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Research Article

PRODUCTION OF NEW TYPE INSULATION MATERIAL: EXPANDED PERLITE-SILICA AEROGEL COMPOSITE

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ABSTRACT

Silica aerogel is a class of nanoporous material with extremely high porosity (85–99.9 %) and specific surface area (500–1200 m^2/g), as in cause very low density, low thermal conductivity. But silica aerogel have some disadvantages. One of this disadvantages is high cost. In this study, to solve this problem has been used low cost precursor which is rice husk ash. Also, we try to improve porosity. To improve the porosity we used expanded perlite (EP). To produced EP is heated the perlite to 760–1100 °C, at which point its native water is converted to vapor and the material is caused to expand to 4–20 times its original volume, then the high-porosity and lightweight aggregates are formed. In this study silica aerogels have been reinforced with EP to product new type composite material which is used as building insulation material. The prepared EP-silica aerogel composite was characterized using SEM and BET measurements.

Keywords: *Expanded Perlite, Silica aerogel, Insulation building material.*

1. INTRODUCTION

Kistler first introduced an idea about displacement of the liquid phase in the gel with gas in 1930s (Stolarski *et al.,* 1999) (Kistler, 1931) (Kistler, 1932). For many years there are many potential applications for aerogel structures. These applicaitons are listed as; heat insulation, sound insulation, oil spill cleanup, low-dielectric constant aerogel films in ultra-large integrated circuits, Cherenkov radiation detectors, electronic components, pharmaceutical distribution systems, chromatography, raw materials and synthesis for engineering rubber and ceramics adsorption (Aravind et al., 2010) (Zulfiqar *et al.,* 2015) (Tang *et al.,* 2017). These materials have a wide range of applications, they have very large surface area (500-100 m^2 g^{-1}), high porosity (% 80-99.8) and low volumetric density (0.003-0.8 g/cm^3), low temperature Conductivity (0.02 W m^{-1} K^{-1}), ultra low dielectric constant (1.0-2.0) is due to their many impressive properties (Aravind *et al.,* 2010) (Wang J., 2015). Although silica aerogel materials that studied for many years have such widespread using area and advanced properties, these advanced properties couldn' t utilized at the desired rate in the industrial area. This is because of the aerogel has low strength, low toughness and brittle (Zhou *et al.,* 2018) (Li *et al.,* 2017). The reason is that silica aerogel is fragile named as "pearl necklace". These pearl necklace has 3-10 nm diameter silica nanoparticles which are connected to each other by forming narrow inter-particle necks and forming a 3-dimensional network (Ma *et al.,* 2012).

Using common organic silica sources such as tetraethoxysilane (TEOS), polyethoxydisiloxane (PEDS) for industrial scale. This situation has been limited to using of silica aerogel. To maintain the industrial application of silica aerogel, it is a priority to find a cost-effective and environmentally friendly synthesis route (Feng *et al.,* 2018). Sodium silicate has been used as precursor to produce silica in industrial production. However, sodium silicate is formed by melting quartz sand and sodium carbonate at a very high temperature of 1300 ° C and this requires a large amount of energy. This method is hazardous for the environment. Because during the producing of 1 ton of silica, 0.53 tonnes of sulfuric acid and 0.53 tonnes of sodium carbonate were used and finally were produced 0.23 tonnes of carbon dioxide (CO_2), 0.74 tonnes of sodium sulfate and 20 tonnes of waste water. In recent years, one of the most important problems in the world is the "greenhouse" effect, especially with regard to CO_2. Therefore, finding a cheap source of preparing silica will allow the producing industrial scales of the silica aerogel. For industrial production, abundant biomass wastes such as rice husk, bamboo, wheat husk were gradually recognized as precursor silica (Liou *et al.,* 2011).

To produced expanded perlite heating perlite to 760-1100 ° C. At this temperature, the water in the perlite has been converted to steam and perlilte has a highly porous and light aggregate structure with 4-20 times increase compared to initial volume of the material (Wang *et al.,* 2018). Moreover, perlite shows chemically inert and has important properties such as fire resistant, high sound insulation. Today, approximately 65 % of the perlite producing is used by the construction industry. For insulating purpose, EP powder has been used as filler material in hollow bricks or as an additive in plasters (Pichór *et al.,* 2009). Furthermore, the porous structure of expanded perlite creates a wide application area for composite materials. For example this composite materials, silica composite for lauric–palmitic–stearic acid/expanded perlite composite, vacuum insulation panel core, a novel paraffin/EP composite, capric acid–palmitic acid/EP composite, expanded perlite/paraffin composite, sodium nitrate/EP (Wang *et al.,* 2018). SiO_2 aerogel is an expensive material when used alone. But, combined by expanded perlite with silica aerogel to produce the composite material could be reduced amount of the SiO_2 aerogel and cost of the producing.

In this work, the silica aerogel was synthesized by using rice husk as starting material and reinforced the perlite to this silica aerogel and heating to 1000 °C to produce expanded perlite (EP)/silica aerogel composite. This new type composite material which can be used as building insulation material. The prepared EP-silica aerogel composite was characterized using SEM and BET.

2. EXPERIMENTAL METHOD

Rice Husk (RH) used for starting material. RH was supported from "Tat Bakliyat" company found in Mersin, Turkey. Chemicals that used in this work sodium hydroxide (NaOH) (Isolab Co.), sulfuric acid (H_2SO_4) (Merck Co.) and tetraethyl orthosilicate (TEOS) (Merck Co.). Perlite was supported from a company named as "Genperé".

In this work RH used as the starting material was first washed with distilled water and dried to remove contaminants. The RH was then heated to 600 °C for 5 hours under normal atmosphere in a muffle furnace (which would increase its SiO_2 rate). The results of XRF analysis of calcined rice husk ash shows in Table 1. SiO_2 value obtained as a result of calcination at 600 °C was 90,10 %. To carry out the extraction of silica from the synthesized rice husk ash, 5 gr rice husk ash (RHA) was extracted at 95 °C in 1 M NaOH solution of 150 ml. The sodium silicate solution obtained after it was filtered to abolish contaminants that remained as undissolved waste. The filtered sodium silicate solution was neutralized using 1 mol / liter H_2SO_4. Silica hydrosol was obtained after this process. 1/10 volume of TEOS was added to the synthesized silica hydrosol to obtain gel. After addition of TEOS, amount of 10% Perlite was added. The gel obtained after this process kept at room temperature for 24 hours to carry out the aging step. It was then washed using de-ionized water to remove unwanted impurities from the aging gel structure. The washed gel was dried for 1 hour at 120 ° C to obtain the final drying step and silica aerogel composite. After drying, it was heated to 1000 ° C to obtained the expanded perlite in the composite and for increase the porosity in the structure. Fig. 3 shows the flow diagram compiling the production of perlite/ silica aerogel composite.

The prepared EP-silica aerogel composite was characterized using SEM and BET measurements.

Table 1. XRF results of rice husk ash

(%mass)	600 °C - 5sa
Na_2O	0,096
MgO	0,76
Al_2O_3	0,35
SiO_2	90,10
P_2O_5	0,97
SO_3	0,53
Cl	0,31
K_2O	5,15
CaO	1,36
MnO	0,15
Fe_2O_3	0,24
ZnO	0,014

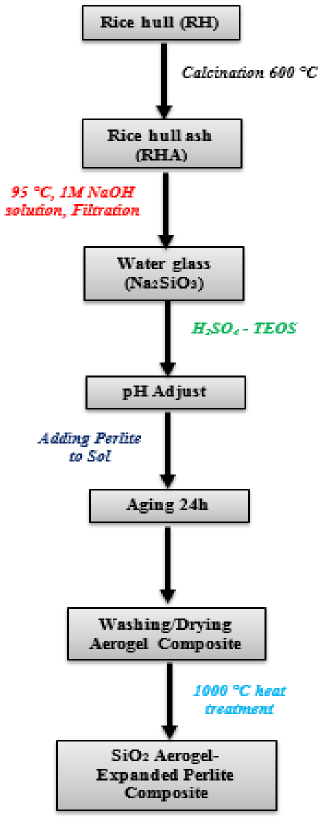
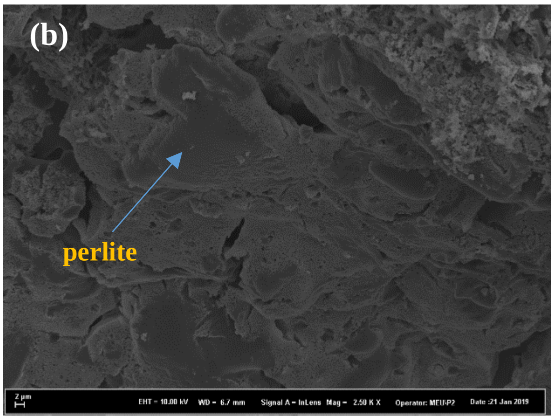
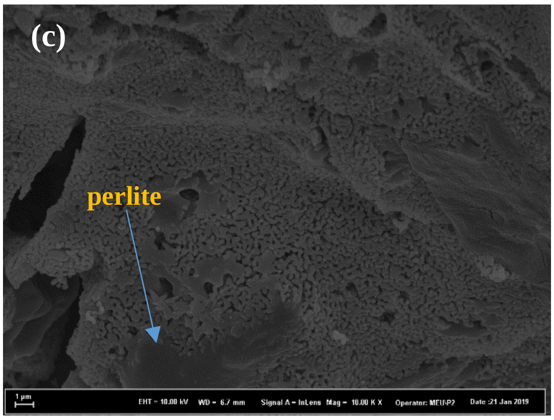


Fig. 1. Flowchart for preparing SiO_2 aerogel from rice husk ash -perlite composite

3. RESULTS

Figure 1. a shows the SEM images of pure SiO_2 aerogel and Figure1. b, c shows the Perlite / SiO_2 aerogel composite. The resulting SEM image is similar to a conventional airgel image. Because in aerogels, there is a chain-like arrangement of nano-sized particles. The resulting structure consists of many grains diffused into one another by the effect of high temperature. Aerogel structures combined with the effect of temperature to form larger structures. There are also many gaps between these particles. Dark colored parts indicated by arrows in the structure are unexpanded perlite added to aerogel. While this structure is expected to have a very high porosity, the amount of pores is negligible as can be seen from the figure. This can be explained by the fact that the unexpanded perlite contained in the aerogel does not expand even after heating to 1000 °C. Although this temperature is suitable for explosion of perlite, there is no expansion of perlite at this temperature; can be explained by the lack of time. It also suggests that the non-explosion of unexpanded pertlite surrounded by aerogels may be caused by inhibition of aerogels. In addition, in our previous study, after drying of silica aerogel at 120 °C, heat treatment under 1000 °C resulted in nano stalactite structures (Basgoz *et al*., 2020). The operating temperature of 1000 °C was particularly selected in this study. There are two reasons for this, one of these; conversion of perlite to expanded perlite; the second reason is to increase the porosity of the composite material to be obtained as a result of the formation of nano stalactite structures similar to the previous temperature. However, in this study, similar structures were not seen on SEM images in the process performed under 1000 °C. This is due to the fact that perlite inside the structure does not allow the formation of nano stalactites. Because, in our study where nano stalactite structures were seen, the reason for the formation of these structures was that TEOS converted to SiO_2 and Diethyl Ether at temperatures above 600 ºC (Nurkowski *et al.*, 2016), when this aerogel was placed in the oven the reaction occurred firstly and the resulting Diethyl Ether burned with the impact of the air and boosted the temperature of the particles in micron size caused by the formation of melting particles together with each other grew and formed a network-shaped structure. Gases from ignition of diethyl ether and air trapped in SiO_2 particles by cause of rapid melting. If the time is enough, the volume of the gases trapped in the molten SiO_2 increases up to 800% because of the heat. Due to this expansion, the particles began to swell like a balloon. Under the effect of temperature, these particles also convert to Cristobalite structure. But, due to the high strength of the silicas, the internal air pressure cannot ecplode the swollen silicas. They appear with cracks on the surface. In this work, perlite prevented this formation.





The N_2 adsorption / desorption isotherms of the silica aerogel-perlite composite are given in Figure 2. The isotherm obtained according to IUPAC classification complies with type IV. Silica airgel appears to be mesoporous (ALOthman *et al.*, 2012). The BET value of silica airgel-pearlite composite was found 30,6762 m^2/g.

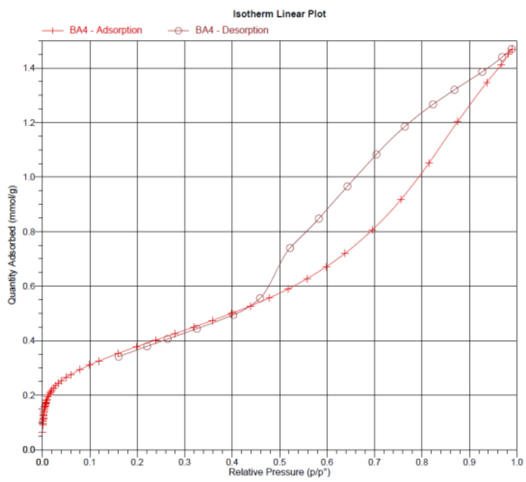


Fig. 2. N_2 adsorption / desorption isotherm of Perlite-SiO_2 composite

Pore structure parameters for pure SiO^2 aerogel and Perlite / SiO_2 aerogel composite are given in Table 2. Adsorption average pore diameter 90.5627A°, Maximum pore volume 0.546639 cm^3/g and BET Surface Area value was determined as 241.441 m^2/g for pure SiO_2 aerogel. For Perlite / SiO_2 aerogel composite, these values were found as 62,1846 A°, 0.047690 cm^3/g and 30.6762 m^2/g, respectively. BET Surface Area value decreased as a result of perlite addition. This is considered to be due to the addition of perlite, and the main reason is believed to be the elevation of the sample to 1000 °C for the expansion of perlite in the perlite-silica aerogel composite. Due to the air trapped between the particles of aerogels with this temperature, the gap decreased with the growth and association of aerogels and caused the BET area to decrease. Pre-widening the perlite and reinforcing it to Silica aerogel will improve the properties of the composite.

In this study, particle size of perlite scattered in the composite and surrounded by aerogel nanoparticle is approximately 5µm. SEM images suggest that perlite additive increases the particle size of the composite and decreases accordingly in the BET surface area. This is consistent with the relationship between specific surface area and particle size reported in the literature (Gregg *et al*, 1967), (Yang *et al.*, 2020).

Table 2. Pore structure values of Pure SiO_2 Aerogel and Perlite/SiO_2 aerogel composite.

	Pure SiO_2 Aerogel	**Perlite/SiO_2 Aerogel Composite**
Adsorption Average Pore Diameter (A°)	90,5627	62,1846
Pore Volume (cm^3/g)	0,546639	0,047690
BET Surface Area (m^2/g)	241,4410	30,6762

4. CONCLUSIONS

Reinforcing expanded perlite to silica aerogels can both reduce the cost of silica aerogels and increase the application areas. For this purpose, silica aerogels were produced from paddy husk and it was aimed to expand the perlite by increasing the composite to 1000 °C by adding unexpanded perlite structure. However, exposure of silica aerogels at this temperature has been shown to reduce the BET surface area expected to increase and has lost its properties. In addition, silica aerogels made it difficult to expand perlite at this temperature. Apart from this method, it has been concluded that better results can be obtained by producing composite using different methods

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Research Article

CLIENT SATISFACTION AS PERCEIVED BY ARCHITECTS AND CIVIL ENGINEERS

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ABSTRACT

A construction project fulfills both the product design and the service provision functions. There are many stakeholders in these processes. Concurrence among the stakeholders surely affects the success of the project. The most important of the stakeholders is customer/client followed by architects and civil engineers. Both architects and civil engineers are involved in the design phase as well as in the execution phase. Customer/client satisfaction is usually considered one of the success criteria of the project. This criterion, however, is a subjective concept, about which tangible values cannot be easily placed, and is determined by perception at best. Whether this perception vary between civil engineers and architects depending on different criteria, is examined in this study. The results of the questionnaires were evaluated statistically. The agreed upon and the most important issues are working together and sharing information. The behavior of client/customer and qualification of employees are the factors that civil engineers and architects do not have the same views on client satisfaction.

Keywords: *Project Success, Stakeholders, Collaboration, Construction, Concurrent Engineering*

1. INTRODUCTION

Different groups are involved in different processes of a construction project. The fulfillment in each of these processes by these groups plays a part in the success of the project. A comparison between the two groups, who are the most likely to be involved in management of the project may yield useful information. One of these two groups is the architects while the other group is the civil engineers. It is certainly important that these groups fulfill their professions, but it is also desirable to study their affects on project output since these groups can be in managerial positions. A project manager has many responsibilities starting from the planning of the project to its completion. In general, it can be said that architects are involved in a construction project since the project emerges as a concept. The architects' participation in the project can also be as the customer representative in the design and construction stages (Burr, 2010; Berman, 2002). In the course of mobilization and implementation, civil engineers undertake more functions compared to architects, including project management (Haltenhoff, 1986). It has been shown that the contribution of the project manager is great for the successful completion of a project (Prabhakar, 2009). On the other hand, the project manager's perception of success may also differ in the subsequent processes of construction and delivery (Shenhar, 1997).

The success of a construction project depends on many criteria. Success can also be expressed or defined using many different criteria. It is natural that every stakeholder involved in the project wants to measure success differently (Khan & Spang, 2013). One study has reviewed the literature about the project's success (Ika, 2009). According to this study, we are not yet aware of the relationship between customer satisfaction and criteria used by project management. As researchers said that the project management should be subjectively evaluated by all groups involved and at the same time the contribution of all stakeholders should be considered. In another study, concurrent engineering practice in construction projects was evaluated considering stakeholders' involvement. In this context, it was emphasized that the contribution of customer requirements to collaborative team work was important (Kamara, 2000). Accordingly, information sharing among stakeholders could be realized, for example, using the virtual reality environment. In one such study, a virtual reality system which could provide information sharing between the office and the construction site has been investigated (Capra, 2010). In one other study, a model was developed to at least estimate the results of a planning process that would support designers to work together and collaborate (Bletzinger, 2006).

Collaboration among different groups, including customers, might be expected to increase the level of project performance and satisfaction (Baiden, 2006). First, however, it was necessary to know the groups or stakeholders affected by customer satisfaction (Brockmann, 2002). It has been argued for that the co-ordination among the groups could be further increased by the clear identification of stakeholders (Aapaoja, 2014). In another study, project performance was assessed based on a comparison of competitive and collaborative working environments (Ruan, 2012). In many studies, customer satisfaction has been taken into consideration (Kärnä et al., 2004; Maloney, 2002; Capra, 2010; Kärnä, 2004; Soetanto et al., 2001), meanwhile in some other studies the contractor satisfaction with customer performance has been investigated (Soetanto & Proverbs, 2002).

As a measure of success, completion of work within the budget or within the scheduled time period can be considered. Another measure is that the manufactured product meets the needs of the user in the long run. In one study, the contribution of the groups in the project to the realization of the long-term business goals was examined (Rowland, 2006). It has been explained that groups and especially project managers should be aware that this contribution was not limited to only time, budget and quality, but also that they had to make as much as possible to realize all business objectives. While the use of the duration or budget limit provides a tangible measure, the satisfaction of the user or the business owner is more abstract concept (Soetanto & Proverbs, 2002). Sometimes a project is over-budget and it is completed too late but it may still be considered successful by certain groups. In addition, some other factors such as work safety, legal aspects, effects on environment and productivity can be evaluated for success as well as budget and duration (Chovichien, 2013). As pointed out by another study, stakeholder perceptions of success could vary (Chan, 2001). Accordingly, the main concerns for architects are aesthetics and functionality rather than costs.

While efforts on customer satisfaction are done in other sectors, the performance evaluation in construction projects is traditionally limited to time, budget, and quality. Nonetheless, the customer satisfaction in construction projects was examined in some research (Kärnä, 2009). The client's perception of project success can vary depending on different factors, including the client him/herself, the project, and the stakeholders of the project (Chan, 2001). It is also necessary that the project is fully understood by the client (Soetanto et al., 2001). In short, the answer to the question of what success is or how to measure it can be very elusive.

2. PURPOSE OF THE STUDY

Everyone involved in construction of a building want the project be considered successful. Different groups or stakeholders, however, have also their own agendas and measure the outcome or success of the project differently. Client satisfaction during and at the end of a project may be seen as one of the important criteria. Work environment, relationships between different groups, needs, and views affect the success of a project. Because of the difference in perception of different groups, this study focuses especially on client satisfaction as a perception of success instead of how to measure success. In this study, it is desired to examine whether there is a change in the opinions of architects and civil engineers regarding customer/client satisfaction. In particular, the relationship between success perceptions and stakeholder relationships is emphasized. The opinions of the mentioned groups toward work environment are also examined.

