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RESEARCH PAPER

A New Approach to Determine the Critical Factors of the Product Quality Optimization: A Structural Equation Modeling (A Case Study: Hydrocarbon Solvents Based Paints Quality)

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ABSTRACT
Quality plays important role for sale in the market. To attain this, many industrial managements are eager to use optimization methods to develop product quality. In this study, by evaluating the relationships between product defects and the factors affecting them, ways to improve product quality are presented. Hence, in this paper, a Structural Equation Modeling (SEM) approach is developed to identify the critical factors affecting product quality in paints industry. To this aim, 94 different laboratory samples including hydrocarbon solvent-based paints are assessed. Smart PLS software is utilized to construct the optimized model to determine critical factors. Results show that the different defects affecting the quality of paint are interrelated. In other words, the creation of a flaw will cause other flaws. It has been found that paint surface mottling that depends on the amount of usage of the Bentonite gel, pigment quantity, and resin quality used in the paint formulation affect the other defects such as orange peeling and Cratering.

KEYWORDS: *Product quality; Optimization; Paint defects; Solvent-based paints; Structural equation modeling.*

1. Introduction

In recent decades, as the competition between organizations increases, factors affecting customer satisfaction have become the major concerns for managers [1]. Customer satisfaction examined by the company in the long-term behavior of the customer is considered a key tool in marketing activities. The quality of products provided by the organization is one of the most effective factors on customer satisfaction [2]. To increase product quality, organizations should pay attention to the factors affecting the quality of products in parallel with quality control and take basic measures to improve these factors. One of the most important aspects of product quality is its physical properties, which may be affected by possible defects during the production process. Therefore, identifying product defects, the relationship between them, and the factors that create them can play an important role in improving the product quality. In this research, Structural Equation Modeling (SEM) has been applied to identify defects affecting product quality, the relationships between them, as well as the factors involved in the occurrence of these defects. Accordingly, initially, the opinions of experts about the model hypotheses including the relationship between product defects and affecting factors on defects are collected and evaluated. Then, using the real data obtained from the measurements in the laboratory, an SEM-based model is constructed and results obtained by comparing the experts' hypotheses with the real data are discussed.

Paint is studied as the evaluated product in this study. The appearance aesthetic, along with the features of a product plays a very important role in a customer idea about product. Humans deals with color in all facets. In addition to creating beauty, paint is used to protect objects against natural factors too. Importance of paints in marketing is recognized as a key factor [3]. The quality of Paint is measured by its appearance.

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Usually, the paints are classified differently such as edible/non-edible paints, plant/non-plant paints, natural/artificial paints, mineral-based/water-based/solvent-based paint, also based on performance in drying. The solvent used in solvent paints has a wide range including: a) alcoholic solvents (Methanol, ethanol, isopropyl alcohol, and so on, b) utility solvents (Acetone, Methyl Ethyl Ketone, Methyl Isobutyl Ketone and so on, c) Ether solvents (Diethyl ether, ether and so on, d) Stearic solvents (methyl acetate, ethyl acetate, normal butylated acetate, etc. e) Terpene solvents (pine oil, di-penton, etc. are the oldest solvents that come from pine and spruce trees, f) aromatic hydrocarbon solvents (benzene, toluene, etc. g) Aliphatic hydrocarbon solvents (White spirit, Oil, etc) h) Chlorine hydrocarbon solvents (methylene chloride, trichloroethylene, etc [4]. Due to common hydrocarbon solvent-based paints in Iran's market, we examined the paints of the hydrocarbon solvent-based (including aromatics, alkali, and chlorides). Solvent-based paints contain a wide range of chemical paints, among which hydrocarbon solvent-based paints are distinguished from other paints with features such as good gloss, long shading, and gloss stability. Solvent-based paints are mostly based on alkyd resins and are from white to black in all types of shades. Alkyd solvent-based paints have good resistance to weathering and moisture thus have a glossy finish. Alkyd solvent-based paints on metal, wood, cement, and plaster surfaces are used in construction industries.

In this study, the relationship between product defects (hydrocarbon solvent-based paints), as well as the factors that cause these defects are identified and investigated. In fact, the purpose of this study is to identification of the set of factors that affect the quality of the product during the production process. It follows a set of objectives including 1) finding the main criteria affecting the quality of hydrocarbon solvent-based paints, 2) assessing whether different specialists are aware of the set of factors affecting the paint quality according to what is obtained in the laboratory, and 3) reviewing, modeling and creating influential basic collections.

