguchi technique is a robust design that involves lowering variation in an experimentation phase. The method's overall goal is to produce a high-quality product at a low cost to the manufacturer. This approach was introduced by Dr. Genichi Taguchi of Japan [10]. This method proposes the use of orthogonal arrays to organise the parameters affecting the process and the levels at which they should be varied; it allows for the gathering of the necessary data to determine which factors have the greatest impact on product quality with the least amount of experimentation, saving resources and time [3]. In Taguchi approach, selecting an appropriate orthogonal array for selected parameters is an important step. [2] In general, each product or process' performance characteristic has to have a nominal or target value. The purpose is to limit the variability in this target value's vicinity. In different operating situations or at different times, the optimal working conditions identified at the end of the experimental investigation should always deliver the same or very close performance value. As a result, the optimization criterion should ensure that the variability in the performance value is minimized [6]. A performance statistic, according to the Taguchi technique, is such an optimization criterion.

Analysis of variance (ANOVA) is a method that investigates and models the relationship between the variables called a response and independent variables and the variables may be one or more[10,11]. The relationships between responses and process parameters are determined, and the validity of these relationships is confirmed using ANOVA [13]. It helps to identify the most important variables affecting the process [1]. On the experimental results, ANOVA is used to differentiate between important and unimportant parameters [2]. The optimum condition is established by examining the principal effects of each factor, which reveal the overall trends of the factors' effects. It becomes easy to estimate the levels of the factors expected to yield the best results once it is known that either a high or low value yields the desired result. Analysis of variance (ANOVA) is a standard statistical procedure for determining the percentage effect of each factor on experimental outcomes [6,9,12].