3. METHODOLOGY

The data examined in this study were derived from the data of a larger study (Coskun 2016; Genç, 2017).The questionnaire were held out to civil engineers and architects asking their perceptions about working conditions and project outcomes. In the survey, civil engineers and architects were asked the similar questions. The cooperative working of stakeholders in a project and the project outputs among which is client/customer satisfaction that could be obtained as a result of this collaborative environment were asked in the survey. The cross-data analyzes were made between the answers they gave about working relations among stakeholders and the customer satisfaction. Thus, the relations between the opinions of the specified groups were tried to be determined.

There were 176 civil engineers and 103 architects responding to the survey. The questions posed in the questionnaire are the likelihood (1: strongly probable, 2: probable, 3: undecided, 4: not likely, 5: very unlikely) of client/customer satisfaction as one of the consequences of the difficulties in collaboration of stakeholders starting from the design stage to the project execution process. People are asked to rank (1: not important, 2: partly important, 3: important, 4: quite important, 5: very important) the different types of difficulties encountered during the implementation of such a cooperative environment from the design phase until completion. The questions require people to express their subjective opinions. There are eight questions about the stakeholders. The factors examined are:

- Fac1: Insufficient use of computer technology in design, manufacturing, and sharing all kinds of information
- Fac2: The lack of participation of the customer to the design process
- Fac3: Lack of participation of professional groups, which will be involved in implementation, to the design team as a result of separation of design and manufacturing phases in projects
- Fac4: Non-developed culture of information sharing and ideas between stakeholders (such as in concurrent engineering)
- Fac5: Attitudes and behavior of owner (such as, changes in production line and specification, and failure in doing timely payments)
- Fac6: Inadequacies of employees (skills, knowledge, personality, honesty, performance, and so on.)
- Fac7: Mistrust, fear and the habit of not saying about the mistakes among the people who worked in the project during both the design and the construction phases
- Fac8: The cultural problems among the professional groups of the project

In the expected project outputs part of the questionnaire, the ratings of customer satisfaction are included. The expected client satisfaction can be the result of the conditions of working environment. Participants are asked that with the favorable or collaborative working conditions how much client/customer satisfaction can be expected.

4. ANALYSIS AND RESULTS

4.1. The Relation Between Factor Levels and Perceived Client Satisfaction Levels: Chi-Square Tests

The values given in the tables are found by considering the responses given by one person to both factors (cross-examination). The top rows of the tables show the ratings given for customer satisfaction; they are given as (1: strongly probable, 2: probable, 3: undecided, 4: not likely, 5: very unlikely). In the left side columns of the tables, there are rating values for the examined factor; they are given as (1: not important, 2: partly important, 3: important, 4: quite important, 5: very important). Row and column totals are given in the right column and the bottom row, respectively.

The expected customer satisfaction was compared with each of the eight factors for each level in the cross-examination. Chi-square statistic was used in the analysis. Evaluated null and alternative hypotheses are;

$H_o: p_{ij} = p_{i.} \cdot p_{.j}$

$H_1: p_{ij} \neq p_{i.} \cdot p_{.j}$

where pi. is row probability, p.j is column probability, and pij is the probability value for the cell i and j. This hypothesis is referred to as the "r x c" contingency table (Steel, 1997).

In addition to p-values, the level of independence between columns and rows can be specified by the phi-coefficient (Steel, 1997). Phi-coefficient is given as equation (1).

$$\Phi = \sqrt{\frac{X^2}{n}} \quad (1)$$

The phi-coefficient can have values between 0 and 1, and values close to 1 indicate strong affinity. The calculated phi-coefficients shown in Table 1 also indicate that the dependencies between columns and rows are not strong.

Table 1. Summary of chi-square tests for in-between groups

Civil Engineers			Architects		
Items	P Value	Phi Coefficient	Factor	P Value	Phi Coefficient
Fac5	0,943	0,216	Fac6	0,946	0,280
Fac1	0,897	0,231	Fac1	0,819	0,324
Fac7	0,782	0,255	Fac7	0,651	0,359
Fac8	0,727	0,264	Fac8	0,536	0,380
Fac2	0,725	0,264	Fac2	0,524	0,382
Fac3	0,496	0,296	Fac3	0,242	0,436
Fac4	0,482	0,298	Fac5	0,216	0,442
Fac6	0,409	0,308	Fac4	0,204	0,445

Row or column totals and ratios in the tables can be used to calculate the ratio or probability of a cell in the table. In this case, the probabilities in table cells can be calculated as pij = pi. p.j.. The cell probabilities can be calculated in this way since the p-values are not closer to zero than one and the null hypothesis is accepted.

According to Table 1, the dependency (or independence) status between some factors and customer satisfaction among groups is different in some factors while that dependency status is in the same order in some other factors. The greatest difference between the two groups is related to the Fac5 and Fac6 factors. For the civil engineer, the independence situation is more pronounced in Fac5 (inadequacies of employees, such as skills, knowledge, personality, honesty, performance, and so on.) but it is the opposite for architects.

For civil engineers; if Fac5 and the response rates for customer satisfaction are assumed to be as in the table, the table cells can be filled in such a way that they are multiplied. But if the response rates for Fac6 and customer satisfaction are assumed to be as in the table, the table cells cannot be filled in such a way that they will multiply meaning that there is an interaction between these two ratios. The table therefore can only be filled out by thinking that there may be other interactions in the background.

4.2 Difference Between Opinions of Civil Engineers And Architects: Comparison of Group Means (Student's t Tests)

While it is shown that there is no relationship between factors and customer satisfaction, there may be a background relationship between the rates for factor levels and the levels of customer satisfaction. Subsequently, it is also tried to determine whether there is a difference in the importance given to the factors that affect customer satisfaction between civil engineers and architects. Using all the data, the arithmetic means of the responses to the ratings given for each customer satisfaction (1: strongly probable, 2: probable, 3: undecided, 4: not likely, 5: very probable) are compared. The hypothesis that the mean of the factors is equal to one another (student's t-test) (H_o:$\mu 1=\mu 2$) is tested assuming different variances ($\sigma 1 \neq \sigma 2$) of two-populations.

When the data were examined, it appeared that there was a difference between the average scores of the two groups at each level. With a few minor differences in mind, these findings could be summarized in the following way as in Table 2.

Table 2. Summary of tests of equality of means tests (t-tests) at each satisfaction level

	1	2	3	4	5
Fac1	same	not same	same	not same	same
Fac2	almost	same	not same	same	same
Fac3	not same	not same	not same	not same	not same
Fac4	not same	not same	not same	not same	not same
Fac5	almost	not same	not same	not same	not same
Fac6	not same	almost	not same	not same	not same
Fac7	same	same	same	same	almost
Fac8	same	same	same	same	same

It can be seen that some factors (Fac1: insufficient use of computer technology in design, manufacturing, and sharing all kinds of information; Fac2: the lack of participation of the customer to the design process; Fac7:mistrust, fear and the habit of not saying about the mistakes among the people who worked in the project during both the design and construction phases; and Fac8:the cultural problems among the professional groups of the project) similarly influence customer satisfaction in varying proportions among both architects and civil engineers.

According to findings, both groups agree that working together of stakeholders and that sharing information during this collaboration is important and also that the problems between groups also affect customer satisfaction.

Since some of the factors (Fac1, Fac2, Fac7, and Fac8) have the same implication by both groups, more attention should be paid to these factors. Paying more attention to these factors may not be challenging at all because it means that both groups think the same. However, when we look at the other factors (Fac3, Fac4, Fac5, and Fac6), there are disagreements. Perhaps the differences develop from the work areas of architects and civil engineers; such as architects have generally closer ties to the client/customer, but civil engineers are more occupied on site and closer to other occupational groups; architects attach more importance to design but civil engineers gives greater consideration to construction. Because of these kinds of differences, the views on working together may be also different.

The influences of some factors (Fac3:lack of participation of professional groups, which will be involved in implementation, to the design team as a result of separation of design and manufacturing phases in projects; Fac4:non-developed culture of information sharing and ideas between stakeholders in concurrent engineering; Fac5:attitudes and behavior of owner, such as, changes in production line and specification, and failure in doing timely payments; and Fac6:inadequacies of employees (skills, knowledge, personality, honesty, performance, and so on.) on customer satisfaction at varying rates can be seen in both the architects' and the civil engineers' opinions.

5. CONCLUSION

According to the results of the contingency tables, it is not possible to determine or estimate customer satisfaction based on the importance ratings given to the factors.

Although not predictable, the opinions of architects and civil engineers differ at least for two factors. For civil engineers, Fac5 based prediction can be made, whereas no prediction based on Fac6 is possible. The opposite is true for architects.

The ratings for some factors ("Fac3", "Fac4", "Fac5", and "Fac6") and client satisfaction ratings were found to be different between civil engineer and architect groups by hypothesis tests of equality of means.

For some factors ("Fac1", " Fac2", " Fac7", " Fac8"), it was seen that the differences were not great (hypothesis tests of equality of means). These two stakeholder groups (architects and civil engineers) have a consensus on these factors, indicating that customer satisfaction may be more likely to be achieved if these factors are focused on. In this case, the more efficient use of computer technology at each step of the construction process may help to increase the client satisfaction. Participation of the client in the design process can also be an effective way to increase client satisfaction. If the disagreement over factor "Fac3" is taken into consideration, the involvement of the client in the design process seems to be more important factor than the other stakeholders' involvement. It can be said that factor " Fac7" is a subgroup of factor " Fac8", in which case it may be appropriate to create a more shared and open working environment, where communication channels work more effectively, among all stakeholders.

The results can also be interpreted as follows: an architect or a civil engineer can be chosen as project manager. If there are differences of approach among these groups and if these differences are recognized or known more precisely then the manager selection can be done more appropriately. If the project specific features (such as work environment, project team, information systems) can be known beforehand, then an architect or a civil engineer can be selected to work with as a project manager to assure a better client satisfaction.

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Research Article

MICROSTRUCTURAL ANALYSIS OF ZnO-CuPc NANOCOMPOSITES SYNTHENISED BY HYDROTHERMAL METHOD

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ABSTRACT

With the discovery of inorganic semiconductors, silicon and germanium became very important materials in the field of electronics. The use of these materials with these limited features for a long time has become insufficient in the face of increasing demands. For this reason, organic semiconductors have revolutionized structures that respond to these demands. In this study, we synthesized ZnO based semi-material with the hydrothermal method. Structural characterizations were made by XRD, SEM (EDX) and FTIR.

Keywords: *Composite, Hydrothermal method, Structural characterization, EDX, XRD, SEM*

1. INTRODUCTION

Semiconductor materials are frequently used in electronics field in the world. Thanks to this equipment used in different signal collector sensors in renewable energy applications, sectors such as computers and medical nuclear have made remarkable progress (Kahraman *et al.* 2014). Generally, inorganic semiconductor materials are used in these applications. Elements such as silicon or germanium play the main role in the formation of these components. However, the fact that the studies with these materials are close to the saturation level requires different searches. Organic materials are the best alternative for this situation and are accepted. In many electronic and optoelectronic applications, inorganic semiconductors (polymeric / non-polymeric) have started to take their place.

Hydrocarbons such as Anthracene and phthalocyanine may show semiconductor properties. The main feature of semiconductors is electrical conductivity, which depends on the mobility and concentration of charge carriers. Organic semiconductors' electrical conductivity, carrier concentrations, and mobility are lower than that of inorganic semiconductors. A comparison of the properties of an organic conductor, Copper phthalocyanine and inorganic semiconductor germanium is given in Table 1.

Table 1.Comparison of the electrical properties of the inorganic semiconductor germanium and organic semiconductor CuPc(Heilmeier *et al.* 1963; Xavier 1997).

Properties	*Inorganic*	*Organic*
Mobility (cm^2/ V. Sec)	3900	1
Carrier concentration (cm^{-3})	2.5 x 10^{13}	$10^6$to 10^7
Trap density (cm^{-3})	-	$10^{12}$to 10^{14}
Resistivity (ohm . cm)	43	10^{14}
Bandgap (eV)	0.67	1.6
Density (g/cm^3)	5.32	1.6

ZnO based composites attracted the attention of researchers (Güler *et al.* 2016; Güler *et al.* 2019). For this research study, our aim is to produce ZnO based composite materials in different compositions by hydrothermal method which is the new production method. Following the production, the structural and morphological properties of the obtained composite materials were investigated. These analyses were conducted with X-Ray Diffraction (XRD), scanning electron microscopy (SEM) and Fourier transform infrared (FTIR) analysis.

2. EXPERIMENTAL

In this work, Zinc acetate $Zn(CH3COO)_2$ and sodium hydroxide NaOH were used. Zinc acetate was dissolved in distilled water. Then, sodium hydroxide 0.85gm was dissolved in 20 ml distilled water, separately and stirring during 1h on the magnetic stirrer. After this, the two solutions put into the same cup, placed into hydrothermal equipment at 160 °C and stayed for 12 h. Then we open the hydrothermal system and the final solution was transferred to autoclave and heated material dried at 100°C for 24h. In this study, four different samples were produced, and details are given as below;

Sample 1: $ZnO_{0.01}$ Mix with 2ml C_6H_5Cl inside a cup,
Sample 2: $ZnO_{0.01}$ Mix with $CuPc_{0.001}$ and 2ml C_6H_5Cl inside a cup,
Sample 3: $ZnO_{0.01}$ Mix with $CuPc_{0.002}$ and 2ml C_6H_5Cl inside a cup,
Sample 4: $ZnO_{0.01}$ Mix with $CuPc_{0.003}$ and 2ml C_6H_5Cl inside the cup.

After the production of the samples, we made the XRD, FTIR, SEM and EDX analysis.

3.RESULTS AND DISCUSSION

3.1. X-ray Diffraction Analysis

The X-ray measurements of the samples were made at room temperature to determine the diffraction planes. The X-ray diffraction pattern of pure CuPc is given in Fig. 1 (Hussein *et al.* 2016).

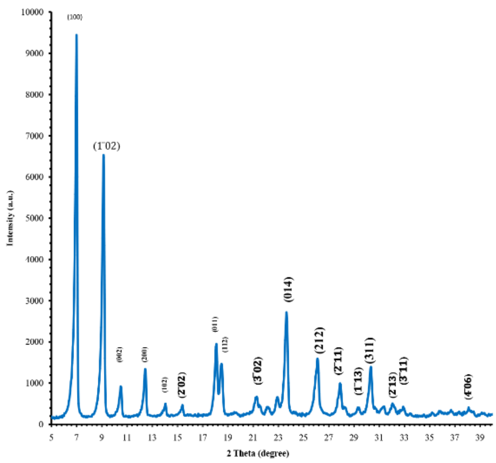

Fig. 1. The XRD spectrum for CuPc powder

Fig.2 shows the X-ray diffraction patterns for ZnO-CuPc composite thin films deposited on a glass substrate. The prepared ZnO-CuPc nanocomposite diffraction pattern displays the hexagonal ZnO phase and for Cu-Pc has different crystal phases: α-, β- and χ– phases. All the peaks of the ZnO thin films correspond to the peaks of ZnO (JCPDS # 0.36- 1451). Peaks ZnO was signed by (*) and peaks CuPc was signed by (+).

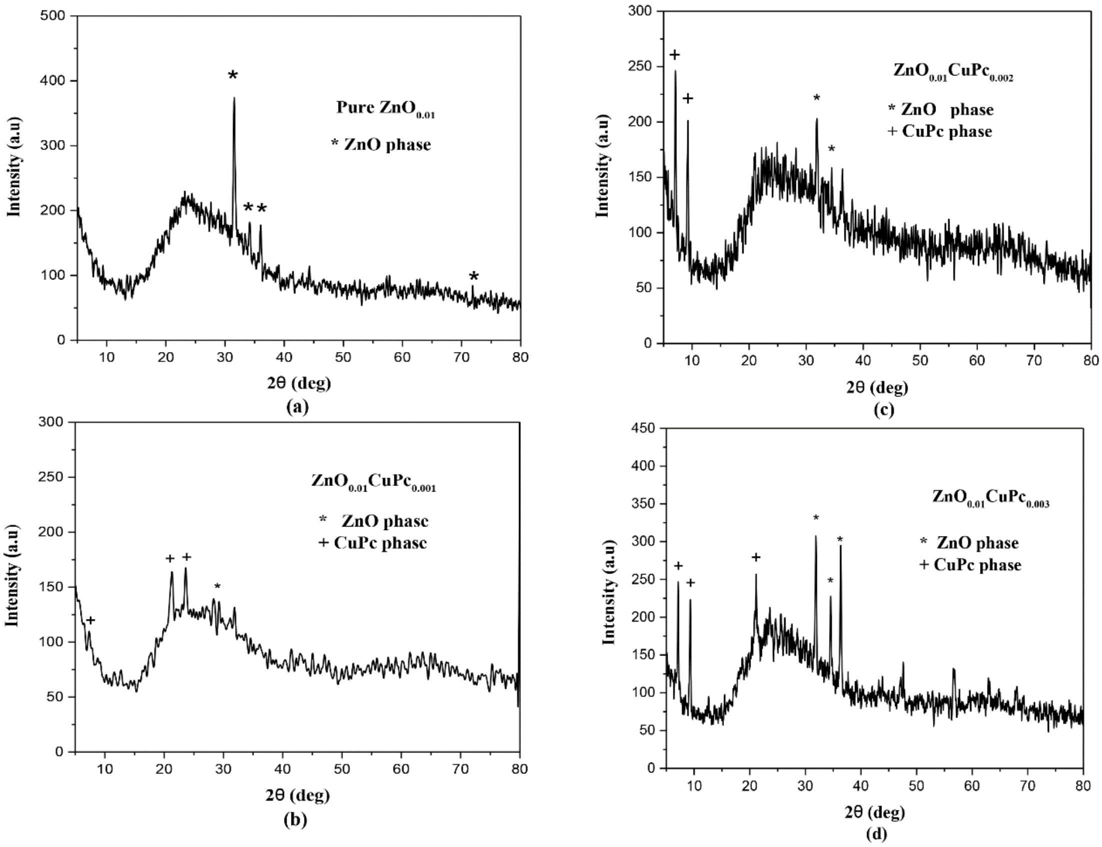

Fig. 2. Diffraction pattern for (a)Pure ZnO, (b)$ZnO_{0.01}CuPc_{0.001}$,(c)$ZnO_{0.01}CuPc_{0.002}$, (d)$ZnO_{0.01}CuPc_{0.003}$

The value of d-spacing, relative intensity and FWHM corresponding to Xray diffraction for all four samples have been tabulated in Table 3. It is found the value d-spacing by this equation.

$$n\lambda = 2d \sin\theta \quad (1)$$

The crystallites sizes (D) of the films are estimated using the Scherrer formula (Scherrer 1918).

$$D = \frac{K\lambda}{\beta COS(\theta)} \quad (2)$$

Where λ is the wavelength of X-Ray used (λ = 1.54 Å), k is shape factor constant taken to be 0.94, θ is diffracting angle and β is the full width at half maximum of peaks in XRD pattern. The value of crystallite size were given in Table 2.

The dislocation density (δ), defined as the length of dislocation lines per unit volume, is estimated using the following equation (Khan *et al.* 2010).

$$\delta = \frac{1}{D^2} \quad (3)$$

We found the dislocation density (δ) showed in Table 2.

The value of lattice Strain (ε) of the samples is estimated using the equation (Saleem *et al.* 2012).

$$\varepsilon = \frac{\beta \cos(\theta)}{4} \quad (4)$$

The calculated value of lattice Strain (ε) were given in Table 2.