2. Review of Literature

Product defects from a consumer perspective not only indicate poor standards in the organization's production processes but also damage their understanding of the product as a whole and the product manufacturer [5]. In this regard, part of the research using quality control techniques provide methods that ensure the organization of production and production of goods according to the set standards (See, for example, [6], [7], [8], [9], [10]). Also, in recent years, research-based quality management methods such as Poka-yoke has been adopted to reduce errors in the production steps and service delivery [11]. In the early 1990s, Taguchi and Clausing [12] examined various industries and found that most manufactured products were defective. They stated that to increase customer loyalty, market share, and profitability of the organization, the products produced must be designed and produced with appropriate quality. However due to the complexity of customer needs, there are still a lot of defects in products from consumers perspective [13]. This trend is in stark contrast to the widespread implementation of statistical controls and quality management techniques among manufacturers (e.g., Six Sigma [14]) designed to achieve zero defects. As a result, data mining techniques, multivariate statistics, and mathematical modeling gradually entered the field. For example, Catenazzo and Paulssen [5] developed and tested a model on how consumers experience product defects in different quality dimensions. Suki [15] developed an SEM-based model to examine the effects of aspects of aviation service quality. Subramanian, et al. [16] examined the impact of customer satisfaction and competition from e-retailers in terms of quality dimensions using SEM. Levêque and Burns [17] developed an SEM-based model that explains the relationships between different factors influencing the perception of water quality. There are many such models that investigate the various factors affecting the quality of a product or service, but so far no study has been done on the relationship between product defects and corresponding factors. Therefore, in this research, experts' opinions as well as results of laboratory data are investigated. Since this study was performed on the paint industry, the literature in this field is discussed below.

Paint is one of the most promising materials used to protect metals from corrosion. The effectiveness of corrosion protection against corrosion is mainly related to factors such as coating quality, metal properties, coating properties, metal, and environment corrosion [18]. Paints and coating are used in a wide range of technologies for different purposes such as decorative and protective, and regardless of their desired performance, they must have robust and firm quality. Many studies have been conducted to identify the factors that affect the quality of paints, most of which investigated these factors in a particular area; such as the study of pigments, solvents, resins, dry film thickness, paint driers, and additive mineral powders. For example, Sinko [19] explored the role of pigments in the performance of excellent coatings, including paints, in preventing corrosion and degradation and the feasibility of adding chromite inhibitor pigment to improve the performance of coatings. The paint and coating industry is growing day by day around the world. Nowadays, paint and coating are important not only for the beauty goal but also for the protection of valuable metals as well as buildings from corrosion, which accounts for roughly 4% of the GNP of the world. Paint and coating companies spend a significant portion of their revenue on research and development to provide higher quality products [20].

In related research, suggestions have often been made to improve the formulation for producing paints to increase their quality. For example, Hage, et al. [21] presented the effect of using the role of catalyzing metals such as manganese and iron in a dry paint. Chukwujike, et al. [22] explored several different alternative alkyd formulas and compared them with each other in terms of viscosity, surface drying, paint dry film thickness, specific gravity, hardness, and paint strength, corrosion resistance, paint sagging and compared the results with each other. Also, Deyá, et al. [23] evaluated pigment coatings for compatibility with the environment and toxicity. Fitzsimons and Parry [24] introduced orange peeling, sagging, cratering, mottling as indicators of paint quality. Johnson, et al. [25] discussed the paints based on alkali solvent and epoxy, the improvement of the paint film, solvent effect, and new methods for solvent removal. Hadzich, et al. [26] studied the improvement of the anti-corrosion properties of alkyd paints. Wypych [4] widely described the role of solvents in various industries, especially in the paint industry. As described earlier, mentioned researches only reported the chemical effect modification or add/removal of a substance of the paint formula, however, in this study, the defects affecting quality, its factors, and also the relationship between qualitative factors are investigated using the multivariate statistical technique of structural equation modeling. So far, this method has been done in many studies, but none of the mentioned studies has evaluated product defects and improving its quality.