Table 2. (2θ), d-spacing, FWHM, Crystallite size, strain and dislocation for ZnO-CuPc nanocomposite samples

Sample	(2θ)(°)	d(A°)	FWHM (°)	FWHM (rad)	The crystallite size (nm)	Strain ($* 10^{-3}$)	Dislocation ($*10^{3}$)(nm)$^{-2}$
Pure $ZnO_{0.01}$	31.69	2.82	0.44	0.0076	19.45	1.86	2.64
$ZnO_{0.01}CuPc_{0.001}$	7.42	12.03	0.36	0.0062	23.6	1.54	1.79
$ZnO_{0.01}CuPc_{0.002}$	9.26	9.62	0.39	0.0068	21.49	1.69	2.16
$ZnO_{0.01}CuPc_{0.003}$	7.13	1.24	0.31	0.0054	26.76	1.34	1.39

Table 3. (2θ), d-spacing, FWHM and percentage intensity for ZnO-CuPc nanocomposite samples

Samples	*(hkl)*	*(2θ) (°)*	*d (A°)*	*FWHM (°)*	*Intensity (%)*
Pure $ZnO_{0.01}$	100	31.69	2.82	0.44	100
	002	34.56	2.59	0.41	21.04
	004	72.50	1.3	0.35	9.81
$ZnO_{0.01}CuPc_{0.001}$	100	7.42	12.03	0.36	36.93
	211	21.24	4.1	0.35	92.03
	100	31.69	2.82	0.31	45.18
$ZnO_{0.01}CuPc_{0.002}$	100	7.09	12.62	0.38	100
	102	9.26	9.62	0.39	76.99
	100	31.74	2.82	0.41	34.4
$ZnO_{0.01}CuPc_{0.003}$	100	7.13	1.24	0.31	100
	102	9.26	9.62	0.33	78.2
	002	31.69	2.82	0.34	50.8

3.2. FTIR Analysis

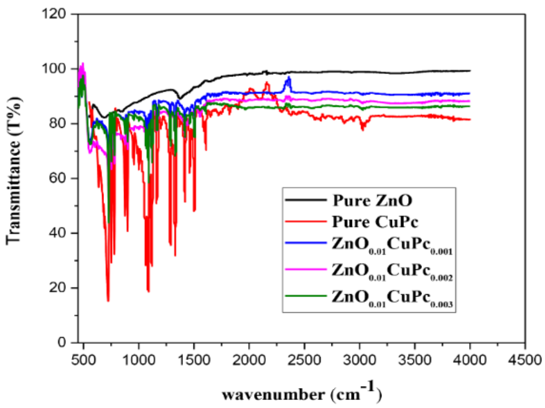

Figure 3. FTIR spectra for ZnO nanoparticles doped CuPc

The FTIR spectra for ZnO-CuPc nanocomposite has been recorded to study the various functional groups of nanocomposites displayed in Fig. 3. Infrared studies were carried out to ascertain the purity and nature of the metal nanoparticles. Metal oxides generally give absorption bands in the fingerprint region i.e. below 1000 cm^{-1} arising from inter-atomic vibrations. The peak observed at 1119.15 cm^{-1} may be due to O-H stretching and deformation, respectively assigned to the water adsorption on the metal surface. The characteristic wurtzite lattice vibrations (Zn-O) are corresponding to the broadband in range 400-600 cm^{-1}(Markova-Deneva 2010). The FTIR spectrum for CuPc, has characteristic peaks at 3040 cm^{-1} and 2930 cm^{-1} for aromatic C–H stretching, 1609 cm^{-1} for C=C macro cycle ring deformation,1504 cm^{-1} for C=N stretching, 1331 cm^{-1} for C–C stretching in is indole, 1090 cm^{-1} for C–H in plane deformation and 728 cm^{-1} for C–H out of plane deformation. The other peaks at 1290 cm^{-1}, 1161 $cm^{-1}$and 1119 cm^{-1} correspond to C−N stretching in indole, C-N enplane bending, C-H in plane bending, respectively (Singh *et al.* 2008).

3.3. Morphological Analysis

In addition to automated SEM techniques, SEM morphological analysis fully characterized the materials. Though automated SEM analysis offers measured information about size, amount of phases and particles present and chemistry, the morphological analysis offers information about the physical relationships of the phases present, crystallinity and size.

The surface morphology of ZnO-CuPc nanocomposite was studied using FESEM at various magnifications and shown in Fig 4 (a,b,c,d). The pure ZnO, clearly shows (at 2500x, 5000x, 10000x, 15000x different magnifications) the formation of typical rod and clusters. In Fig. 5-7 (a,b,c,d) for ZnO-CuPc clearly shows (2500x, 5000x, 10000x, 15000x magnification) the formation of typical rod and clusters. The ESX spectrum of the samğles are given in Table 4, Table 5, Table 6 and Table 7, respectively.

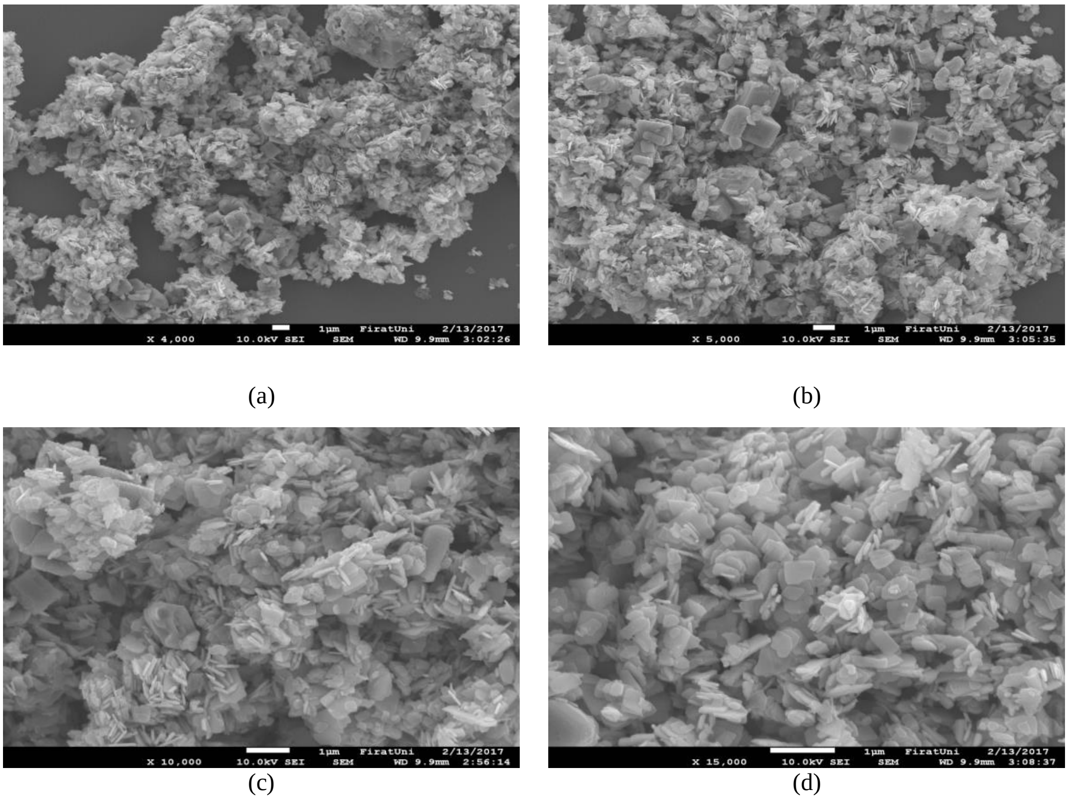

Figure 4. SEM micrograph for pure $ZnO_{0.01}$ (a) 4000x, (b) 5000x, (c) 10000x, (d) 15000x magnification

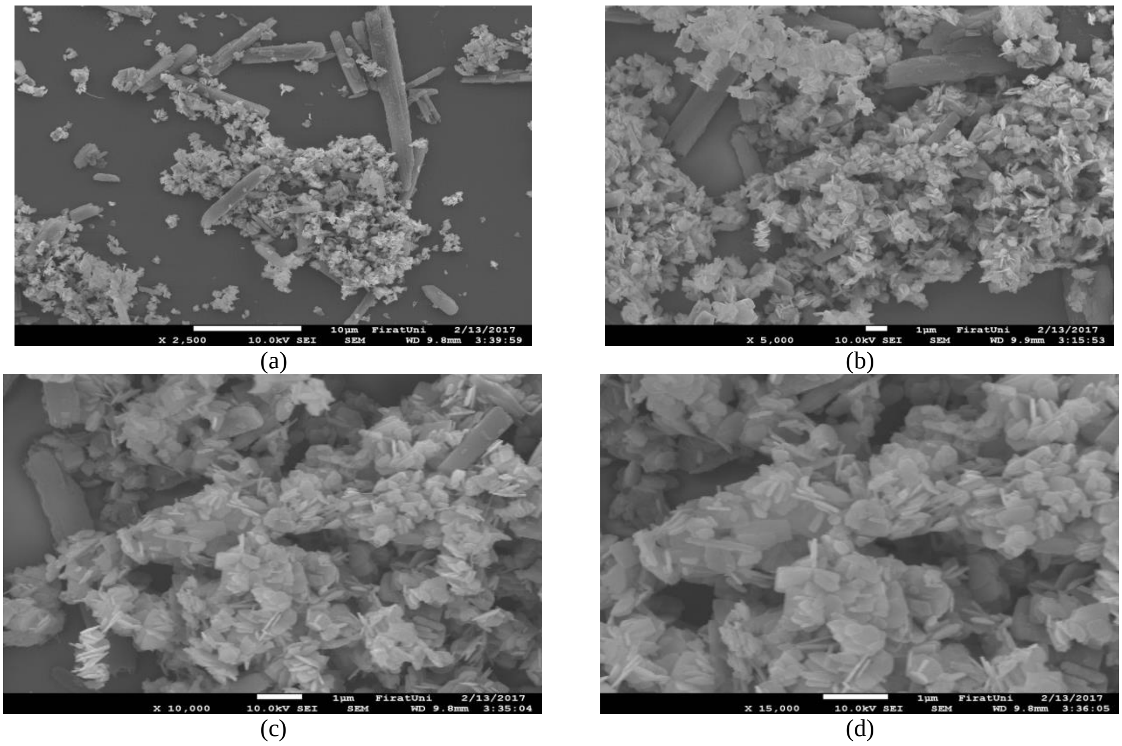

Figure 5. SEM micrograph for $ZnO_{0.01}$ $CuPc_{0.00101}$ (a) 4000x, (b) 5000x, (c) 10000x, (d) 15000x magnification

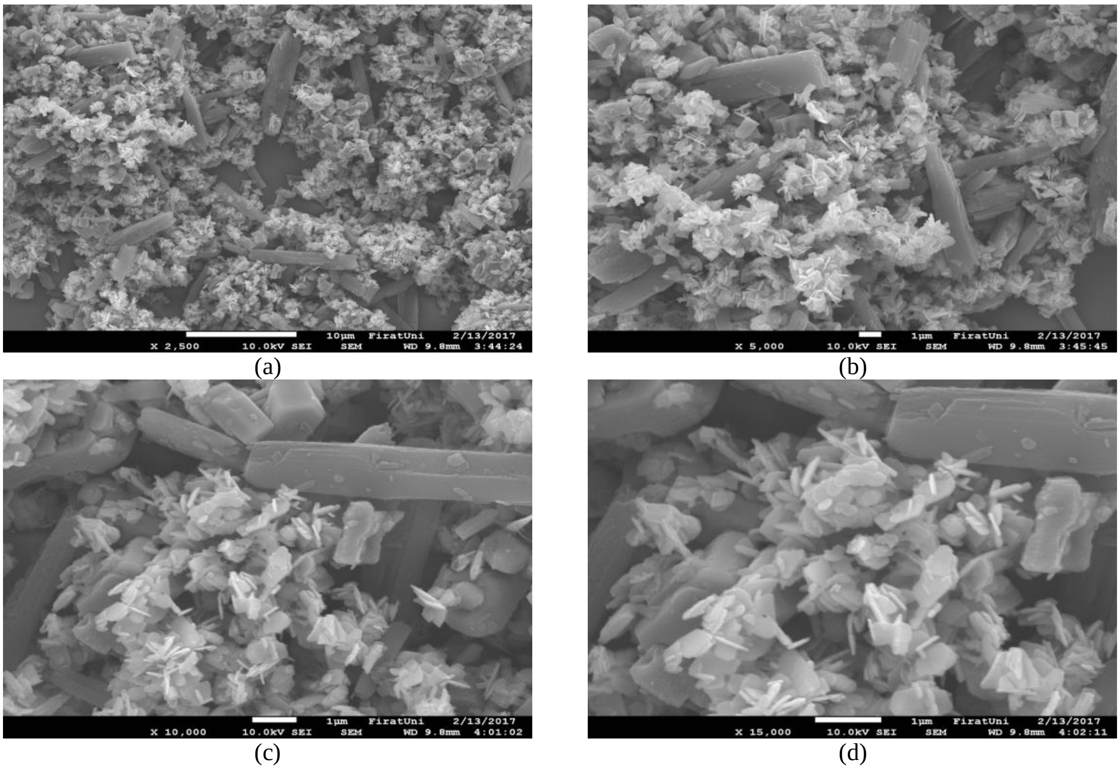

Figure 6. SEM micrograph for $ZnO_{0.01}$ $CuPc_{0.00201}$ (a) 4000x, (b) 5000x, (c) 10000x, (d) 15000x magnification

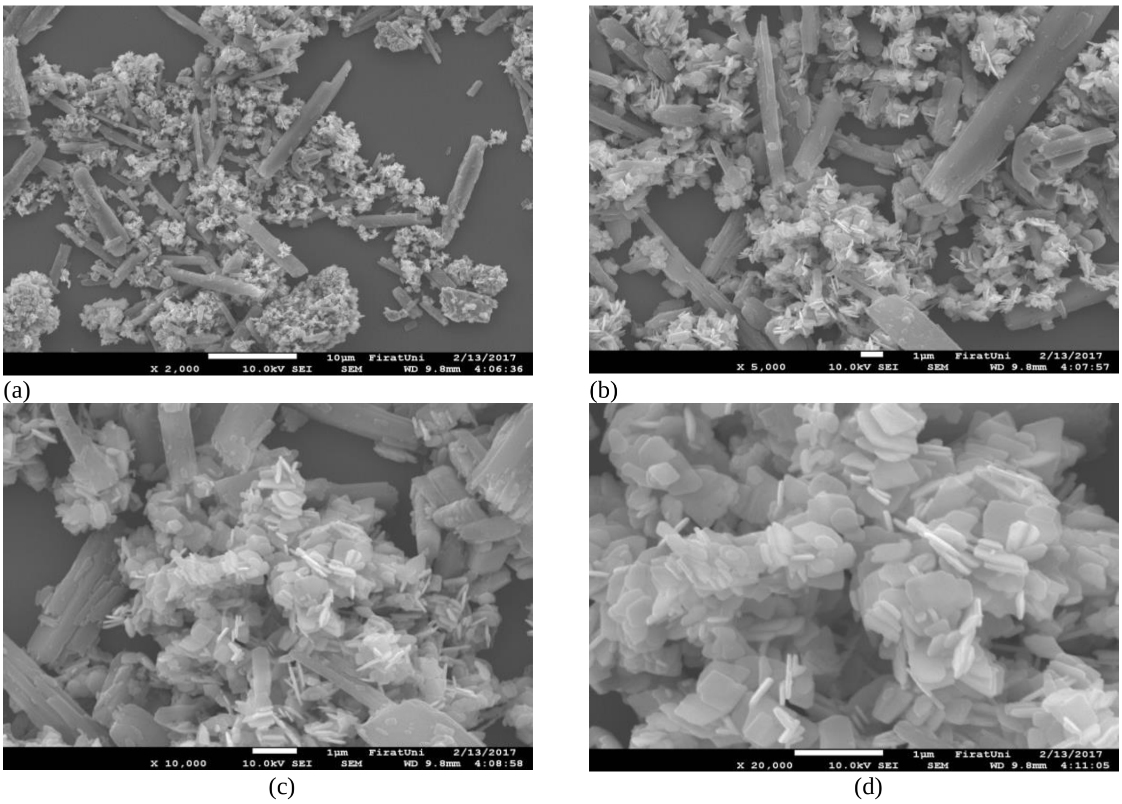

Figure 7. SEM micrograph for $ZnO_{0.01}$ $CuPc_{0.00301}$ (a) 4000x, (b) 5000x, (c) 10000x, (d) 15000x magnification

Table 4. EDX analysis for pure $ZnO_{0.01}$ sample.

Element	*Weight%*	*Atomic%*
O K	21.33	52.56
Zn L	78.67	47.44
Totals	100.00	

Table 5. EDX analysis for $ZnO_{0.01}$ $CuPc_{0.001}$ sample

Element	*Weight%*	*Atomic%*
C K	32.87	52.08
N K	8.05	11.89
O K	17.78	22.97
Cu L	1.43	0.46
Zn L	39.87	12.61
Totals	100.00	

Table 6. EDX analysis for $ZnO_{0.01}$ $CuPc_{0.002}$ sample

Element	*Weight%*	*Atomic%*
C K	59.83	75.30
N K	13.45	14.51
O K	5.55	5.24
Cu L	8.27	1.97
Zn L	12.91	2.99
Totals	100.00	

Table 7. EDX analysis for $ZnO_{0.01}$ $CuPc_{0.003}$ sample

Element	*Weight%*	*Atomic%*
C K	43.14	64.27
N K	9.15	11.69
O K	12.98	14.52
Cu L	1.45	0.41
Zn L	33.28	9.11
Totals	100.00	

4. CONCLUSION

ZnO was synthesized by using the hydrothermal technique then doped with CuPc to make composites with different compositions. Characterization study was carried out using XRD, SEM and FTIR. The XRD patterns are used for phase identification and they showed the amount of impurities and structure depending on the peaks present in the samples. Diffraction pattern displays the hexagonal phase ZnO and for Cu-Pc have different crystal phases: α-, β- and χ– phases. XRD Scherer's formula is used to find the crystallite size of ZnO and doped with CuPc ($0.9\lambda/(B^*\cos\theta)$). SEM micrograph used to determine the microstructure and typically rod and clusters formations were observed. FTIR spectra have been recorded to several functional groups.

Acknowledgements

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Research Article

MODELING AND SIMULATION OF DYNAMIC MECHANICAL SYSTEMS USING ELECTRIC CIRCUIT ANALOGY

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ABSTRACT

Modeling and simulation are prerequisite to analysis and design of engineering systems. Modern engineering systems often are multy disciplinary, i.e., may include blocks from different majors of engineering, such as electrical, mechanical, fluid, etc. Availability of a unified approach for system modeling will make it easy for engineers or researcher from a certain discipline to model the systems from other disciplines. For example, with availability of a unified modeling methodology an electrical engineer will be able to model a system composed of electrical, mechanical and fluid systems. Modeling of complex mechanical systems is not always easy for engineers from other disciplines. On the other hand, it is much easier to establish mathematical model of electric circuits. Furthermore, simulation software is much richer for electric circuits. Therefore, in this paper a methodology is proposed for unifying the modeling of electrical and complex mechanical systems by obtaining electric circuit model of complex mechanic systems. In developing the proposed methodology, analogy between the electrical and mechanical elements have been used as tools. Proposed methodology has been applied to modeling and simulation of a relatively complex mechanical system and benefits accrued from this approach has been discussed. It is further proposed that the approach presented in this paper can be easily extended to modeling of dynamic systems from other engineering disciplines.

Keywords: *Unified Modeling, Simulation, Complex Mechanical Systems, Electric Circuit, Analogy*

1. INTRODUCTION

Modeling and simulation are prerequisite to the design of a dynamic system, because directly proceeding to the designing and manufacturing a system and then testing for expected performance would be inevitably expensive. Wide-spread availability of high speed and high storage capacity computers made the simulation process even more attractive. Modeling and simulation lie at the intersection between theory and experiment and highly valued in scientific discovery. Simulation provides additional insights that are often impractical or impossible to discover through real-world experimental and theoretical analysis alone. It could be viewed as virtual experimentation that could be implemented in any circumstances. Benefits of the modeling and simulation can be summarized as follows:

a) A simulation model executed on a computer system can compress the time frame in thousands of folds and can be used to investigate quickly the effects of a changes in a real-life situation that take place over several years.
b) Simulation could be used to study complex systems, that would be very difficult to investigate, without runing a simulation model on a fast digital-computer.
c) The effects of various changes on a complex systems performance can be easily investigated without producing a physical prototype.
d) Simulation culd be used to investigate situation that true hands-on experiments would be dangerous in real life
e) Optimization routines can be incorporated into the simulation models and system can be designed with optimum performance in various aspects.

There are several software packages available for simulation of mechanical systems such as MATLAB/Simulink toolbox SimMechanics (Hrankova and Pastor,2013; Virgala at. all., 2013), SIMULIA (SIMULIA, 2008), ANSYS (ANSYS, 2008) and COMSOL (COMSOL, 2008). Also, there are many publications on modeling and simulation of mechanical systems such as (Macchelli, 2009, Dulau and Oltean, 2016, Mohammed, 2015). Modeling of dynamic systems from each individual engineering specialization are given in several texts (Ogata, 2002, Ogata, 2004, Woods and Lawrence, 1997, Close at al., 2002, Ljung and Glad, 1994, Rowell and Wormley, 1997).

However, modern engineering systems are often multy disciplinary, containing blocks from different engineering disciplines. As such, modeling of a multy disciplinary dynamic systems by an engineer or researcher from a single discipline will rise some difficulties. Therefore, availability of a unified modeling methodology will be much useful in modeling process. Towards this aim, in this paper a unified modelling methodology is proposed for unifying the modeling of electrical and mechanical systems by obtaining electrical circuit model of complex mechanical systems. In developing the methodology of proposed unified model, analogy between the electrical and mechanical elements, that are given in several text (Ogata, 2004, Woods and Lawrence, 1997, Close at al., 2002), have been used as tools. It should be noted here that a reverse modeling methodology, i.e., modeling an electrical circuit as an equivalent mechanical system is also possible, which may be preferred by mechanical engineers.

The unified modeling methodology proposed in this paper, has been applied to modeling and subsequently simulation of a complex mechanical system. It has been shown that how the proposed approach simplifies the modeling of complex mechanical dynamic systems. The benefits accrued from proposed approach have been discussed. It is also proposed that the approach explained in this investigation can similarly be extended to the dynamic systems from other engineering disciplines,

2. METHODOLOGY

In translational mechanical systems there are three main system elements, which are mass (M), stiffness element (K) and viscous friction element (B). The most common stiffness element is she spring, which will be considered in this paper. Corresponding elements in a rotational mechanical system are moment of inertia, rotational stiffness and rotational viscous friction. Similarly, in electrical systems there are well known three elements main that are inductance (L), capacitance (C) and resistance (R). The governing equations between mechanical and electrical systems show a complete similarity as shown in the Table 1 and Table 2. This gives opportunity for a perfect analogy between mechanical and electrical systems. Based on this characteristic it is possible to develop unified modeling methodology for modeling complex dynamic mechanical systems in the form of electric circuits. Analogy given in Table 1 is known as direct analog or force-voltage analog in which each velocity corresponds to an electrical current and each displacement corresponds to an electrical charge (Ogata, 2004).

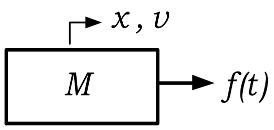
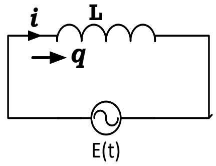
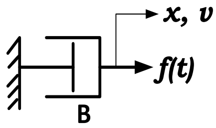
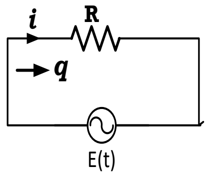
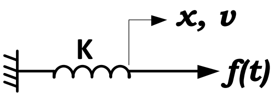
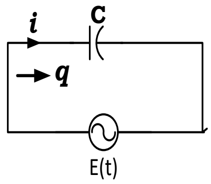
Table 1: Analogy between the electrical and mechanical elements

Symb.	Mech.	Unit	Symb.	Electrical Analog	Unit
$\boldsymbol{f}$	Force	N	$\boldsymbol{E}$	Voltage	V
$\boldsymbol{x}$	Disp.	m	$\boldsymbol{q}$	Electrical Charge	C
$\boldsymbol{v}$	Speed	m/s	$\boldsymbol{i}$	Electric Current	A
$\boldsymbol{M}$	Mass	kg	$\boldsymbol{L}$	Inductance	H
$\boldsymbol{B}$	Viscous Friction	Ns/m	$\boldsymbol{R}$	Electrical Resistance	Ω
$\boldsymbol{K}$	Spring	N/m	$\boldsymbol{\frac{1}{C}}$	Capacitor	F

(symb.: Symbols, Mech: Mechanical, Disp.: Displacement)

Analogy between the governing equations of the mechanical and electrical elements given in Table 1 are written in Table 2. It can be seen from Table 2 there is complete similarity between the governing equations of the mechanical and electrical elements. This gives opportunity for developing a unified modeling methodology between the two systems.

Table 2. Governing equations of the mechanical and electrical elements given in Table 1.

Mechanical Elements and governing equations	Analogue Electrical elements and analog governing equations
 $M\dfrac{dv}{dt}=M\dfrac{d^2x}{dt^2}=f(t)$ $v=\dfrac{dx}{dt}$	 $L\dfrac{di}{dt}=L\dfrac{d^2q}{dt^2}=E(t)$ $i=\dfrac{dq}{dt}$
 $Bv=B\dfrac{dx}{dt}=f(t)$	 $Ri=R\dfrac{dq}{dt}=E(t)$
 $Kx=f(t)=K\int vdt$ $x=\int vdt$	 $\dfrac{q}{C}=E(t)=\dfrac{1}{C}\int idt$ $q=\int idt$

The analogy between the physical elements and related governing equations given in tables 1 and 2 clearly show that there is a complete similarity between the two systems. Therefore, the two systems always can virtually represent each other.

The key elements in developing a unified modeling methodology is the form of organizing the interconnects between the different blocks of the mechanical systems, in the corresponding equivalent electrical circuits. These key elements can be laid down as follows:

a) Each mass in a mechanical system corresponds to a circuit loop in the equivalent electrical circuit. Therefor the number of loops in the equivalent electrical circuit is defined by the number of different masses in the mechanical system.

b) The interconnect elements in each mass block in mechanical systems corresponds to the electrical elements shared between the equivalent electrical circuit loops.

c) In a mechanical system the series connected elements carrying the same value of force correspond to the parallel connected elements in the equivalent electric circuit.

d) In a mechanical system velocity of each mass corresponds to the each loop current in the equivalent electrical circuit.

e) In a mechanical system displacement of a mass corresponds to the total electrical charge accumulated on each associated capacitor in the equivalent electrical circuit.

f) In a mechanical system the displacement difference between the two masses corresponds to the total charge on the associated capacitor placed on the branch of equivalent electric circuit that is common to the loops associated with each mass.

3. APPLICATION AND DICUSSIONS

An example mechanical system is shown in Fig. 1.

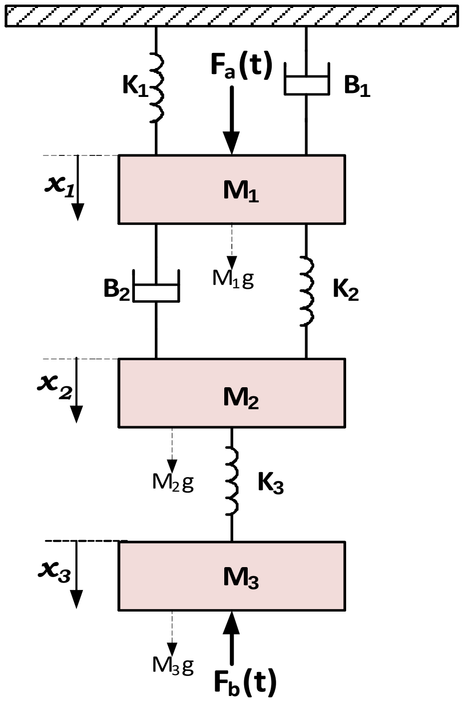


Fig. 1: Example suspended mechanical system

A suspended system is selected in order in which the gravitational forces can be accounted for. The gravitational forces are shown as M_1g, M_2g and M_3g respectively, where g is the usual gravitational acceleration (g=9.8 m/s^2). If references for displacements x_1, x_2 and x_3 are taken as the positions of the masses, before application of the external forces Fa(t) and Fb(t),

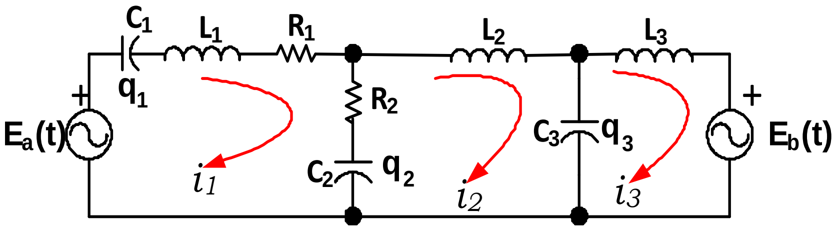


Fig. 2: Equivalent Electrical circuit of the mechanical system given in Fig. 1

but after the system being suspended and the sprigs are lengthened, i.e., as the first equilibrium position is attained, then all the gravitational forces can be dropped from the model equations. In this case the model equations of a suspended systems become like the model equations of a translational systems. Therefore, the way of modelling applied to the suspended system in hand will be equally valid for translational systems as well. In this

Applying the principles of the analogy that have been explained earlier in section 2.1, the electrical equivalent circuit of the mechanical system given in Fig. 1 will be as shown in Fig. 2:

The system parameters are selected as:M_1=18 kg, M_2=12 kg, M_3=9 kg, K_1=220 N/m, K_2=350 N/m, K_3=200 N/m, B_1=20 Ns/m, B_2=15 Ns/m and the two applied forces are selected as:

$$F_a(t) = 60\sin(2t)e^{-0.1t} + 120\ N \quad \text{and}$$
$$F_b(t) = 30\cos(2t)e^{-0.08t} + 20\ N$$

Applying the principles of the analogy that have been explained earlier in section 2.1, the electrical equivalent circuit of the mechanical system given in Fig. 1 will be as shown in Fig. 2:

Source voltages **$E_a(t)$** and **$E_b(t)$** in Fig. 2 are corresponding to the applied forces $F_a(t)$ and $F_b(t)$ respectively.

At the beginning the system was in equilibrium position and at instant t=0 both forces are applied simultaneously.

The amplitudes of equivalent electrical circuits parameters naturally are $L_1=M_1$, $L_2=M_2$, $L_3=M_3$, $C_1=1/K_1$ $C_2=1/K_2$, $C_3=1/K_3$, $R_1=B_1$, $R_2=B_2$, $E_a(t)=F_a(t)$ and $E_b(t)=F_b(t)$. Equations governing the circuit given in Fig. 2 will be as follows:

case values of the displacement and velocities of the masses can be taken as zero.

$$E_a(t) = (R_1 + R_2)i_1 + L_1\frac{di_1}{dt} + \frac{q_1}{C_1} + \frac{q_2}{C_2} - R_2 i_2 \tag{1}$$

$$0 = -R_2 i_1 + R_2 i_2 - \frac{q_2}{C_2} + L_2\frac{di_2}{dt} + \frac{q_3}{C_3} \tag{2}$$

$$-E_b(t) = -\frac{q_3}{C_3} + L_3\frac{di_3}{dt} \tag{3}$$

$$\frac{dq_1}{dt} = i_1 \tag{4}$$

$$\frac{dq_2}{dt} = i_1 - i_2 \tag{5}$$

$$\frac{dq_3}{dt} = i_2 - i_3 \tag{6}$$

Organizing the above six simultaneous differential equations into State-Space model (Ogata, 2002; Ogata 2004) one obtains:

$$\begin{aligned}\dot{x}(t) &= Ax(t) + Bu(t)\\ y(t) &= Cx(t) + Du(t)\end{aligned} \tag{7}$$

Where A is the system matrix, B is the input matrix, C is the output matrix, x(t) are the state variables, $y(t)$ are the output variables and $u(t)$ are the input forcing functions. For the system in hand the open form of these matrixes is given in equation (8). The matrices A, B and $u(t)$ are available from equation (8). The outputs are taken as state variables themselves then the matrix D is a 6 by 2 zero matrix and matrix C is a 6 by 6 unity diagonal matrix.

$$\begin{bmatrix}\frac{di_1}{dt}\\ \frac{di_2}{dt}\\ \frac{di_3}{dt}\\ \frac{dq_1}{dt}\\ \frac{dq_2}{dt}\\ \frac{dq_3}{dt}\end{bmatrix} = \begin{bmatrix} -\frac{R_1+R_2}{L_1} & \frac{R_2}{L_1} & 0 & -\frac{1}{L_1C_1} & -\frac{1}{L_1C_2} & 0\\ \frac{R_2}{L_2} & -\frac{R_2}{L_2} & 0 & 0 & \frac{1}{L_2C_2} & -\frac{1}{L_2C_3}\\ 0 & 0 & 0 & 0 & 0 & \frac{1}{L_3C_3}\\ 1 & 0 & 0 & 0 & 0 & 0\\ 1 & -1 & 0 & 0 & 0 & 0\\ 0 & 1 & -1 & 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} i_1\\ i_2\\ i_3\\ q_1\\ q_2\\ q_3 \end{bmatrix} + \begin{bmatrix} \frac{1}{L_1} & 0\\ 0 & 0\\ 0 & -\frac{1}{L_3}\\ 0 & 0\\ 0 & 0\\ 0 & 0 \end{bmatrix} \begin{bmatrix} E_a(t)\\ E_b(t) \end{bmatrix} \tag{8}$$

Equation (8) can be solved by any numerical method or can be solved by using MATLAM/Simulink (Danbey and Harman, 2004). In this paper 4th order Runge-Kutta method has been selected as solution tool (Chapra and Canale, 2010) and MATLAB is used for programming.

The simulation results are shown in Fig. 3 for the velocities of the three masses.

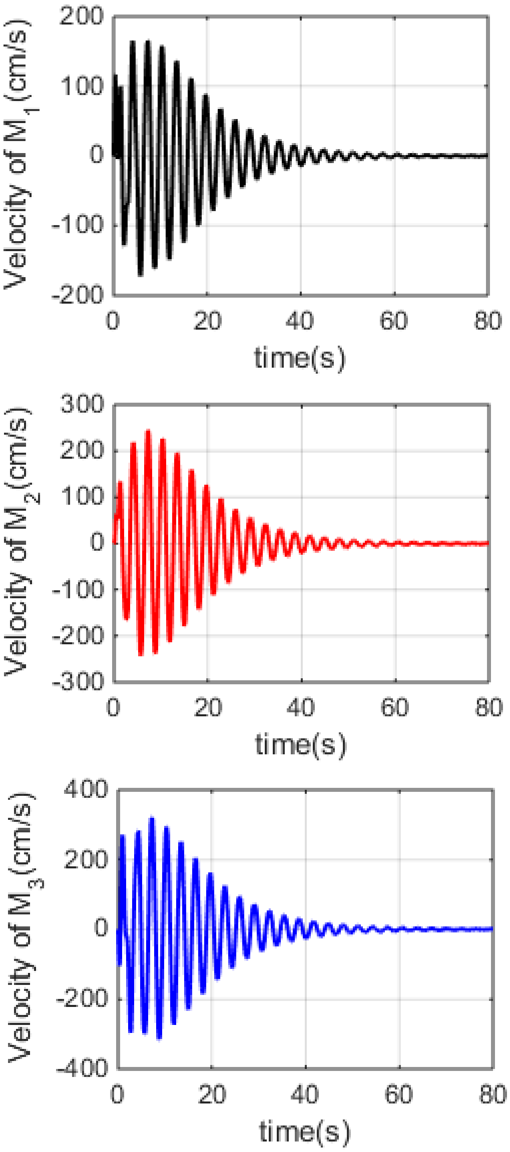


Fig. 3. Velocities of the 3 masses M_1, M_2 and M_3

Examination of the Fig. 3 shows that when the system attains new equilibrium position velocities of the 3 masses becomes zero, which is the expected natural results. This shows the success of the proposed unified modeling approach. Therefor expected correct results are obtained without deriving real mechanical equations.

A new equilibrium position established because as the time progressed the decaying sine and cosine terms in force expressions becomes zero and only the constant components remains. Fig. 3 also shows that, although the larger force on the top side has much higher constant term than the amplitude of exponentially decaying component (60 to 120 N), the velocity of the middle mass attains higher value then the velocities of the both top and bottom masses, because the middle mass is affected by the vibration of both the top and bottom masses which are under the transient force components that are displaced from each other by 90° time phase difference (sine and cosine terms are displaced by 90°).

The simulation results are shown in Fig. 4 for the displacements of the three masses.

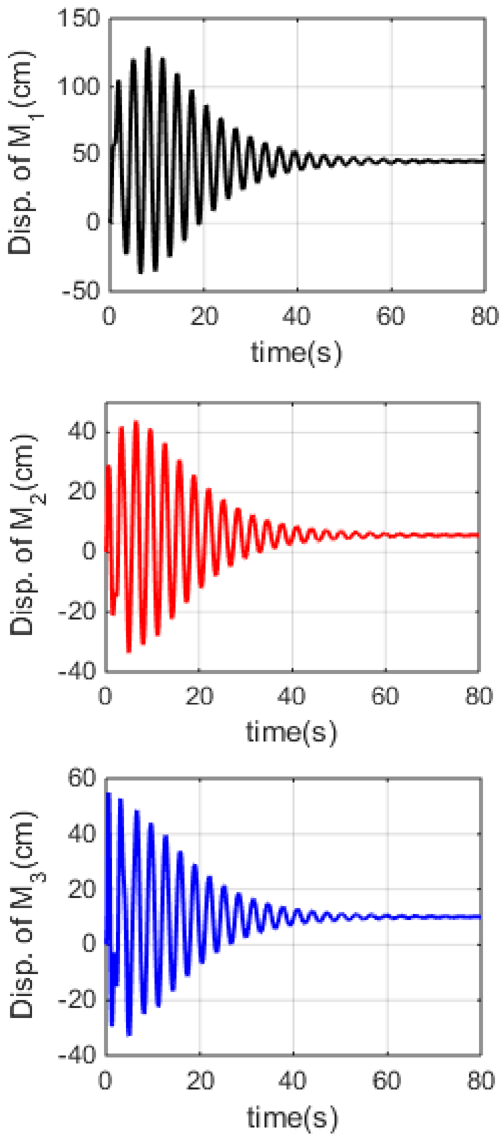


Fig. 4. Displacement of the 3 masses M_1, M_2 and M_3

Fig. 4 shows that the displacements exhibit large excursions between positive and negative values. These large excursions in the displacements are the combined results of the effect of the phase difference between the sinusoidal components of the applied forces and the natural vibrations arising from sudden application of the forces. From Fig. 4 also can be observed that mass M1 which is under lager force has much higher positive displacement and higher steady-state displacement, which is a further proof of the correctness of the applied approach.

To verify that the effect of phase difference in the exponentially decaying sinusoidal components of the forces, the displacements are re-determined by removing the above said phase difference, i.e., converting the cosine term to sine term in $F_b(t)$, where forces are expressed as:

$$F_a(t) = 60\sin(2t)e^{-0.1t} + 120\ N \quad \text{and}$$
$$F_b(t) = 30\sin(2t)e^{-0.08t} + 20\ N$$

The displacements computed under this condition is presented in Fig. 5. It can be observed from this figure that when keeping all force amplitudes same as before but removing only the phase difference between the forces, the large excursions in the displacements are greatly reduced. On the other hand, the settling time is shortened to a large extent. The remaining transient components are almost the result of natural vibration arising from sudden application of the forces.

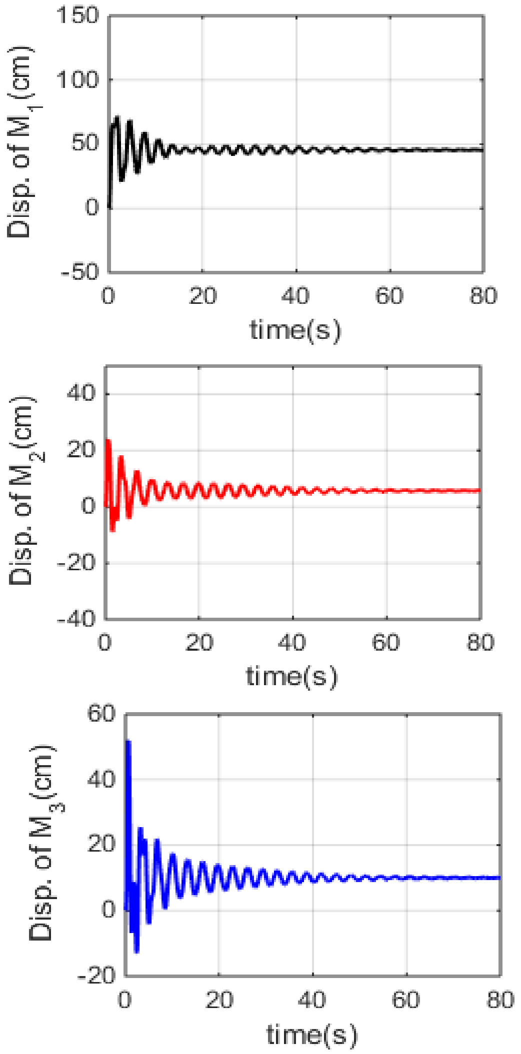


Fig. 5. Displacements of the three masses under new set of forces (amplitudes are same as before but the phase difference between the forces are removed).