SEM is a technique used in a variety of fields such as psychology, design, transportation, and many other sciences. For Example, Ajayi and Oyedele [27] used the SEM to develop and evaluate critical factors in the design phase of a development project aimed at minimizing its losses and identifying important and unnecessary factors. Yeni, et al. [28] investigated the relationship between factors such as awareness, attitude, shame, anxiety, and depression and quality of life in epilepsy patients in the framework of SEM in a study conducted at one of the clinics in Istanbul [14]. In another research, Wang, et al. [29] presented the interfaces of the variables that influenced the suicide of people with HIV and analyzed the results. Najaf, et al. [30] surveyed 23 identifiable factors in urban transport traffic that were supposed to address the five hidden factors in 100 US regions and analyzed the impact of each factor.

Clearly most applications of SEM is made in investigating the relationships of influencing factors on a specific and practical goal. In this paper, we aim to investigate the factors influencing the quality of hydrocarbon solvent-based paints. Therefore, the main purpose of this paper is to determine the indicators with a major effect on hydrocarbon solvent-based paints to optimize the quality of the paints using the SEM.

3. Research Methodology

In this paper, we develop SEM to optimize product quality in the paint industry. To this aim, first, we provide a list of defects in the quality of the hydrocarbon solvent-based paints, then 94 laboratory samples are gathered through questioner. In the following, the sampling for SEM is discussed.

3.1. Qualitative sampling

Here are several group discussions to explain the expert opinions about the impact factors transition to hydrocarbon solvent-based paints were used. Unlike interviews, this data collection method allows participants to consider each other's opinions during discussions [27]. As suggested by Merriam [31], the targeted sampling method has been used to reach the participants, since it allows researchers to freely select information from participants to gain an understanding of the phenomenon under study. Two main sources that help the participants to access the research are the paint and resin industry experts' databases and their own experiences with other colleagues in different parts of the company. In total, 38 participants focused on 6 group meetings. The nature of the interrelation of the activity field of individuals in these discussions allows for the creation of a common understanding of those who engage in production and the sale of paint.

In this paper, the first step was introducing a quality questionnaire, which included deficiencies affecting the hydrocarbon solvent-based paints. Then a questionnaire was sent for experts in the paint industry including supervisors and staff of the quality control unit, supervisors and staff of the research and development unit, supervisors and laboratory staff, production line managers, and sales experts for five active chemical complexes in the domain of paint industry in Iran including Tirajhe, Shakiba, Sahar, Ronaq and Afshar commercial names. A total of 38 specialists with different specializations participated in this questionnaire, each of which is broken down in Table 1.

Tab. 1. Overview of the research respondents

Row	Type of experts	Total Number of experts	Percentage (%)
1	The staff of the quality control unit	10	26
2	The staff of the Research and Development unit	7	19
3	Laboratory staff Unit	8	21
4	Sales experts	7	18
5	Production line Managers	6	16
	Total	38	100

Besides, in Table 2, we have identified the type of grouping according to the individuals in these six companies. These questionnaires were developed in such a way that 38 experts participated in 6 sessions and all members of these groups were asked to identify defects and factors that affect solvent-based paint quality in terms of work experience and free study.

Tab. 2. Overview of the group discussions and the participants

Total	Frequency	Categories of the Participants	Group (company)
7	The staff of the quality control unit the staff of the research and development unit Laboratory staff unit Sales experts Production line managers	2 1 2 1 1	1
6	The staff of the quality control unit The staff of the research and development unit Laboratory staff unit Sales experts Production line managers	2 1 1 1 1	2
8	The staff of the quality control unit The staff of the research and development unit Laboratory staff unit Sales experts Production line managers	1 2 2 2 1	3

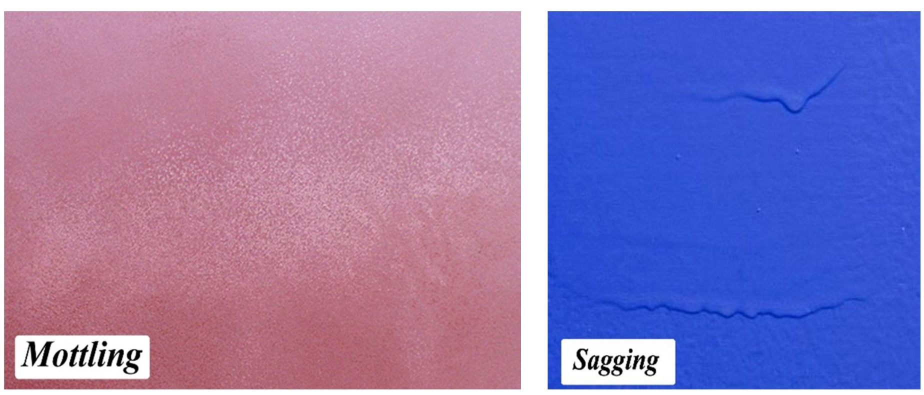
7	The staff of the quality control unit The staff of the research and development unit Laboratory staff unit Sales experts Production line managers	2 1 1 2 1	4
6	The staff of the quality control unit The staff of the research and development unit Laboratory staff unit Sales experts Production line managers	2 1 1 0 1	5
8	The staff of the quality control unit The staff of the research and development unit Laboratory staff unit Sales experts Production line managers	2 1 1 1 1	6

3.1.1. Qualitative data analysis

After collecting questionnaires, we compiled the reliability of the collected data to find out that expert opinions on the selection of factors influencing the quality of paint. The internal coordination of the factors in the questionnaire and the suitability of the data for analysis are analyzed using Cronbach's alpha. With Cronbach's alpha in the range 0 to 1, the value of 0.7 represents an acceptable fit [32]. Cronbach's alpha for each variable is presented in Table 3. Results from Table 3 show that collected data from experts for all variables have suitable reliability. Also, several paint defects are shown in Figure 1.

Tab. 3. Non-parametric analysis of paint defects for the questionnaire from experts

Cronbach's alpha	latent factor	Row
0.83	Sagging	
0.88	Orange Peeling	
0.71	Cratering	
0.78	Mottling	
0.77	durability	



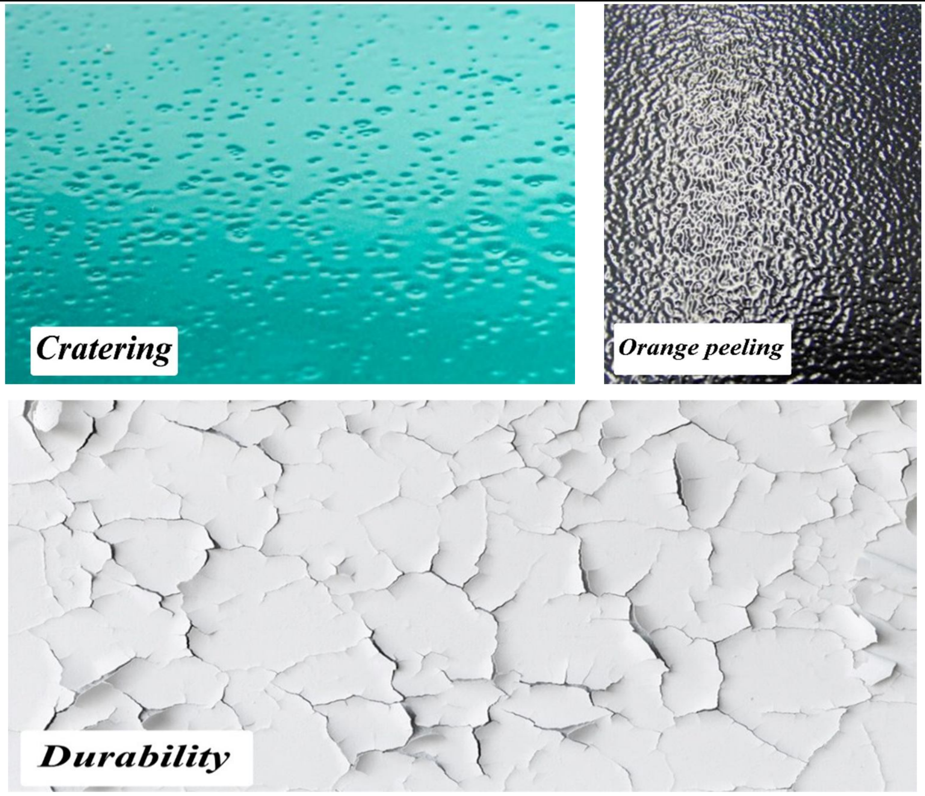


Fig. 1. The several paint defects

Fitzsimons and Parry discussed about the main part of the information about the identification of the defects affecting the quality of the paints and the cause of the defects [24].