It can be observed From Figs. 4 and 5 that the final steady-state values of the displacements are same in both cases (46.4 cm, 5.7 cm and 9.8 cm respectively), i.e., they are not affected by the decaying components of the forces. Only the constant terms (120 N and 20 N) are effective on the steady-state values of the displacements.

To verify the above arguments further, the exponentially decaying sinusoidal components are removed from force expressions and displacements are recalculated, i.e., when force expressions are:

$$F_a(t) = 120\ N \quad \text{and}$$
$$F_b(t) = 20\ N$$

Results of this calculations are plotted in Fig. 6

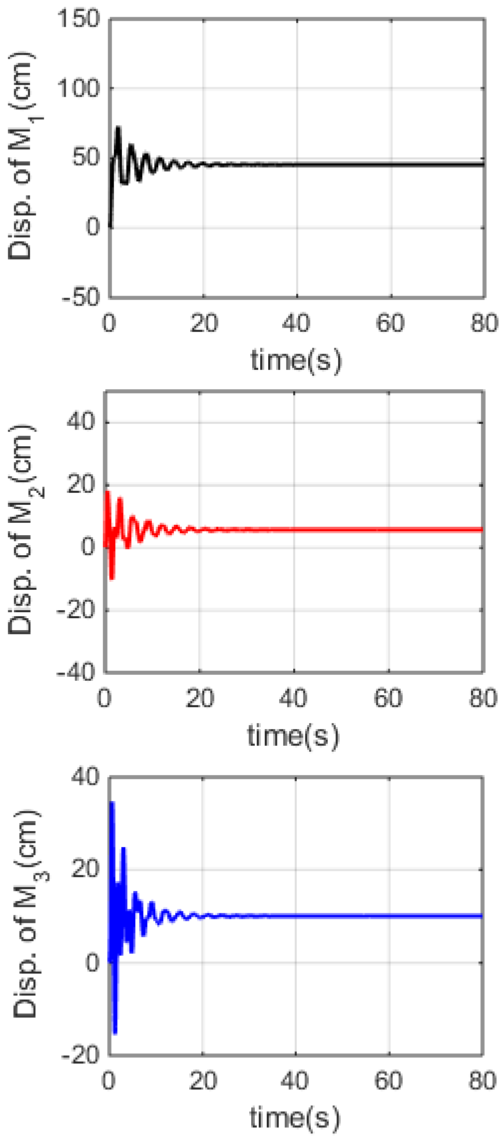


Fig. 6. Displacements of the three masses under when $F_a(t)$=120 N and $F_b(t)$=20 N

Comparison of the figs. 5 and 6 show that the results are almost same in both cases. There are only minor differences in the transient portions of the displacements. This clarifies all the above argument regarding the phase difference between the applied forces.

An experienced system engineer could easily identify that the obtained results are well in lie with the expected results.

The proposed unified modeling methodology can easily be extended to some other dynamic engineering systems such as the fluid systems. Analogy between the basic three elements of the electric systems and the basic fluid quantities, fluid resistance, fluid capacitance and fluid inductance or inertance and also analogy between their governing equations are given in (Close, at al., 2002, Woods and Lawrence, 1997).

4. CONCLUSION

In this paper a unified modeling methodology has been proposed for unifying the modeling of dynamic mechanical systems and electrical systems. Electrical circuits has been taken as the base system and modeling dynamic mechanical systems are modelled as electrical circuit. The unified modeling methodology is based on the analogy between the corresponding basic elements in the mechanical and electrical systems. The main elements of the proposed unified modeling methodology have been laid down in details and then it has been applied to modeling and subsequently simulation of a relatively complex dynamic mechanical system. It is shown how a complex dynamic mechanical system can be easily modelled as electrical circuit, without deriving the true mechanical equations, for example going through free body diagrams, which is not always easy for engineers or researches whose are not mechanical engineers. Further the proposed methodology is benefiting from the relatively easy modeling of electrical circuits. Simulation has been performed for different forms of applied forces and expected results were obtained at each case. This gives confidence about the proposed unified modeling methodology.

Similar unified modeling methodology can be easily extended to dynamic systems from other engineering systems such as fluid systems.

It is also recommended that the prosed methodology could be useful to the practicing engineers and educational purposes.

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Research Article

INTEGRATED AHP-FMEA RISK ASSESSMENT METHOD TO STAINLESS TANK PRODUCTION PROCESS

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ABSTRACT
This study aims to evaluate the hazards of the stainless tank production process in a company by using the Integrated Analytic Hierarchy Process (AHP) and Failure Mode and Effect Analysis (FMEA) methods. First, the hazards in the stainless tank production process were identified. Identified hazards were assessed with the FMEA method to calculate Risk Priority Number (RPN) for each hazard. The same hazards were then weighted by using the AHP method. Finally, AHP and FMEA are integrated to achieve a more objective result by using two subjective methods. According to the integrated method results, risks have been prioritized and an objective ranking has been established for action plans.

Keywords: *Analytic Hierarchy Process, Failure Mode and Effect Analysis, Risk Priority Number, Stainless Tank*

1. INTRODUCTION

Work accidents can be defined as unexpected events, often causing deaths, injuries, loss to machines and equipment, or stopping production for a certain period, which can often be counterworked if essential measures are taken. Occupational safety is defined as by creating healthy and safe working conditions in the work environment; minimizing work-related accidents and occupational diseases and thus increasing productivity by counterwork material and moral losses (Kurt, 1993; Ceylan, 2000).

Accidents at work in the world and Turkey have become a significant problem. Even though occupational accidents are a common issue of all countries; it can be reduced to a specific extent by taking essential measures. Countries failing to take these measures are more affected by accidents (http://europa.eu.int/comm/eurostat;http://laborsta.ilo.org)

The most important conclusion of occupational accidents is the death, injury or disability of the employees. Besides, serious material losses are another important conclusion of occupational accidents. Even though it is a very serious improvement on the floor in occupational health and safety issues in Turkey, this should be done on the subject is also irrefragable that much is true. In recent years, the number of accidents per employee decreases. However, when the accident statistics of the last six years are analyzed, it is seen that there are 75840 occupational accidents per year in our country and 1103 employees lost their lives in these accidents. Besides, the material loss brought to our country by these accidents is estimated to be around 45 billion TL / year (Ceylan and Gül, 2015)

The most important aim of our country's National Occupational Health and Safety policy is to reduce the frequency of occupational accidents. (Ceylan and Başhelvacı, 2011; Korkmaz and Avsallı, 2012). To achieve this goal, other than avoiding hazards, various studies should be performed to identify and evaluate risks in advance and to eliminate or minimize these risks.

The danger is defined as a situation that can cause great harm or extinction. The purpose of hazard identification is to identify the problems and levels that may arise from the workplace environment. Risk is the likelihood of a specific and unwanted event (danger) occurring within a certain period. The control of risks is to evaluate the measures to be taken within a certain hierarchy for each risk. Control and evaluation should be done to determine the priority order of the work to be performed. The goal in the control hierarchy should always be to eliminate danger and minimize the risk. Risk Assessment is the process of estimating the magnitude of risks arising from hazards in any system and deciding whether these risks are acceptable, taking into account the adequacy of existing controls. (Ceylan and Başhelvacı, 2011).

Song et al. (2007) applied the FMEA technique to quantitatively analyze the importance of each activity in terms of structural assembly and safety of steelworks. Dey (2010), aims to develop an integrated framework for managing project risks by analyzing risk at a project, work package, and activity levels and developing reactions in this study. As a result of this study, AHP is an existing approach to achieve concurrency in controversial decisions. Wessiani and Sarwako (2015), applies fuzzy FMEA in his method taking into account the limitation of traditional FMEA in assessing the risk score by expert judgment, and these reform risks are classified according to RPFNs. Li and Zeng (2016) aim at the supplier selection method by applying failure modes and effect analysis (FMEA) to evaluate the risks in the decree process. In the literature, FMEA and AHP methods are encountered in different sectors and applications.

As seen in the literature, there are many studies where FMEA and AHP methods are applied. In this study, two subjective methods are integrated to make a more objective evaluation of the scores obtained by applying FMEA and AHP methods.

In this study, 17 risks were identified by observing the stainless tank production process in the factory. After identifying potential risks, the risk-threat table was first established. Risk Priority Scores (RPN) of risks were calculated using the FMEA method. Risks were also evaluated by the Analytical Hierarchical Process (AHP) method to calculate weights (w_i) of hazards. Finally, the two methods were combined and the importance of the risks identified. In this way, it is aimed to reach a more objective result from two different subjective evaluations.

2. MATERIALS AND METHODS

2.1. Materials

This study was conducted in a company operating in the field of manufacturing and engineering that produces stainless tanks in Turkey.

Stainless tanks are mainly used in the food industry, industrial plants, hotels, and hotels to obtain potable water. Some design conditions must be determined before the stainless tank is manufactured. Depending on the criteria such as chemical properties, pressure, and temperature of the fluid to be stored in, they can be manufactured with or without walled stainless steel quality.

The stainless tank production process starts with CNC cutting. Rectangular metal sheets are cut by CNC machine to required measures. Then metal sheets are twisted by wreath machine to the desired shape. After CNC cutting, small protrusions are formed on the surface. These protrusions are eliminated during the grinding phase. Then, start to weld opening. One of the methods of steel joining is the application made to make the welding process more effective. After these processes are performed, tapping is performed to connect the two metals without requiring filling material. In the welding process, the end parts of the stainless tank after twisting are joined here and the main profile is formed. Finally, the stainless tank is washed together with special chemicals and it is made resistant to rust in the passivation process.

2.2. Methods

2.2.1. Analytical hierarchy process (AHP)

AHP method originally developed by Thomas Saaty as a Multi-Criteria Decision Making (MCDM) method (Saaty, 1980). AHP can be described as a decision making and making method used in case the decision hierarchy can be described and gives percentage dispersion of decision points in terms of the factors affecting the decision. The steps to be taken to solve a decision-making problem related to AHP are as follows; First of all decision-making problem is identified. Then the inter-factor comparison matrix is formed by using Table 1. After that percentage of factors are determined. Finally, consistency in factor benchmarks is measured (Sivrikaya and Ünal, 2018).

Table 1. AHP Comparison Table (Saaty, 1980)

Rating	**Description**
1	"Equal importance"
3	"Moderate importance of one over another"
5	"Strong importance of one over another"
7	"Very strong importance of one over another"
9	"Extreme importance of one over another"
2, 4, 6, 8	"Intermediate values"

2.2.2. Failure mode and effects analysis (FMEA)

FMEA is a conventional reliability and safety analysis technique that has indulged wide implementation of distinct products over several decades (Goddard, 2000).

In general, possible errors are identified in the FMEA technique; the causes of each feasible error are identified, their effect on the customer is assessed, the controls that are applied are reviewed, regulative actions are committed and their application is monitored. Three parameters help determine error priorities. These are the effect of severity (S), error probability (P) and detectability (D).

In its most general form, the method can be summed up in five main steps. First of all the method is started with early studies. Then, suitable error types, causes, effects, and current controls are used to identify the error. Risk Priority Numbers are calculated by determining the effect of severity (S), probability (P), detectability (D). Risk Priority Numbers are calculated by multiplying the effect of severity (S), error probability (P) and detectability (D). After that, sorting according to the risk priority number and determining the errors and actions to be taken. Finally, the determined activities are implemented and the new risk priority number is calculated (Yılmaz, 2000; Aran, 2006). Severity, probability and detectability values are presented in Tables 2,3 and 4 respectively. After calculation of the RPN score, hazards are evaluated according to Table 5.

Table 2. Severity Table (Xu et. al, 2002)

Effect	**Effect of Severity (S)**	**Degree**
Warning	The potential error that can cause catastrophe	10
Warning	Failure of warning and failure, which can lead to high damage and mass deaths	9
Too High	Failure of warning and failure, which can lead to high damage and mass deaths	8
High	It causes complete damage to the equipment and has the effect of death, poisoning, 3rd-degree burn, acute fatal disease, etc.	7
Middle	Affecting the performance of the system, causing loss of limb and organ, severe injury, cancer, etc.	6
Low	Fracture, permanent minor disability, 2nd-degree burns, brain concussion, etc.	5
Very Low	Error causing short-term discomfort with minor injuries such as being injured, minor cuts and abrasions, crushes, etc.	4
Small	Error slowing down system operation	3
Very Small	Error slowing down system operation	2
No	No effect	1

Table 3. Probability Table (Xu et. al, 2002)

Effect	**Error Probability**		**Degree**
Too high: Unavoidable Error	More than 1/2	50,00%	10
	1/3	33,33%	9
High: Error Repeatedly	1/8	12,50%	8
	1/20	5,00%	7
Moderate: Occasional Error	1/80	1,25%	6
	1/200	0,50%	5
	1/2.000	0,05%	4
Low: Relatively Few Errors	1/15.000	0,006%	3
	1/15.0000	0,0006%	2
Few: Unlikely Error	Lower than 1/1.500.000	-	1

Table 4. Detectability Table (Xu et. al, 2002)

Effect	**Effect of Detectability (D)**	**Degree**
Unnoticeable	It is not possible to discover the cause of the potential error	10
Very little	It is too far to discover the cause of the potential error	9
Little	It is far to discover the cause of the potential error	8
Very low	Low potential to detect the cause of the potential error	7

Low	The cause of the potential error is too low to discover	6
Middle	The cause of the potential error can be discovered the medium	5
High Average	The high average for discovering the cause of the potential error	4
High	High potential to detect the cause of the potential error	3
Very High	The cause of the potential error is too high to be discovered	2
Almost Certain	It is almost certain that the cause of the potential error can be discovered.	1

Table 5. RPN Scale (Xu et. al, 2002)

RPN	FMEA-Measure
RPN < 40	No need to take precautions
40 ≤ RPN ≤ 100	It is useful to take precautions
100 < RPN	Precautions must be taken

3. RESULTS AND DISCUSSIONS

In this part, the hazards that can be encountered in the stainless tank production process of a company serving in the complete design, manufacturing, engineering and assembly works of the industrial plants have been determined with observations and expert opinions. Obtained hazard definitions are presented in Table 6.

Table 6. Hazard Definitions

Hazard No#	Definition of Hazard
1	Oxygen cylinders used in the factory are close to the welding machine and the spiral machine, which can cause an explosion.
2	The tubes may explode as the worker uses electronic cigarettes near oxygen cylinders.
3	Due to the overhead crane on the CNC machine, the operator can be hit and injured by careless handling.
4	Workers may have an occupational accident as they are tired and careless due to their busy working tempo.
5	Since the remaining parts are put very close to the machine after cutting on the CNC machine, the operator and workers can get caught in the parts and fall and be injured.
6	As a result of insufficient lighting in the production area of the factory, workers may have accidents and injuries.
7	Due to the length of the cables of some hand tools used, the parts may fall and workers may be injured.
8	Due to broken parts of the wooden support where some heavy metal parts are placed, the parts may fall and cause injury.
9	As the rope used for lifting and transporting heavy parts is worn out, the part may fall during lifting or transportation and cause injury or death.
10	The operator may be injured if the filter on the CNC machine falls.
11	Since the dust pot does not have a lid, overfilled metal parts can be injured by the employees passing by the ladle.
12	Workers may fall and get injured due to loosening in some parts of the metal step around the twisting machine
13	As workers enter the tank during welding, it may result in death if the employee or the tank falls.
14	Workers may be injured as a result of broken hand tools.
15	Employees may fall and get injured due to the inadequate metal step which is used for welding or entering the tank.
16	Failure to perform regular morning checks of the trucks may damage the vehicle.
17	Accidents can occur due to the narrow internal road.

The hazards identified during the stainless tank production process were evaluated by the FMEA method. During the assessment, the effect of severity, the probability of error and the probability of detectability were taken into consideration. Table 2, Table 3 and Table 4 were used for each component. After determining the required values, RPN was calculated for each hazard. As a result of the RPN calculation, the hazards are ranked according to their RPN score and presented in Table 7.

Table 7. FMEA Application Results

Hazard No #	RPN Score	Priority	Interpretation
16	240	1	Precautions must be taken
13	216	2	Precautions must be taken
4	162	3	Precautions must be taken
14	140	4	Precautions must be taken
3	70	5	It is useful to take precautions
15	60	6	It is useful to take precautions
5	48	7	It is useful to take precautions
10	45	8	It is useful to take precautions
6	40	9	It is useful to take precautions
17	30	10	No need to take precautions

1	27	11	No need to take precautions
9	25	12	No need to take precautions
12	24	13	No need to take precautions
8	21	14	No need to take precautions
11	20	15	No need to take precautions
2	18	16	No need to take precautions
7	9	17	No need to take precautions

According to this ranking, Hazard #16 has the highest RPN score and Hazard #13, Hazard #4, Hazard #14 is calculated as the top risks as well while Hazard #9 has the lowest RPN score.

As the second application step of the study hazards is identified in the stainless tank production process has been prioritized by using the AHP method. A CR (Consistency Ratio) of less than 0.10 indicates that the comparisons made by the decision-maker are consistent. As a result of the dual evaluation of the hazards which are in the stainless tank production process, the weight score for each hazard is calculated and presented in Table 8. Table 1 was used for this evaluation.

Table 8. AHP Application Results

Hazard No #	Wi	Priority Order
13	0,1931	1
12	0,1599	2
8	0,1298	3
9	0,1140	4
15	0,0821	5
1	0,0634	6
16	0,0499	7
2	0,0470	8
5	0,0314	9
3	0,0283	10
6	0,0235	11
11	0,0188	12
17	0,0168	13
7	0,0128	14
4	0,0116	15
14	0,0093	16
10	0,0074	17

According to these weights, the hazards are prioritized within themselves. This order of priority is given in Table 8. According to these results, while Hazard #13 has the highest weight, Hazard #10 has the lowest weight. When both results are compared, differences in prioritization occur. For instance, the top 5 hazards which have the highest RPN value are different from the top 5 hazards which have the highest weight.

The values given when determining the RPN and Weight score of hazards may vary according to the opinion of the expert performing the risk analysis. If the expert is indecisive, or if he or she evaluates even one parameter differently when analyzing by another expert, the risk score or weight may be calculated differently. As a result of different calculations, a hazard that needs to be taken into the action plans can be ignored.

Even though measurements in FMEA and comparisons in AHP are performed by the same expert team in the company; results vary from each other which illustrates the subjectivity of the methods which confuses about which hazard should be taken into consideration. Hence, a combination of these two methods has been performed to decrease the subjectivity level, to prevent the negative effects of these subjective evaluations and a more objective result has been tried to be obtained. As a result of AHP-FMEA integration, RPN * *Wi* scores of risks in the stainless tank production process were determined and presented in Table 9.

Table 9. Integrated AHP-FMEA Application Results

Hazard No #	Wi*RPN	Priority Order
13	***41,7260***	***1***
16	***11,9821***	***2***
15	***4,9297***	***3***
12	***3,8383***	***4***
9	***2,8518***	***5***
8	2,7260	6
3	1,9817	7
4	1,8919	8
1	1,7122	9
5	1,5092	10
14	1,3135	11
6	0,9424	12
2	0,8472	13
7	0,1160	14
17	0,5062	15
11	0,3765	16
10	0,3358	17

When hazards are prioritized according to integrated AHP - FMEA risk assessment results, Pareto analysis has been applied to the results to identify which hazards should be taken into action plans primarily. The Pareto chart for integrated results is presented in Figure 1. According to the results, the company needs to focus on Hazard #13, Hazard #16, Hazard #15, Hazard #12, Hazard #9 because of the 80-20 rule of Pareto.

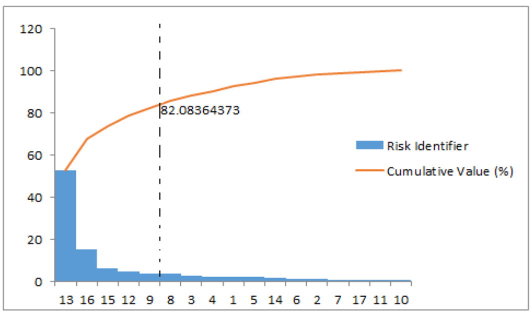

Figure 1. Pareto Chart for Integrated Results

4. CONCLUSION

The use of risk assessment methods performed in companies within the framework of Occupational Health and Safety differs in sectors. The differences between the results of the methods; In risk analyzes performed at decision points where experts are inadequate or hesitant when applying the methods, the results of incorrect prioritization of hazards and incorrect classification of related hazards appear.