3.2. Quantitative sampling and data collection

After preparation of the list of factors, quantitative data should be gathered. For this purpose, we randomly collected 94 samples of the paint in the archives of the production. Measurable factors include the degree of dilution (viscosity), type of paint driers, solvents vapor used in paint formulation (Boiling point), amount of paint driers used, paint dry film thickness, the duration of mixing in Cauldron, amount of phthalic recycled, and PET that use in the base paints resin formula, rate of use of hydrocarbon solvents in the paint formulation, quality of pigments used in the paint formulation, quality of the fatty acid available in the base resin, type of the paint cans, number of filters used to produce during each production, amount of calcium carbonate consumed in the formula, type of filters used in the production, pigment milling time, percentage of solvent fat, amount of pigment in the formula, quality of the resin used in the base of paint, amount of anti-settling agent, use of Benton gel, amount of Petro in paint formula and Paint adhesion are extracted from the product documentation.

3.2.1. Data screening and reliability analysis

To prepare data for better statistical analysis, some screening operations including detection of samples outside the scope, and determination of the correlation between the variables and the sub-variables of each variable are performed and presented in the following subsections.

3.2.1.1. Identification of outlier

Outliers cause the connection between two variables to be weakened or eliminated. By deleting this data, inaccurate results can be largely avoided. This is because the presence of outlier data might either cause the obtained structural model to be inconsistent, or the path coefficients of the model might not be valid. So as presented by Kline [33], Mahalanobis Distance (D) is suggested to model the SEM to test any outliers point in the data. According to the number of variables, the value of the chi-square test statistic for rejecting points, where distance is meaningful is equal to 21 degrees of freedom and a confidence level of 0.05. Results show that six of 94 samples have significantly higher distances than other samples, hence, these samples should be removed from the computing process.

3.2.1.2. Kayser, meyer, olkin (KMO) index

In this section, the KMO index is calculated to show the appropriateness of data for SEM. The computation result shows that the KMO is 0.77, which proves that the data has decent validity for analyzing the factors and continuing the research process for SEM.

3.2.1.3. Kruskal-wallis (K-W) Test

K-W test is applied to determine the effect of candidate paints on the pattern provided under 95% confidence level. To this aim, the type of paint applied in the sample and factors affecting quality are used as grouping and test variables, respectively. So that we already registered samples for a particular type of paint for each sample. These divisions are as shown in Table 4 based on the type of pigments used in paint. As shown see in Table 5, the values obtained for all variables are more than 0.05, which indicates the reliability of the observations.

Tab. 4. Classification of candidate paint in samples by pigments

Symbol	Type of paint
1	Lining Paint that includes Ocher and Gray
2	Semi-shiny paint
3	Bright shade Shiny Paint
4	Bright shade Opaque paint
5	Dark shade Shiny Paint
6	Dark shade Opaque paint

Tab. 5. Non-parametric analysis for paint quality factors

Label	Influencing factors on the quality of hydrocarbon solvent-based paints	Identification source	Kruskal–Wallis
S	Sagging		
S_1	Viscosity	Laboratory test - Examination of 100g samples by viscometer	0.678
S_2	Type of Paint Driers	Production Documentation	0.731
S_3	solvents vapor used in paint formulation (Boiling point)	Production Documentation	0.38
S_4	Percentage of solvent fat used	Production Documentation	0.674
S_5	Amount of Anti-settling agent used	Production Documentation	0.349
S_6	Paint Dry Film Thickness	Laboratory test by Optical micrometer	0.454
O	Orange Peeling		
O_1	The amount of calcium carbonate that consumed	Production Documentation	0.653
O_2	the amount of hydrocarbon solvents used in the paint formula	Production Documentation	0.952
O_3	Quality of pigment used in the formulation	Production Documentation	0.778
O_4	Quality of the fatty acid used in the base resin	Production Documentation	0.858
O_5	Amount of Paint Driers in the formulation	Production Documentation	0.93
O_6	The time to Milling pigments in the mill	Production Documentation	0.179
C	Cratering		
C_1	quality of paint cans	Production Documentation	0.996
C_2	Number of filters consumed in a production	Production Documentation	0.374
C_3	quality of filter that used	Production Documentation	0.724

M	Mottling		
M_1	amount of pigment in theformulation	Production Documentation	0.611
M_2	quality of resin used in the formulation	Production Documentation	0.283
M_3	Amount of Bentonite Gel in the formulation	Production Documentation	0.846
D	Durability		
D_1	The amount of Petroleum resin in the paint	Production Documentation	0.281
D_2	duration of mixing in Cauldron	Production Documentation	0.362
D_3	Paint adhesion	Laboratory test (Qualitative ranking)	0.324
D_4	The amount of Phthalic Recycled, and PET that use in the base paint resin formula	Production Documentation	0.135

3.3. Conceptual model

In this subsection, five hypothesizes are proposed to test the relation between paint defects as follows. Also, the schematic relationship between these defects is presented in Figure 2.

H_1: Sagging causes the Orange Peeling.

H_2: The Mottling causes the Orange Peeling of the surface of the paint.

H_3: Cratering of the surface of the paint causes the Orange Peeling its surface.

H_4: Cratering affects the Durability of the paint.

H_5: Mottling affects Cratering.

3.4. The SEM

SEM is a multivariate technique used to examine the relationship between some indicators and latent variables. According to Ajayi and Oyedele [27], SEM includes regression analysis, factor analysis, multiple correlations, and path analysis, which makes it a powerful statistical tool. In this paper, the mentioned hypotheses are tested by SEM using smart PLS software. Also, SEM is used to investigate the relationships between the critical factors affecting the quality of hydrocarbon solvent-based paints to optimize the quality of these types of paints.

3.5. Model construction

In this subsection, the SEM-based model is proposed to confirm the hypothesized relationship in paint quality optimization. Figure 3 shows the path coefficients and the t-value statistics for the mentioned hypotheses.

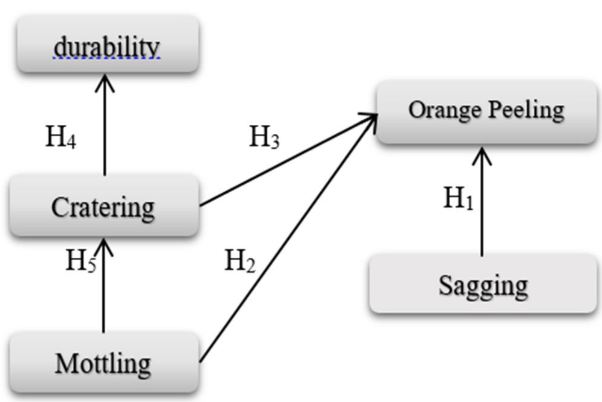


Fig. 2. Hypothetical model for paint defects relationship

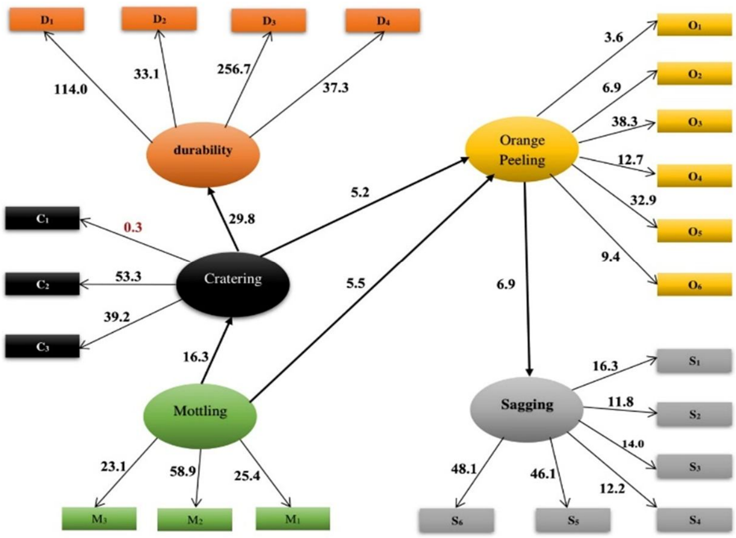


Fig. 3. t-value statistics for the SEM-based model

3.6. Model reliability and performance evaluation

According to expert opinions, the observed factor of "type of the paint cans" affects "Cratering of the surface of the paint", and the use of higher quality cans affects the overall paint quality. Collected data showed that this obvious factor with a path coefficient of 0.06 (t-value = 0.3) had no significant effect on any factor such as becoming obsolete. Therefore, this factor is removed from the model and then, the model is re-executed and modified which is shown in Figure 4.