In this study, an integrated risk assessment method for the stainless tank production process is performed. FMEA, AHP, and AHP-FMEA integration methods are applied and results are compared for the selected process. In this study, first, 17 hazards were identified in the stainless tank production process. To assess these risks, the FMEA method was applied. The severity, probability, and detectability of the risk were considered when FMEA was implemented. The Risk Priority Number (RPN) was calculated for each risk after FMEA was administered. Then the risks were weighted by applying AHP. The AHP-FMEA integration method was applied to avoid differences in the aforementioned results and to obtain more objective results.

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PIONEERING INSTITUTIONS IN SECTOR ON REAL ESTATE APPRAISAL

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ABSTRACT

The institutions that take the leading role in the evaluation of the real estate should be determined. Real estate valuation takes place in a multi-headed organizational structure and is benefited from institutions in both the public and private sectors. The method of determining the institutions will be examined through the social network analysis methodology of the network of relations between public institutions and the private sector. With the numerical and visual analyzes the following questions will be examined: "Which is the director and responsible institution to undertake the task of collecting the institutional structure under one roof?", Which is the institution that uses the real estate appraisal results most in their works?, Which institution is the most cooperating in acquiring data on real estate appraisal?, Which are the most known institutions that make real estate appraisal?, Which of the institutions that make real estate appraisal are most trusted?". The study will be conducted in order to find answers given to the related questions. As a result, relations between institutions engaged in real estate appraisal business are assessed by social network analysis and interoperability issuing "awareness network" will be put forward.

Keywords: *Real Estate Appraisal, Network Analysis, Organizational Communication, Interoperability, Awareness*

1. INTRODUCTION

In the competitive and variable environment of life in recent years, it has become compulsory for any service providing process to be fast, quality and economical in general. A new approach to service provisioning is possible only if different service providers can cooperate or collaborate effectively. Interoperability infrastructures are required for this (Zutshi, 2012; Charalabidis, 2015; Diallo, 2016). TNCIS (Turkey National Geographic Information System) and services not in the field, in all other areas, such as e-government has emerged in a very significant way (Güney, 2015; Polat, 2015; Ozbek, 2016; Saralioğlu, 2019).

According to significant studies carried out regarding today's public and private sector structures show that requires active collaborations, both functional and physical and within hierarchical boundaries (Vaubel, 2016; Smith, 2017; Wang, 2019;). Such a study is carried out through informal networks between institutions. In this study, collaborations and communication networks are put forward by using social (organizational) network analysis and suggestions are introduced (Tichy, 1979; Borgatti, 2003; Carrington, 2005; Ujwary-Gil, 2019). The awareness network can be established as to whether or not the institutions are aware of each other's data and which exchange data among themselves and which institutions are represented with network analysis that often happens (Thibaut, 2012; Barabási, 2016; Jones, 2017). These two analyzes can be integrated and interpreted.

Throughout the country, public and private sector institutions that make property appraisal were identified, and a network of invisible relationships between them were uncovered and thus; it was attempted to determine the premise institution to undertake the task of gathering under a single roof in the evaluation of real estate with the obtained numerical and visual analysis data (Friedman, 2017; MacGregor, 2018).

In this study, targeted benefits across Turkey by determining the roofing Institution of real estate valuation are summarized below:

Determination and registration of real estate values is necessary for the provision of tax justice and planned development in the country. It is important to know the value of real and legal persons ' private property in terms of recording economic transactions. It is important to determine the value of the real estate in terms of expropriation, housing sector, reduction of company assets and litigation load, to arrange expert reports on real estate values in cases based on Geographical Information Systems, scientific technical data, and to carry out the expropriation operations fairly and smoothly. Urban transformation projects of public, the property rights of real and legal persons to be treated with respect, urban rent and the city of society, social peace, and peace in terms of a public service that is the view of stakeholders that must be performed immediately.

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2. REAL ESTATE VALUATION

Planning of cities and economic development of the reconstruction plans are only possible by evaluating the real estate with appropriate methods (Yu, 2016; Kauko, 2018; Ertas, 2019; Nanda, 2019). Moreover, the revaluation of the real estate value increases arising from public investments can be realised by evaluating these properties before and after the investment (Wang, 2018). Real estate appraisal is also of great importance in terms of selecting new settlement areas, consolidating of fragmented parcels in urban areas and arranging them following the plan, clarity and trust of real estate markets, monitoring price changes in the market, guiding real estate buyers, sellers, owners and entrepreneurs (Lucius, 2001; Krause, 2012). Real estate valuation is one of the essential economic bases of developed societies. In our country, real estate appraisal transactions are not dependent on any standard, and they have adverse effects on economic and social balances. Since the real estate appraisal system still does not exist, many valuation cases have come to our country, economically there are significant tax losses of the state, and there are many differences in the real estate market. Due to the increasing number of discussions in this subject and the increasing need for information related to the subject, it is necessary to provide a more healthy system of valuation of real estates (Whitney, 2009; Smith; 2016; Unel, 2017). The same or similar activities for real estate can be realised by more than one institution. In our country, inter-institutional coordination is of great importance in terms of preventing repetitive work and, if necessary, sharing of acquired experiences. On the other hand, according to the administrators and employees of the institutions operating in the real estate, there is no effective coordination among the institutions in our country (Iversen, 2016; Esen, 2017; Lundsgaarde, 2018).

3. SOCIAL NETWORK ANALYSIS

The earliest findings of SNA are known to be found in the writings of ancient Greek scholars. The primary development regarding this area started in the 1930s with studies in different fields progressing independently of each other (Scott, 1988; Wasserman, 1994; Knoke, 2008). Network analysis which is being examined in the fields of psychology, sociology, mathematics, statistics and informatics, is today a research area which is mentioned with its applications spreading in a comprehensive framework including social scientists, informatics experts, politicians, economists, sociologists and mathematicians (Freeman, 2004; Carrington, 2005; Borgatti, 2009).A study by the American scientist Jacob Moreno (1938), a sociogram or diagrammatic map benefiting dots and lines to illustrate social relations has been adopted as an important starting point for the development of social network analysis. In his study of the foundations of sociometry, Jacob Moreno used methods including graphical representations, which allowed individuals or social groups to identify the relationships within quantifiable quantitative parameters. Moreno focused on the relationships between people rather than people and has made concrete ideas about the social network or social texture that had not been previously apparent (Freeman, 1996;. Borgatti, 2010)

SNA is a method of investigating the structure of social relationships that exist between people. ; It is also an analytical framework for examining the relationships between social entities. Through SNA, the social network is defined as the relationship between social actors, mapping and surveying studies. The SNA is based on the assumption that the importance of the relationship between interactive groups. Social entities, defined as actors, are represented as nodes in the plane. Social relations are a result of people's experiences, in other words, how it felt and that also affects the subjective field to which information or resources available with these experiences. The benefit of the SNA is that it allows us to examine the relationships among people and then examine their interconnectedness. SNA is a method that is frequently used to reveal social dynamics in sociological and organizational studies. Identifying information, sharing patterns in education and online learning environments are used to understand social capital accumulation in the network. Since knowledge is an essential factor in the formation of wealth, economic actors want to direct information to themselves. It is one of the reasons that make SNA valuable. The answer to the question of the conditions under which actors who are close to knowledge can use this situation as an advantage can be obtained through the SNA (Freeman, 2017; Borgatti, 2018).

3.1. The Criteria of Social Network Analysis

In the process of examining the network structure with the SNA**,** it is observed that SNA focuses on the connections between the actors rather than the attributes of the network. During the analysis process, several values obtained as a result of identifying and digitizing the relationships between actors in the network are called criteria. With the criteria used in the SNA is provided by comparing networks, identifying types, analyzing the complex structure of networks, and making the network understandable. By determining criteria such as density, centrality for a network, the position, connections and weaknesses or strengths of an actor in the social network can be revealed. Various criteria can be achieved by performing SNA at different levels when the analysis is done for the whole network. There are different criteria for examining subgroups in the network and in evaluating each actor in the network. Although they have different names, basically each node in a network is called a node, while linking connections/relationships between entities. In visualization applications, the connections between the two nodes are generally expressed as “edge”, since they are indicated by a line connecting the nodes (Wasserman, 1994; Carrington 2005; Knoke, 2008).

In order for the SNA to be carried out, a number of data must be available describing Which actors are connected. Mathematical measurement and calculation methods are used to identify and analyze the social network mechanism created after the introduction of network relation data; It is differentiated from the statistical methods used in data analysis of any quantitative research in the field of social sciences. In the social network analysis, specific measurement methods are used to explain the position of the actors in the network and formed as a whole in order to define the network mechanism. In order to explain the relations between the actors and the network mechanism, Jablin and Putnam discussed the methods of measurement in four groups. These are (Jablin, 2004);

- Measurements of social network mechanism used for relationships: It provides the analysis of the structure of the relations between the actors in a network organization and the determination of the extent of the actors within the network. It is also used to describe the qualitatively differentiated aspects of network relationships.

- Measurements of social network mechanism used for actors: The hierarchical structure of a network mechanism is very important in terms of determining the power relations and determining the communication patterns.

- The roles of the actors in the network mechanism: It shows the tasks played by the actors on the network. Measurements of the social network mechanism used to identify network devices: It is used to define the network features as a whole. Information such as the size or density of the network mechanism generated. Also, it is after entering the data by determining network relationships. In organizational research, it provides the determination of the effectiveness of established relations within an area of activity.

Table 1. Social network mechanism measures used for actors (Jablin, 2001; Taktak, 2019**)**

Measure	Definition
Degree	The number of direct connections to other actors.
Indegree	Number of connections of other elements to the actor (receiving connections).
Outdegre e	The number of connections of the actor to other elements (sending connections).
Closeness	The closeness of an actor to other actors within the network or the degree of accessibility. It is generally calculated by averaging an actor's path distance (direct or indirect connections) to all others. While a direct relation is valued at 1, indirect relations are valued at a lower number proportionately.
Between	It is the degree of an actor's preference to be or intermediate between two actors which are closest to each in the network mechanism. It is generally calculated according to the average of all possible bilateral relations in the network.
Centrality	It is the measure of an actor's degree of being positioned in the center in the network mechanism. The measures of degree, closeness, and between are generally used as the determinants of the centrality. Some centrality measures weight an actor's relation with others by using others' degree of centrality.

Density	The ration between current connections and possible connections in the network mechanism.

Table 2. The Role of actors in network (Jablin, 2001; Taktak, 2019)

Measure	Definition
Star	An actor had a high centrality in the network.
Liaison	An actor who provides the relationship of two or more groups that cannot otherwise be related to each other.
Bridge	An actor who is a member of two or more groups.
Gatekeeper	An actor was controlling the flow of information with a single connection between one part of the network and the other part.
Isolate	An actor who has no or very little connection with others.

4. IMPLEMENTATION

Based on the institutions shown in Table 3, the cooperation of the institutions which have a network of relations within the scope of real estate appraisal is examined by using SNA method.

Table 3. Organizations associated with real estate valuation In Usak Province (Taktak, 2013)

Name of Institution	Abbreviation
Usak Municipality	UM
Special Provincial Administration	SPA
State Hydraulic Works	SHW
Housing Development Administration	HDA
Forest Management Directorate	FMD
The Directorate of Highways	DH
Department of Environment and Urbanization	DEU
Directorate of Title Deed Registry and Cadastre	DTDRC
Foundations	F
Turkish Electricity Distribution Company	TEDC
Governorship	G
Provincial Directorate of Agriculture	PDA
Real Estate Agent	REA
Banks	B
National Real Estate Department	NRED
Licensed Bureau of Surveying Engineering	LBSE
Telecom Directorate	TD
Directorate of Disaster Affairs	DDA
Independent Survey and Cadastre Office	ISCO
Chamber of Commerce	CC
Chamber of Agriculture	CA
Directorate of Museums	DM
University of Usak	UU
Courts	C
Natural Gas Distribution Company	NGDC
Directorate of Provincial Food Agriculture and Livestock	DPFAL

Survey questions were asked to each institution in Table 3 in the form of face-to-face interviews to the relevant experts on Real Estate Appraisal. For five survey questions which are functional in terms of SNA method, the numerical values given by the people who filled out the questionnaire were prepared as a separate Table. The obtained data were statistically and visually evaluated, and the evaluations were performed by Gephi 0.9.1 software which is one of the SNA software and preferred for scientific publications. As the sample of the study, 26 organizations in public and private sectors that used or generated spatial data were selected (Tab. 3).

Likert type scale was used in this study. Based on the recommendations, an odd-numbered scale was used. Additionally, the scale of 0-8 was chosen to show the weight in the network figures clearly. As the study would have a network mechanism sample, the sample was selected to be limited in space. The position-based approach was used to define the limits of samples (Burt, 1983). In the position-based approach, the presence of a membership relation for the network in which actors are in can be proved. The reason why limited space is used in the study is that the number of researched and compared relations increase exponentially with the number of volunteers. Therefore studies in which sociometric data is collected and use a matrix approach usually have 40 or fewer samples (Seevers, 2015). For that reason, it can be concluded that the sample used in this study is adequate for sociometric research. All of the volunteers in the sample were engineers or people with a technical job.

Table 4. Social network analysis survey questions

No	Relations which show the network potential for data sharing	disagree ⟵⟶ agree
1	Which are the most known institutions engaged in the business of real estate valuation ?	0 1 2 3 4 5 6 7 8
2	What is the institution that uses the real estate valuation data in its work ?	0 1 2 3 4 5 6 7 8
3	Which institutions are cooperated most to obtain the data related to real estate valuation ?	0 1 2 3 4 5 6 7 8
4	Which of the institutions that make real estate appraisal are trusted the most ?	0 1 2 3 4 5 6 7 8
5	Which is the guiding and responsible body to undertake the task of gathering institutional structuring under a single roof?	0 1

4.1. Showing Relations of Cooperation, Trust and Data Sharing Within Social Network

Without proper coordination and cooperation between institutions, it is not possible to reach institutional and social goals. Stability and development are realised through inter-agency cooperation and compliance. When corporate relations are carried out, healthily, stability and social development become easier. The institutions need to obtain public trust towards the decisions and actions they take and to get approval and support from their target groups. It is essential to establish public trust and pay due attention to institutions operating in the public sector. Because public institutions are state governing bodies, they have the responsibility of both the administrative power and the public benefit that this administrative power brings. Effective data sharing of organizations is an interoperability system that provides instant access to and use of services. The data needed by the institutions to carry out their activities; It is a comprehensive application that tries to create a fast, economical and efficient way to reach it. Data-based technological applications are increasing day by day and the number of users increases, as well.

Today, for data sharing between institutions, it is necessary to determine the functional, physical and hierarchical boundaries of institutions and to ensure practical cooperation between them. Social networks are the systems that will reveal the invisible cooperation between institutions. SNA, which can be expressed as the digitization and scientific nation of the relations between the actors, is used to transform the existing networks of relations between organizations or organizations into numerical data. According to the digitized data, the shape and characteristics of the network obtained will reveal the efficiency of the institutional or inter-institutional communication network. It also guides taking necessary measures or providing support on the issues analysed.In this study, in order to be able to have an idea about the functioning of the institutions. Besides, the way in which they are perceived by those concerned, an application has been made at the local dimension. In the central district of Uşak province, the existing relationship network between public institutions, local administrations, private sector and real estate appraisal and business sectors that produce data on real estate valuation is presented. The resulting existing networks are aimed to obtain information about the status of the real estate appraisal at the national scale. In the thesis, the relationship between the institutions was examined from a social point of view. It is not from a technical point of view. With this examination, a study has been carried out which can reveal the interoperability of the institutions which are not aware of them and which do not depend on a particular rule. In the research, social network analysis is examined, and the organizational structure between institutions is put forward.In this context, the survey questions 1, 2, 3, 4, 5 given in Table 4, which would reveal the cooperation within the network, were directed to the concerned.

Survey Question 1: Each organization that uses or produce data on real estate valuation was asked the question "Which are the most known institutions engaged in the business of real estate valuation?". Network and centrality graphs were created using the data obtained from the answers to this question. Actors and data access network among actors is shown in Fig. 1.

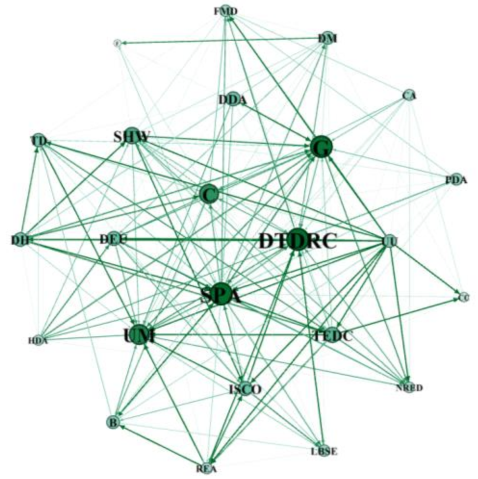

Fig. 1. Network map of actors and links between actors according to answers to the first question

The numerical value of the frequency of public institutions meeting with each other was calculated as 415. The maximum number of bonds that can occur in the network is 650 (n (n-1) = 26.25 = 650). Based on this number of bonds, the overall density of the network was calculated as 415/650 = 0.638. For a network of 26 public institutions, this value is seen to have a density above average. 63.8% of the maximum number of ties that can occur between the actors are in the network. It can be said that public institutions' awareness of real estate valuation among each other is above the middle level.

The calculated "in degree, out degree, in closeness, out closeness, in eigenvalues, out eigenvalues and between values" and the institutions with the highest and lowest values are shown in Table 4, according to the answers of the public institutions, namely the actors, to the first question of the survey;

Table 4. "Which one is known to most real estate appraisal organization?" In-out degree, in-out closeness, in-out eigenvalues and between proximity values results for this question are:

No	Institutions	OutDeg	Indeg	OutClose	InClose	OutEigen	InEigen	Between
1	UM	2.28	5.88	0.806	1	0.195	0.411	0.03
2	SPA	4.36	4.56	1	1	0.338	0.313	0.068
3	SHW	2.84	3.04	0.806	1	0.239	0.217	0.036
4	HDA	1.88	0.76	0.694	0.658	0.188	0.061	0.003
5	FMD	1.16	1.76	0.641	0.735	0.111	0.119	0.002
6	DH	2.6	2.16	0.694	0.926	0.247	0.169	0.01
7	DEU	2.56	1.76	0.758	0.658	0.232	0.156	0.007
8	DTDRC	3.12	6.36	0.962	1	0.248	0.441	0.059
9	F	1.2	0.48	0.641	0.568	0.115	0.039	0
10	TEDC	2.16	1.92	0.694	0.781	0.18	0.147	0.006
11	G	3.56	3.84	1	1	0.291	0.261	0.068
12	PDA	1.48	0.76	0.714	0.595	0.132	0.079	0.001
13	REA	1.56	3.8	0.658	1	0.14	0.272	0.006
14	B	1.6	2.32	0.641	0.962	0.149	0.187	0.01
15	NRED	1.16	2.48	0.61	0.862	0.119	0.218	0
16	LBSE	1.36	1.2	0.694	0.595	0.128	0.143	0.003
17	TD	1.8	1.48	0.714	0.625	0.16	0.137	0.003
18	DDA	1.84	0.64	0.806	0.581	0.171	0.071	0.003
19	C	2.48	2.04	0.962	0.658	0.204	0.183	0.019
20	ISCO	2.12	2.16	0.694	0.694	0.186	0.197	0.005
21	CC	0.92	1.08	0.581	0.658	0.093	0.07	0
22	CA	1.8	0.36	0.694	0.568	0.151	0.034	0
23	DM	2.12	0.64	0.781	0.595	0.188	0.065	0.004
24	UU	3.76	0.96	0.862	0.962	0.32	0.069	0.041
25	DPFAL	1.52	0.88	0.714	0.581	0.134	0.11	0.001
26	NGDC	2.04	1.96	0.694	0.758	0.167	0.151	0.004

Survey Question 2: Each organization that uses or produce data on real estate valuation was asked the question "Which institution uses the real estate valuation data in its work ?" and network and centrality graphs were created using the data obtained from the answers to this question. Actors and data access network among actors is shown in Fig. 2.