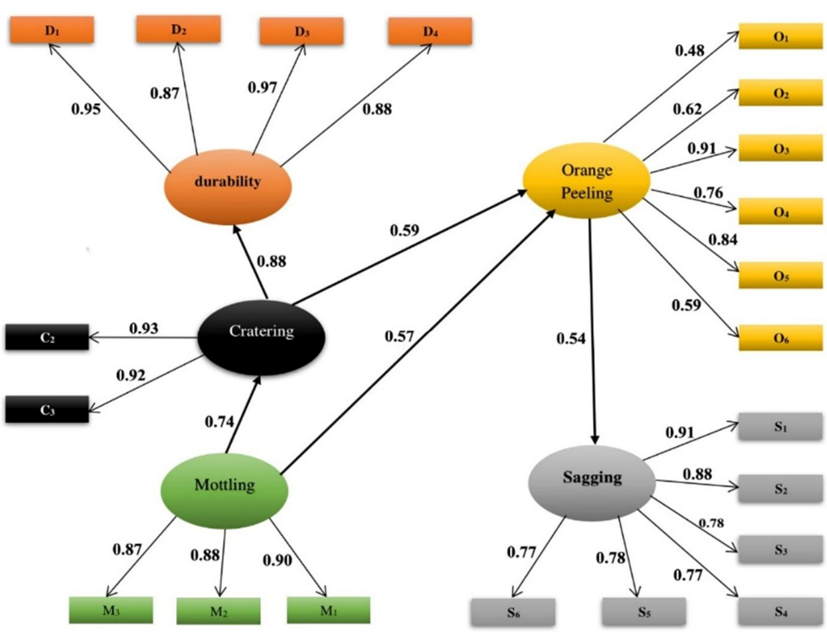


Fig. 4. Modified SEM-based model

The convergent validity analysis is performed using Average Variance Extracted (AVE). Note that, value 0.5, shows that more than half the structure variance is due to its indices [20].

Computation results show that the AVE value for the Sagging factor is 0.67. Also, related values for the Orange Peeling factor, Cratering, Mottling, and durability factors are 0.52, 0.86, 0.79, and 0.85, respectively. As a result, all variables have convergent validity. To evaluate the differential validity of structures with reflection indices, the average variance extracted should be larger than the squares of correlations between structures and the other models that make up the model. Therefore, to investigate the correlation between latent factors, the AVE value of each latent factor is placed on the main diameter of the correlation matrix of the variables. Note that, the AVE value (reported in Table 6) indicates that the correlation of latent factors has a suitable condition.

Tab. 6. Comparison of the squared value of the AVE for latent factors

	A	B	C	D	E
A	0.82				
B	0.54	0.72			
C	0.21	0.16	0.93		
D	-0.08	0.13	-0.74	0.89	
E	0.17	0.05	0.88	-0.86	0.93

Furthermore, in this subsection, we evaluate the conceptual using the path coefficients (i.e. standard regression weights) and the explained variance of R^2 for the intrinsic or dependent variables. If the variable does not reach the desired threshold of Falk and Miller [34] which is 0.1 for the variance described, it implies that this variable is bound to other factors that are not included in this research. Table 7 shows that all four endogenous variables have the minimum desired value.

Tab. 7. The amount of cement for latent factors

Dependent latent factors	R^2
Sagging	0.297
Orange Peeling	0.179
Cratering	0.548
durability	0.776

Also, the Goodness of Fit Index (GOF) of the model is calculated using Equation (1) by Tenenhaus, et al. [35] to evaluate the fitting of internal equation models and external measurements of data.

$$GOF = \sqrt{\overline{communality} \times \overline{R^2}} \tag{1}$$

Based on the categorization of Cohen [36] specified size of R^2 with a minimum value of 0.5, the GOF of the proposed model is 0.58, which indicates the good fitness of the model. Table 8 contains hypothesized relationships, path coefficients, correlations, t-value statistics, percentage of explained variance, and relations between the latent factors of this condition. To determine the contribution of observed factors for the explained variance (R2) related to the endogenous variables in the proposed model, researchers must calculate the exact results obtained from the multiplicity of path coefficients (between the two latent factors) in the correlation between the two latent factors [34].