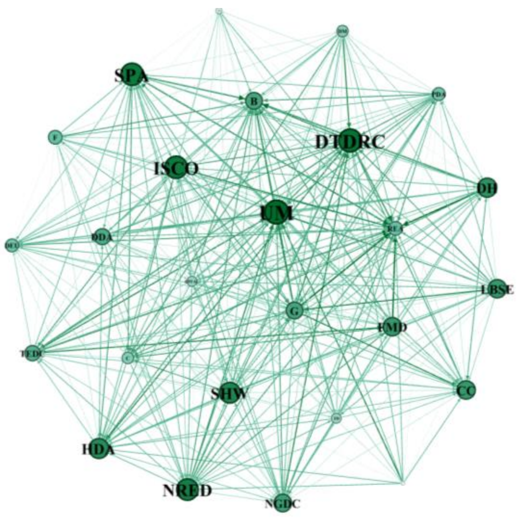

Fig. 2. Network map of actors and links between actors according to answers to the second question

Table 5. "Which institution uses the real estate valuation data in its work?" In-out degree, in-out closeness, in-out eigenvalues and between proximity values results for this question are:

No	Institutions	OutDeg	Indeg	OutClose	InClose	OutEigen	InEigen	Between
1	UM	3.92	5.24	1	1	0.225	0.278	0.03
2	SPA	4.64	3.84	1	0.926	0.255	0.216	0.019
3	SHW	3.88	3.32	0.962	0.893	0.222	0.193	0.018
4	HDA	3.48	4.48	0.833	1	0.207	0.245	0.016
5	FMD	3.96	3.12	0.926	0.833	0.225	0.183	0.007
6	DH	4.52	3.04	1	0.806	0.248	0.177	0.008
7	DEU	2.56	3.12	0.735	0.833	0.153	0.175	0.003
8	DTDRC	4.48	5.4	1	0.962	0.245	0.289	0.023
9	F	3.04	1.44	0.962	0.676	0.175	0.079	0.002
10	TEDC	3.56	3.24	0.806	0.833	0.211	0.198	0.005
11	G	4.64	3.44	0.962	0.758	0.257	0.181	0.005
12	PDA	4.28	1.88	1	0.641	0.241	0.106	0.001
13	REA	1.88	6	0.658	1	0.109	0.323	0.002
14	B	2.4	5.72	0.735	1	0.142	0.306	0.007
15	NRED	3.88	4.12	0.893	1	0.226	0.215	0.018
16	LBSE	4	2.28	1	0.781	0.23	0.126	0.006
17	TD	2.4	2.4	0.714	0.758	0.139	0.136	0.001
18	DDA	3.36	2.56	0.893	0.781	0.198	0.146	0.004
19	C	1.44	3.68	0.61	1	0.072	0.198	0.003
20	ISCO	4.56	3.84	1	0.926	0.255	0.212	0.022
21	CC	2.6	4.4	0.781	1	0.152	0.244	0.01
22	CA	1.48	1.08	0.676	0.694	0.076	0.058	0
23	DM	3.24	1.2	0.893	0.658	0.183	0.069	0
24	UU	1.84	0.76	0.625	0.694	0.1	0.042	0.001
25	DPFAL	1.88	3.08	0.641	0.862	0.106	0.17	0.002
26	NGDC	3.84	3.08	0.962	0.781	0.221	0.171	0.005

The numerical value of the frequency of public institutions meeting with each other was calculated as 415. The maximum number of bonds that can occur in the network is 650 (n (n-1) = 26.25 = 650). Based on this number of bonds, the overall density of the network was calculated as 519/650 = 0.798. For a network of 26 public institutions, this value is seen to have a density above average. 79.8% of the maximum number of ties that can occur between the actors are in the network. It can be said that the public institutions use real estate valuation studies among each other, and it is above the middle level.

Survey Question 3: Each organization that uses or produce data on real estate valuation was asked the question "Which institutions have cooperated the most to obtain the data relating to real estate valuation?". Network and centrality graphs were created using the data obtained from the answers to this question. Actors and data access network among actors is shown in Fig. 3.

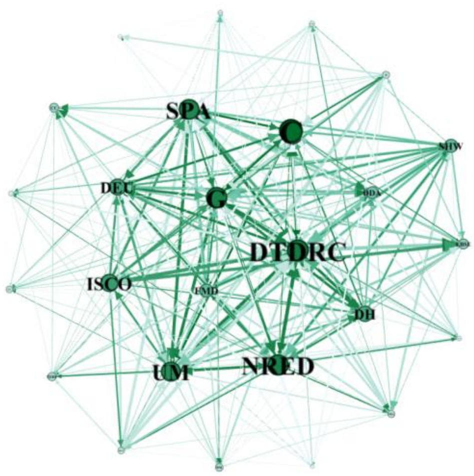

Fig. 3. Network map of actors and links between actors according to answers to the third question

Table 6. "Which institutions are cooperated with the most to obtain the data relating to real estate valuation?" in-out degree, in-out closeness, in-out eigenvalues and between proximity values results for this question are:

No	Institutions	OutDeg	Indeg	OutClose	InClose	OutEigen	InEigen	Between
1	UM	2.48	4.52	0.735	1	0.241	0.346	0.031
2	SPA	2.8	4.68	0.758	1	0.254	0.354	0.032
3	SHW	2.84	1.72	0.714	0.735	0.275	0.169	0.009
4	HDA	2.32	0.44	0.658	0.556	0.23	0.055	0.001
5	FMD	2.32	1.4	0.694	0.758	0.23	0.134	0.013
6	DH	2.4	2.28	0.714	0.833	0.241	0.222	0.02
7	DEU	2.48	3.28	0.714	0.862	0.251	0.275	0.021
8	DTDRC	2.88	5.76	0.806	1	0.265	0.422	0.046
9	F	0.68	0.72	0.581	0.625	0.068	0.073	0.004
10	TEDC	1.08	0.92	0.641	0.658	0.107	0.079	0.004
11	G	2.76	4.12	0.781	1	0.258	0.308	0.048
12	PDA	1.4	1.08	0.625	0.641	0.15	0.112	0.002
13	REA	2.36	0.68	0.714	0.556	0.234	0.048	0.002
14	B	2	0.96	0.676	0.595	0.185	0.048	0.01
15	NRED	2.4	3.4	0.833	0.926	0.229	0.295	0.061
16	LBSE	2.04	1.52	0.735	0.625	0.212	0.149	0.008
17	TD	1.64	0.24	0.625	0.556	0.172	0.022	0.001
18	DDA	2.04	1.6	0.758	0.658	0.204	0.171	0.012
19	C	1.84	3.48	0.926	0.962	0.174	0.278	0.09
20	ISCO	2.52	1.76	0.893	0.735	0.249	0.166	0.038
21	CC	1.16	1.16	0.625	0.694	0.115	0.132	0.007
22	CA	0.64	0.36	0.625	0.556	0.063	0.029	0.002
23	DM	1.08	0.6	0.694	0.595	0.109	0.072	0.003
24	UU	0.68	0.76	0.61	0.641	0.072	0.09	0.001
25	DPFAL	0.84	0.32	0.658	0.556	0.084	0.026	0.001
26	NGDC	0.76	0.68	0.595	0.625	0.083	0.053	0.001

The numerical value of the frequency of public institutions meeting with each other was calculated as 368. The maximum number of bonds that can occur in the network is 650 (n (n-1) = 26.25 = 650). Based on this number of bonds, the overall density of the network was calculated as 368/650 = 0.566. For a network of 26 public institutions, this value is seen to have a density above average. 56.6% of the maximum number of ties that can occur between the actors are in the network. For public institutions it can be said that the intensity of establishing cooperation with each other in obtaining data on real estate valuation is at a moderate level.

Survey Question 4: Each organization that uses or ***produce data on real estate valuation*** was asked the question " Which of the institutions that make real estate appraisal is trusted the most ?". Network and centrality graphs were created using the data obtained from the answers to this question. Actors and data access network among actors is shown in Fig. 4.

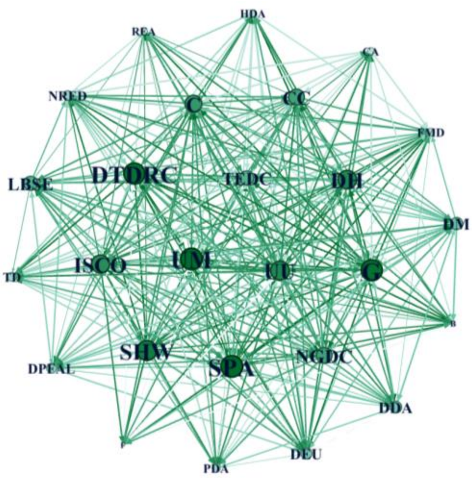

Fig. 4. Network map of actors and links between actors according to answers to the fourth question

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Table 7. "Which of the institutions that make real estate appraisal is trusted the most ?" in-out degree, in-out closeness, in-out eigenvalues and between proximity values results for this question are:

No	Institutions	OutDeg	Indeg	OutClose	InClose	OutEigen	InEigen	Between
1	UM	6.72	6.32	0.962	0.862	0.248	0.241	0.041
2	SPA	7.04	6.88	0.962	0.862	0.252	0.262	0.042
3	SHW	7.2	5.6	1	0.758	0.258	0.222	0.021
4	HDA	3.84	3.16	0.658	0.581	0.157	0.128	0.002
5	FMD	0.32	6.32	0.49	0.833	0.015	0.249	0
6	DH	8	5.12	1	0.714	0.283	0.205	0.017
7	DEU	2.16	5.16	0.658	0.714	0.092	0.209	0.003
8	DTDRC	6.04	7.04	0.926	0.862	0.231	0.273	0.074
9	F	2.04	2.88	0.581	0.568	0.086	0.115	0
10	TEDC	3.92	5.76	0.676	0.806	0.154	0.222	0.011
11	G	7.96	6.48	1	0.806	0.281	0.246	0.031
12	PDA	2.76	3.6	0.658	0.625	0.121	0.155	0.001
13	REA	1.28	3.96	0.568	0.694	0.049	0.166	0.002
14	B	0	4.88	0.25	0.758	0	0.193	0
15	NRED	2.32	5.44	0.595	0.735	0.08	0.219	0.004
16	LBSE	5.24	4.24	0.833	0.658	0.199	0.179	0.005
17	TD	3.52	3.96	0.641	0.658	0.142	0.167	0.002
18	DDA	4.28	3.88	0.735	0.658	0.186	0.163	0.003
19	C	8	4.2	1	0.658	0.283	0.175	0.013
20	ISCO	7.04	4.2	1	0.694	0.259	0.172	0.02
21	CC	6.4	4.2	0.893	0.676	0.223	0.176	0.015
22	CA	3.36	3.04	0.641	0.61	0.128	0.132	0
23	DM	5.56	3.36	0.806	0.625	0.194	0.141	0.004
24	UU	6.72	6.44	0.862	0.806	0.244	0.244	0.02
25	DPFAL	3.92	3.96	0.676	0.658	0.154	0.167	0.001
26	NGDC	8	3.56	1	0.625	0.283	0.153	0.005

The numerical value of the frequency of public institutions meeting with each other was calculated as 425. The maximum number of bonds that can occur in the network is 650 (n (n-1) = 26.25 = 650). Based on this number of bonds, the overall density of the network was calculated as 425/650 = 0.654. For a network of 26 public institutions, this value is seen to have a density above average. 65.4% of the maximum number of ties that can occur between the actors are in the network. Public institutions; It can be said that the reliability of public institutions among each other about real estate valuation is above the middle level.

Survey Question 5: Each organization that uses or produce data on real estate valuation was asked the question "Which is the guiding and responsible body to undertake the task of gathering institutional structuring under a single roof?". Network and centrality graphs were created using the data obtained from the answers to this question. Actors and data access network among actors is shown in Fig. 5.

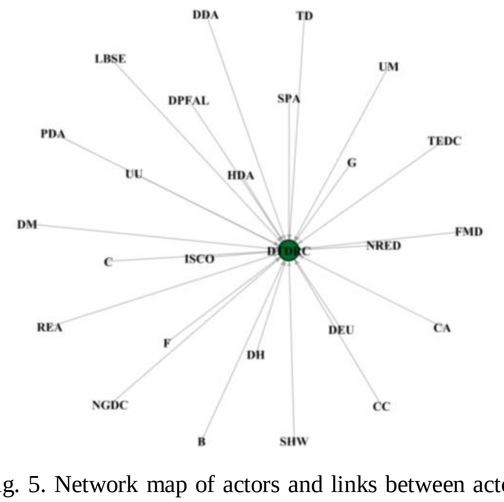

Fig. 5. Network map of actors and links between actors according to answers to the fourth question

Table 8. " Which is the guiding and responsible body to undertake the task of gathering institutional structuring under a single roof ?" in-out degree, in-out closeness, in-out eigenvalues and between proximity values results for this question are:

No	Institutions	OutDeg	Indeg	OutClo	InClos	OutEig	InEige	Betwee
1	UM	0.04	0	0.51	0.5	1	0	0
2	SPA	0.04	0	0.51	0.5	0	0	0
3	SHW	0.04	0	0.51	0.5	0	0	0
4	HDA	0.04	0	0.51	0.5	0	0	0
5	FMD	0.04	0	0.51	0.5	0	0	0
6	DH	0.04	0	0.51	0.5	0	0	0
7	DEU	0.04	0	0.51	0.5	0	0	0
8	DTDRC	0	1	0.5	1	0	-1	0
9	F	0.04	0	0.51	0.5	0	0	0
10	TEDC	0.04	0	0.51	0.5	0	0	0
11	G	0.04	0	0.51	0.5	0	0	0
12	PDA	0.04	0	0.51	0.5	0	0	0
13	REA	0.04	0	0.51	0.5	0	0	0
14	B	0.04	0	0.51	0.5	0	0	0
15	NRED	0.04	0	0.51	0.5	0	0	0
16	LBSE	0.04	0	0.51	0.5	0	0	0
17	TD	0.04	0	0.51	0.5	0	0	0
18	DDA	0.04	0	0.51	0.5	0	0	0
19	C	0.04	0	0.51	0.5	0	0	0
20	ISCO	0.04	0	0.51	0.5	0	0	0
21	CC	0.04	0	0.51	0.5	0	0	0
22	CA	0.04	0	0.51	0.5	0	0	0
23	DM	0.04	0	0.51	0.5	0	0	0
24	UU	0.04	0	0.51	0.5	0	0	0
25	DPFAL	0.04	0	0.51	0.5	0	0	0
26	NGDC	0.04	0	0.51	0.5	0	0	0

It is understood from the calculated in-degree centrality values that institution “DTDRC” is found to be the most directing and responsible institution by other institutions in the survey. On the other hand, all institutions with the lowest in the degree of centrality were determined to be the least needed institutions by other institutions.

4.2. Conclusions on the Roles of Organizations in the Network

Centrality measurements are important in determining the positions and roles of institutions in the network. In Table 2, five actor roles defined for social networks have been identified in the Social Network Analysis Criteria section. In order for the determination of roles, institutions with high values regarding degree, closeness and between centrality measurements are shown.

Star: The central actors in the network were star roles. When the degree, closeness and between chart values are considered, the institutions that are the star of the network are DTDRC, SPA, UM, REA, B and G. These institutions are also in a critical position for social networking because they have the most direct connections. The active involvement of these institutions in the network appears to play an important role in terms of network mobility.

Liaison: It connects two different groups within the social network structure and identifies discrete actors who are not included in these two groups. When the analysis of social network structures is observed/ examined, it is seen that there are not two independent groups within each other, but also there are no institutions that act as linkages and are separated from the groups.

Bridge: The role of the actor is defined as being a member of several groups and providing the connection with other groups. When the analysis of the social network structures is examined, there are no institutions in the role of bridges since there are no two or more blocks in this social network**.**

Gatekeeper: It is defined as the actor who mediates or controls the flow of information within the social network structure. It is possible to determine the intermediary institutions with the help of measurements of the centrality. When Table number? Is examined in this context, it can be seen that DTDRC, UM, C, G and SPA are gatekeeper institutions. These institutions have a high potential to control the flow of data between institutions within the network and are intermediaries of shared data. If these institutions leave the network, it may be possible to break the relationship of other institution pairs.

Isolate: It refers to those institutions that have little connection with other institutions within the social network structure. Degrees centrality table results are the analysis values that allow the identification of private institutions within the network. When the degree centrality charts are analyzed, it is seen that TD, DPFAL, CA, HAD and DM institutions have the lowest degree centeredness within the network. It is clear that these actors have low effectiveness in terms of accessing, sharing data and participating in communication within the network. In order to increase the mobility of the network, it is essential to identify the institutions in this isolated role rather than randomly increasing communication and data exchange.

5. CONCLUSION

In this study, awareness of institutions producing or using spatial data is tried to be revealed. Thus, it is aimed to contribute to the ongoing future planning process on Real Estate Appraisal. The relation between spatial data for real estate appraisal and all sectors doing business have been examined from the social side, not from the technical side. It is tried to put forward with the "social networks" the system of working together, which the institutions have created unconsciously and which do not adhere to an absolute rule. It is thought that these results and evaluations can be reflected in the whole country.
General evaluation; The overall inter-institutional assessments in connection with the characteristics of the resulting networks are summarized below:

- A large number of institutions in different fields of activity communicate with each other in the areas they need.
- The information or data requested from the institutions is not at a level that will contribute to the development of the strategy of the institution in an advanced dimension.
- The personnel of the institutions have a moderate level of awareness in terms of operating and achieving quality. However, their request for such data sharing is at the forefront.
- It can be said that there is a demand for access to information and data of some institutions, but the level and quality of this demand is generally insufficient.
- It is seen that some institutions are not in a very useful position in the network relationship and do not have any mobility to take part in the Real Estate Appraisal business.
- It can be said that the institutions are willing and conscious about consulting each other in the decision-making processes, but there is not much mutual contribution yet.
- It is understood from the survey that there are many deficiencies in the institutions regarding technological infrastructure, which is considered to be one of the essential components of Real Estate Appraisal.
- It is determined that the qualified and trained personnel in the institutions are insufficient in terms of quantity and quality. It is understood from the survey data that there are no in-service support programs in parallel with the developing technology.

As a result, the current study has made many conclusions and evaluations visible about, how real estate appraisal function is; which institutions play an active role in this matter, which institutions produce and use the most data. Therefore, it is possible to shed light on which institutions should be taken into consideration in all kinds of arrangements and initiatives for real estate appraisal.

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Research Article

TEMPORAL MONITORING OF LAND USE/LAND COVER CHANGE IN KAHRAMANMARAS CITY CENTER

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ABSTRACT

Irregular urbanization causes problems such as decrease in fertile agricultural areas, irregular industrialization and urbanization. To provide a healthier life opportunity for future generations without disturbing nature, it is essential to determine the temporal changes in land use and to make land management plans accordingly. In this study, land use/land cover (LULC) change occurred in Kahramanmaras province within 30 years was investigated by remote sensing and integration of Geographic Information Systems. Landsat satellite images of 1988-1998-2008-2018 were obtained for the production of LULC maps. Each image was classified according to supervised classification approach using the support vector machines (SVMs) algorithms. The confusion matrix was created for each year to examine the accuracy of the LULC maps. The overall accuracy of the thematic maps was obtained as 91.76%, 93.56%, 86.89% and 88.29%, respectively. Also, Kappa values of thematic maps for each year were obtained as 0.88, 0.91, 0.81 and 0.84, respectively. When the results were examined, the development of industry in the city area and the construction of the airport contributed to the development of the social and economic structure of the city. The increase in the number of housing in the related regions has led to an increase in the amount of urban areas and a decrease in agricultural areas.

Keywords: *Change detection, Support vector machines, Land use, Land cover, Kahramanmaras,*

1. INTRODUCTION

Urbanization covers the processes from the first periods of humanity to the transition to settled life (Tok, 2006). Humans need to fulfill their basic needs to survive on Earth. To supply these requirements, they have carried out land-use activities. Over time, population growth slowed down in rural areas and the population increased rapidly in urban areas (Işık,2006). The increase in urban population is caused by factors such as the attractiveness of the city's opportunities, the search for a job, the desire of parents to prepare a better future for their children, the expectation of benefiting from quality education and health opportunities, the feeling of being safer in the city, migration and industrialization (Başel, 2011).

As a result of uncontrolled developments in urban area, many problems arise such as the use of productive agricultural lands in industrial activities and the establishment of settlements on unsuitable lands (Ercan, 2020). To ensure regular development in cities, unplanned construction on land should be prevented, temporal changes in land use should be determined and necessary land use planning should be made (Denizdurduran, 2012). In order to supply the needs of the rapidly increasing urban population, rapid and reliable geographic information about the cities is needed. In this respect, remote sensing offers sufficient advantages for the production of data required for controlled planning in cities by means of data servers and analysis methods (İderman, 2006).