Tab. 8. Proposed model Outputs

Suggested Relationships	Path coefficients	Correlations	T-value	Percent explained variance
Orange Peeling - Sagging	0.545	0.544551	6.87	29.67
Mottling - Orange Peeling	0.575	0.134414	5.79	7.72
Mottling - Cratering	0.74	0.740033	16.52	54.76

Cratering - Orange Peeling	0.595	0.169802	4.62	10.10
Cratering - durability	0.881	0.881162	28.94	77.63

According to Falk and Miller [34], the explained variance must explain at least 1.5% of the variance of the dependent variable. If this value is less than the minimum, it means that this strategy is underway the effect of other factors that are not mentioned in this research. In this paper, all the proposed relations have achieved this condition. In order to reject the null hypothesis at the 5% significance level, the observed t-value must be greater than 1.96. As shown in Table 8, the t-value for all paths is greater than this value, which confirms the main hypotheses of this study. In hypothesis 1, it was predicted that the Orange peeling factor can positively affect the Sagging. This is because, at a 0.05 significance level with a beta coefficient of 0.545, the t-value is 7.5. In addition, t-value for hypothesizes 2, 3, 4 and 5 are 5.33, 5.34, 26.95 and 15.44, respectively. According to these results, it was confirmed that the Mottling factor has a direct and significant effect on Orange Peeling. Also, it was confirmed that the Mottling affects the Orange Peeling factor. Besides Cratering factor has a significant effect on the Orange Peeling factor, and also Cratering factor has a direct effect on the Durability factor, and finally, the Mottling factor has a significant impact on Cratering factor. These results can be seen in Figure 4.

4. Computational Analyses and Practical Implications

In this section, we present some practical implications and useful suggestions for paint producing companies to optimize the quality of paint.

1- These companies should take into account the fact that "Mottling of the surface after painting", which is one of the major imperfections of paint, has a direct relationship with two factors including "surface orange peeling of the paint" and "cratering of the surface of the paint after painting", as well as indirect contact through the orange peeling factor on the factor of " Sagging ".

2- According to the model, “Mottling of the surface after painting” is influenced by three measurable and controllable factors including the use of bentonite gel, rate of pigment application, and quality of resin used in the paint.

3- There is a significant relationship between the quality of resin in paint and the number of replaceable filters in a production. Companies should consider this item to choose their resin supplier to a better resin quality, lower number of replaceable filters and consequently saving money.

4- The quality of fatty acid used in the based resin improves the quality of the resin. This is why Mottling factor is to be associated with the Orange Peeling factor.

5- The amount of pigment in the formulation also has a significant effect on Mottling and thus on other imperfections, such as Orange Peeling. Also, the time of pigment milling, and the quality of pigments, are consistent with the amount of pigment in the paint formula. Furthermore, the use of bentonite gel is also important in reducing the risk of the mentioned defects.

6- Cratering factor has a significant effect in increasing the Orange Peeling and the relation between the quality of the pigments used and duration of milling with the number of filters used in production. This indicates that as the quality of the pigments increases, the milling time and the number of filters used decreases.

7- Since resin manufacturers use recycled Phthalic, PET and Petro resin in the formulations should be concerned to reduce production costs.

8- In the Sagging factor, controllable factors such as proper solvent selection in terms of fat and boiling point are the proper type of paint driers factor that is most commonly used in lead, calcium, and cobalt, as well as the amount of Anti-settling agent. Also, the viscosity of paint is also effective in this factor.

9- In general, since the Mottling effect coefficient on other variables is a significant amount, attention to reducing this defect is an important factor in improving quality. Therefore, paint companies should try to reduce this defect to a large extent to prevent other defects in the product and consequently increase the quality of the product significantly.

5. Conclusion and Future Research

In this study, a multivariate statistical technique called SEM has been used to improve product quality; So that after identifying the defects of the product and also the factors affecting each, the relationships between them are discovered and confirmed, and then these relationships were analyzed regarding the quality of the final product. The product studied in this paper is solvent-based paints and a multivariate technique based on SEM is applied to optimize the quality to improve the success rate of sales. To this aim, five hypothesizes are assumed, and to test them, an SEM approach is applied. Results showed that all hypotheses are correct. In addition, to show the relationship between affecting factors, some SEM-based models are proposed and results showed that there are significant relationships between these factors affecting on quality of paint. As future research, applying the proposed method to improve the quality of the other paints including water-based paints, edible paints, and all kinds of coatings could be investigated with other researchers. This method can also be used in various areas of production or services to understand the relationships between factors affecting the quality of the product or service.

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