It is important to identify the existing land use/land cover (LULC) of cities for successful urban planning. Although LULC is obtained through traditional inventories or surveys, satellite remote sensing saves time and costs in determining the geographical distribution of temporal changes in LULC on a regional scale. Satellite image analysis provides an effective way to learn about the temporal trends and spatial distribution of urban areas needed to understand land change, model the current situation and prepare future projections (Yuan et al., 2005). Monitoring of temporal LULC in urban areas is possible by temporal analysis of satellite images (Hegazy, 2015; Leichtle, 2017; Jimoh et al., 2018; Goksel and Doğru 2019; Orhan et al., 2019). Different classification algorithms such as can be used in the supervised classification of images for selected periods (Otukei and Blaschke 2010; Karakuş et al., 2017; Göksel, 2018;). The Support Vector Machines (SVMs), one of these algorithms, uses optimization algorithms to find the optimal boundaries between classes. These boundaries ensure that unstable pixels are assigned to the correct classes (Üstüner et al., 2013; Demirkan, 2017). Since SVM has been shown to have a successful classification algorithm in many studies (Mondal et. al.,2012; Kumar et. al., 2015; Thanh and Kappas, 2018), it has been preferred in this study.

In this study, it is aimed to determine the LULC change occurring in 30 years in Kahramanmaraş by using satellite images. Landsat 5 TM (Thematic Mapper) and Landsat 8 OLI (Operational Land Imager) images were used to achieve this goal (Table 1). SVMs algorithm was used in the production of LULC classes for each year. By comparing the generated LULC maps, the change in the urban area was analyzed.

2. STUDY AREA AND DATA SET

Kahramanmaraş, that was selected as the study area, is located at 37° 34' 31" latitude and 36° 55' 22" longitude locations. Kahramanmaraş is located at the junction of the Mediterranean Region, Eastern Anatolia Region and Southeastern Anatolia Region. Due to its location, it has been influenced by three different climates and has enabled many different types of fruits, vegetables and plants to be grown (Geography of Kahramanmaraş, URL1).

The study area covers 321.84 km^2 and covers the city center and its surroundings (Fig. 1). The study area includes a wide range of LULC classes such as artificial surfaces, wetlands, cultivated agriculture, uncultivated agriculture, industrial area, forest, bare soil-rocky area.

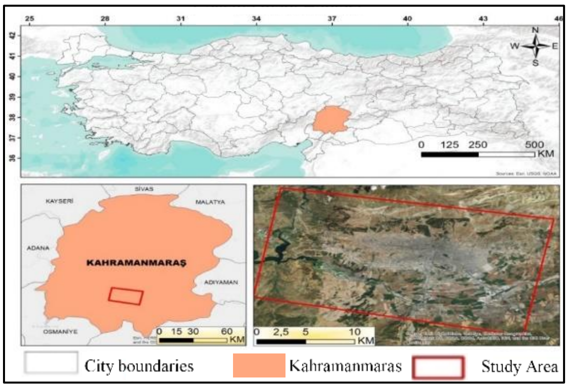

Fig. 1. Study area, red boundary indicates application area.

According to the number of population, Kahramanmaraş is the eighteenth largest city in Turkey. In the mid-1980s, migration from rural to urban areas started in parallel with the developments in the industry. After this period, there was a rapid increase in settlements in the city (Sandal and Karademir, 2013). In this study, the general city center change of Kahramanmaraş province has been examined since the industrialization period has increased. In order to reveal the general change, the temporal analysis was carried out in 10-year periods. Landsat images, free satellite images provided by the US government, were used to determine the 30-year changes in the study area. The research area was examined in four periods as 1988, 1998, 2008 and 2018. When the images were selected for analysis, Attention was paid to ensure that the images are close-dated and cloudless. LULC maps were generated for each period using multispectral bands common to both Landsat 5 and Landsat 8 images (Table 1).

Table 1. Spectral bands used in the classification process and image dates

Bands	Wavelength	Spatial resolution
Blue	0.45-0.52	30
Green	0.52-0.60	30
Red	0.63-0.69	30
Near Infrared	0.76-0.90	30
Shortwave Infrared -I	1.55-1.75	30
Shortwave Infrared -II	2.08-2.35	30
Table 1. Cont.		

(Table 1. Cont.) Images Date and Satellite Names			
15.07.1988 (Landsat 5)	27.07.1998 (Landsat 5)	22.07.2008 (Landsat 5)	18.07.2018 (Landsat 8)

3. METHOD

Each object on the Earth has spectral properties. The grouping of objects with the same spectral properties in satellite images is called classification (Oruc et al., 2007). It is classified under two headings as supervised and unsupervised classification. Unsupervised classification is generally the preferred method when there is no prior knowledge of the terrain. In this method, spectral classes of pixels with the same properties are created. (Çölkesen, 2009; Kavzoğlu and Çölkesen, 2010). In supervised classification, signature files are created for the objects to be subjected to the classification process, taking into account the sample regions on the Earth. According to this signature file, each pixel in the image is assigned to the class in which it is most similar (Ekercin, 2007). In this study, SVMs, which is one of the supervised classification methods, is preferred (Vapnik, 1995). SVMs are a learning method in the field of statistical learning theory. SVMs are based on finding the maximum separation boundary in different samples by transferring non-linear sample space to a high dimension where samples can be separated linearly (Demirci, 2007; Eray, 2008).

SVMs are a classification algorithm frequently used in the classification process in the field of remote sensing in recent years (Mondal et. al., 2012; Kumar et. al., 2015; Thanh and Kappas, 2018). The main advantage of this method is that it can easily generalize high-dimensional data with few training data. SVM works with pixels at the boundaries of classes called support vectors, so it is possible to obtain accurate classification with the small training set. DVMs use kernel functions for separate classes in complex datasets to identify hyperplanes with non-linear mapping operations. Generally, linear, polynomial, radial basis function (RBF) and sigmoid kernels functions are used in the classification of remote sensing images. Comparing the classification success of these four functions, it was observed that RBF kennel function given better results than others. In this study, images belonging to different years were classified using the RBF kernel function (Kavzoğlu and Cölkesen, 2009; Yang et al. 2011; Esetlili et al. 2018).

The workflow of determining the temporal change at Kahramanmaraş city center was shown in Fig. 2. First of all, Landsat 5 and Landsat 8 images of the related years were obtained. LULC classes were determined in the study area and training data were collected. According to the training data, classification process was performed with SVM algorithm for each year. In order to test the accuracy of the obtained LULC maps, 256 random points were placed in the study area. The error matrix was generated by these points and the classification accuracy was calculated. In the last stage of the study, the change of land use classes according to artificial surfaces was determined between the selected years.

Accuracy assessment was performed using error matrix (Table 2). In Table 2, the rows represent the classification values while the columns represent the reference values. $n_{i.}$ value is defined by the $\sum_{j=1}^{k} n_{ij}$ equation, while $n_{.j}$ is defined by the $\sum_{i=1}^{k} n_{ij}$ equation. Using error matrix, User's Accuracy (Eq. 1), Producer's Accuracy (Eq. 2), Overall accuracy (Eq. 3) and Kappa statistics (Eq. 4) were calculated for each LULC maps (Cohen, 1960; Congalton and Green, 1999; Jenness and Wynne, 2005).

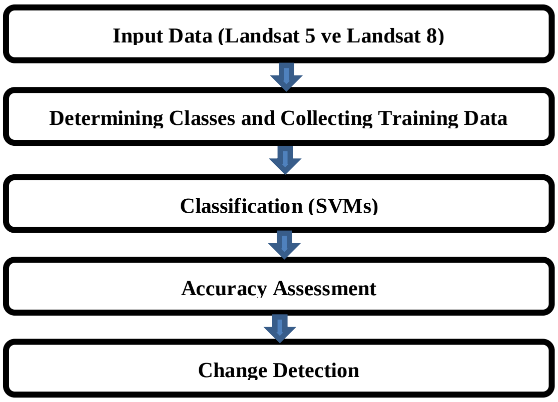

Fig 2. The workflow in Kahramanmaras city center temporal analysis

Table 2. Theoretical representation of the error matrix (Jenness and Wynne, 2005)

Classification Data	Reference Data: j_1	j_2	j_k	$n_{i.}$
i_1	n_{11}	n_{12}	n_{1k}	$n_{1.}$
i_2	n_{21}	n_{22}	n_{2k}	$n_{2.}$
i_k	n_{k1}	n_{k2}	n_{kk}	$n_{k.}$
$n_{.j}$	$n_{.1}$	$n_{.2}$	$n_{.k}$	$n_{..}= n$

$$User's\ Accuracy = \frac{n_{ii}}{n_{i.}} \quad (1)$$

$$Producer's\ Accuracy = \frac{n_{jj}}{n_{.j}} \quad (2)$$

$$Overall\ Accuracy = \frac{\sum_{i=1}^{k} n_{ii}}{n} \quad (3)$$

$$Kappa = \frac{n\sum_{i=1}^{k} n_{ii} - \sum_{i=1}^{k} n_{i.}n_{.i}}{n^2 - \sum_{i=1}^{k} n_{i.}n_{.i}} \quad (4)$$

The explanations of the values given in the equations are as follows (Cohen, 1960;Congalton and Green, 1999; Jenness and Wynne, 2005).

- k: the number of ROWS in the error matrix,
- n_{ii}: i th row and i th column element of the error matrix,
- n_{jj}: j th row and j th column element of the error matrix,
- $n_{i.}$: Sum of the i th row elements of the error matrix,
- $n_{.i}$: Sum of the i th column elements of the error matrix

4. RESULT AND DISCUSSION

In this study, LULC change of Kahramanmaraş city center from 1988 to 2018 was observed at 10-year intervals. Satellite images for each year were classified into seven classes that were artificial surfaces (asphalt roads, building) wetlands, cultivated agriculture, uncultivated agriculture, industrial area, forest, bare soil-rocky area (Fig. 3).

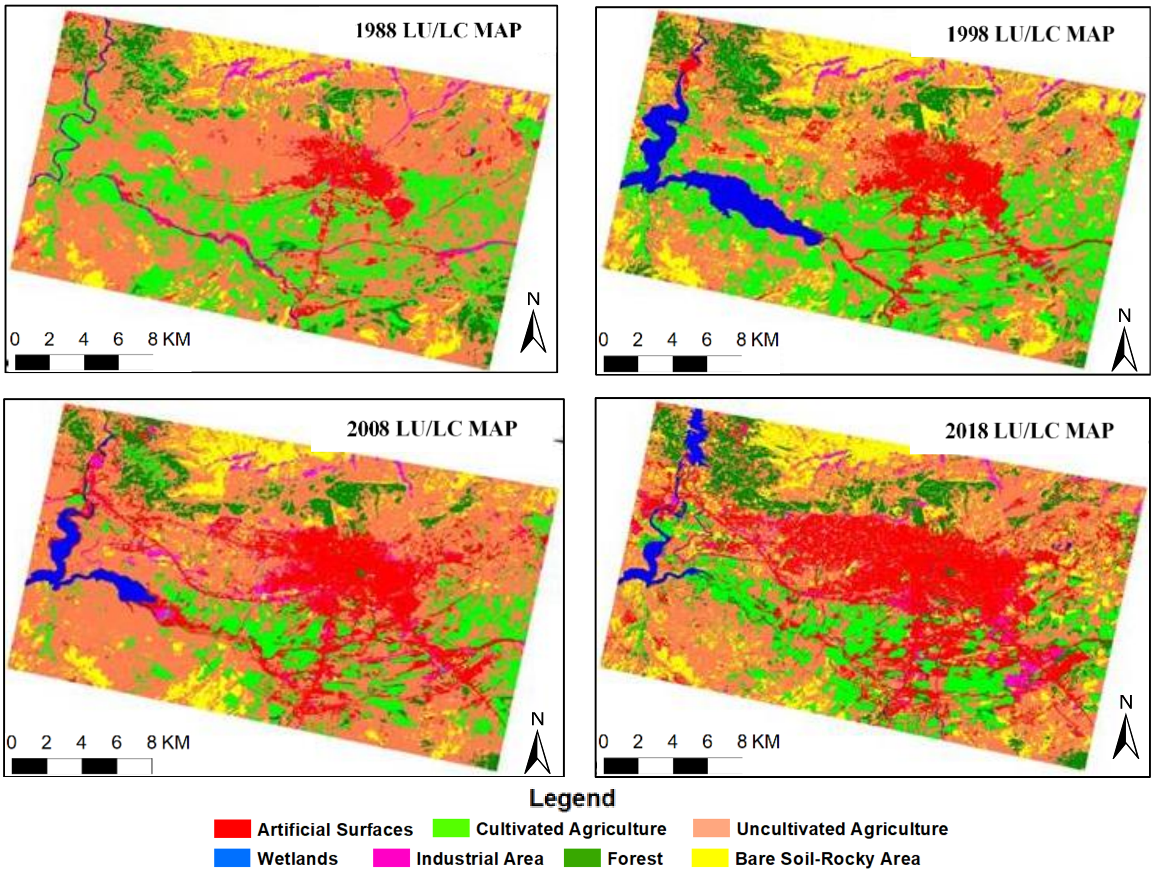

Fig. 3. Land use and land cover maps for each year

Accuracy analysis was performed on the LULC maps obtained after classification. During the accuracy analysis, 256 random points were generated. Reference class values and predicted values obtained by classification are assigned to the points. To determine the accuracy of the classification, Producer's Accuracy (P.A.), User's Accuracy (U.A.), kappa coefficient and overall accuracy values were calculated for each year over the error matrix (Table 3). According to accuracy results, the overall accuracy of the thematic maps was obtained 91.76%, 93.56%, 86.89% and 88.29%, respectively. Also, Kappa values for each year were obtained as 0.88, 0.91, 0.81 and 0.84, respectively.

Table 3. Accuracy analysis results of the produced LULC maps for each year

LU/LC Classes	1988		1998		2008		2018	
	U.A.	**P.A.**	**U.A.**	**P.A.**	**U.A.**	**P.A.**	**U.A.**	**P.A.**
Wetlands	87.80	100	72.41	95.45	100	100	100	100
Bare Soil-Rocky Area	68.42	76.47	100	66.67	68.42	81.25	56.00	87.50
Uncultivated Agriculture	96.26	89.57	96.30	89.66	87.79	92.23	96.43	81.82
Industrial Area	66.67	100	100	97.87	71.43	71.43	100	100
Artificial Surface	100	100	100	93.75	87.50	84.85	88.10	97.37
Forest Area	100	93.33	100	100	83.33	76.92	85.00	100
Cultivated Agriculture	87.80	100	90.00	100	95.83	79.31	91.30	87.50
Overall Accuracy	91.76		93.56		86.89		88.29	
Kappa	0.88		0.91		0.81		0.84	

The area information for each class was calculated in hectares (ha) and the results are given in Table 4. Agricultural areas are presented as total of cultivated and non-cultivated agricultural areas. Considering the Table 4, wetlands were 133.92 hectares in 1988. After the Sır dam started to operate in 1991, wetlands increased by 1323.63 hectares in the first ten-year period. When the second and third ten-year periods were examined, a decrease of 851.31 hectares and 23.31 hectares was observed in wetlands, respectively. In the thirty-year period there has been a decrease of 7204.9 hectares of agricultural land. An increase of 500 hectares in forest areas and 4867.4 hectares in artificial surfaces have been observed. Also, industrial areas increased 35.3 hectares.

Table 4. Area of LULC classes for each year.

LU/LC Classes	1988 (ha)	1998 (ha)	2008 (ha)	2018 (ha)
Wetlands	133.9	1457.5	606.2	582.9
Bare Soil-Rocky Area	2565.1	4726.71	2916.1	3618.5
Agriculture Area	25142.2	20115.1	20579.7	17937.3
Industrial Area	752.9	425.6	965.5	788.2
Artificial Surface	1899.2	3090.9	5090.2	6766.6
Forest	1690.7	2368.4	2026.5	2190.4

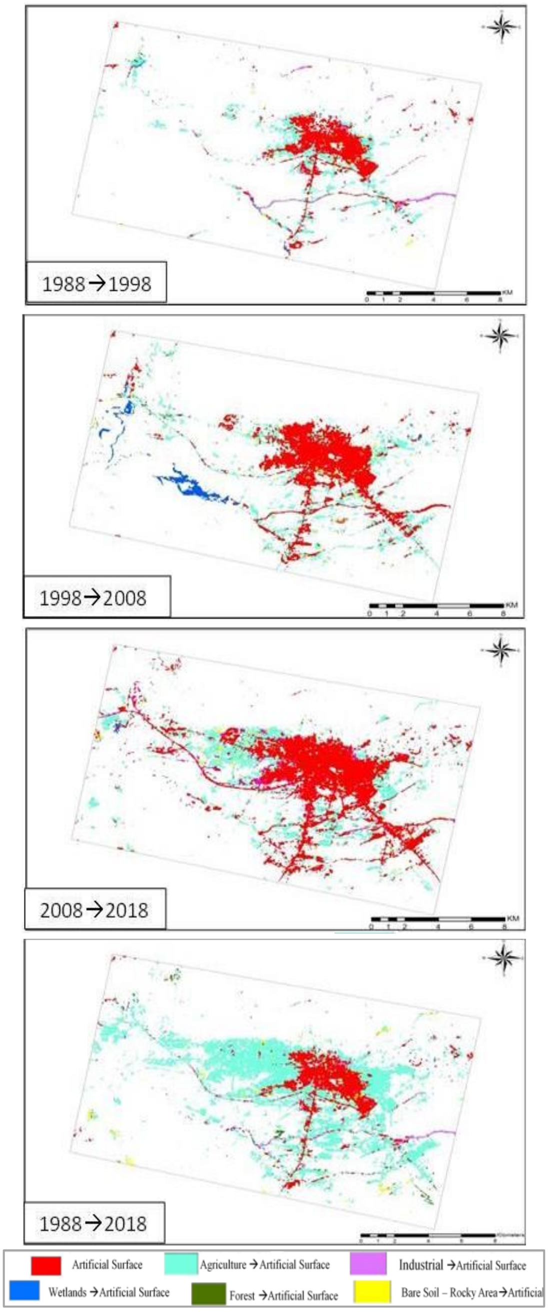

Fig. 4. LULC change detection maps from 1988 to 2018

Scope of the study, in addition to the 30-year change between 1988 and 2018, change maps were prepared in 4 different periods (Fig.4). When the change map from 1988 to 2018 is analyzed, it is seen that the city shows great development, especially in the West direction. It can also be said that there is a considerable expansion in the East and South-East direction. It can be seen that artificial surfaces caused a great decrease in agricultural areas. In parallel with the expansion of the city area, it is seen that a large amount of agricultural land has disappeared.

Population data from the Turkey Statistics Institute (TUIK) was obtained to demonstrate the relationship between population growth and urban development (TUIK: URL-2). The relationship between population and urban area expansion was given in Fig. 5. When the figure is examined, it is seen that artificial surfaces increase in parallel with the increase in the urban population.

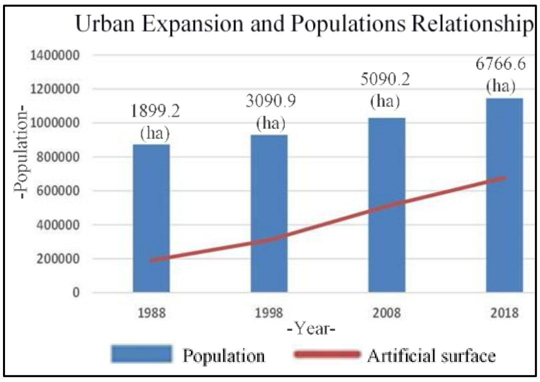

Fig. 5. The relationship between population and artificial surfaces

The speed and direction of urban development are essential in terms of future city planning. In this study, changes occurring in the 30 years in Kahramanmaraş were investigated with Remote Sensing techniques. One of the most important results occurring in the region between the years 1988-2018 is the decrease in the agricultural areas, while the increase in the residential areas is observed regularly. Due to the continuous increase in the population of Kahramanmaraş, agricultural areas are destroyed. The continuous decrease of these agricultural areas may interpret that the city has been converted into urban areas to meet the settlement needs. As a result of this transformation, it has been clearly observed that agricultural areas are used irregularly and land management plans for these areas should be made.

5. CONCLUSION

In this study, the temporal change of LULC classes of Kahramanmaraş city center was investigated. Accordingly, Landsat satellite images were used in 10-year periods between 1988 and 2018. Satellite images for each year was classified by the SVMs algorithm. The direction and amount of urban development is revealed through the obtained maps. In this context, the artificial surfaces in Kahramanmaraş city center have increased by 304% in the 30-year period. While this increase was realized, especially a large amount of agricultural land disappeared. When the growth in the artificial surfaces is compared with the population data, it is seen that the urban areas increase with the increase in the population.

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