BAŞKENT UNIVERSITY
INSTITUTE OF SCIENCE AND ENGINEERING

ENVIRONMENTAL POLLUTION AND COST EFFICIENT EQUIPMENT SELECTION IN CEMENT FACTORIES

ÇİMENTO FABRİKALARINDA ÇEVRE KİRLİLİĞİ VE MALİYET AZALTICI EKİPMAN SEÇİMİ

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1. Kaynakça hariç
2. Alıntılar hariç
3. Beş (5) kelimeden daha az örtüşme içeren metin kısımları hariç

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ABSTRACT

ENVIRONMENTAL POLLUTION AND COST EFFICIENT EQUIPMENT SELECTION IN CEMENT FACTORIES

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In this study, it is aimed to be able to select the technological equipment to minimize the dust particles and various harmful gases released during the cement production process. "TOPSIS Method" is used as a method to carry out the work. The data used in the method are taken from the dust removal system reports of 6 different cement factories active in Turkey. The clinker production capacities of the factories are identical to each other; but the dust removal systems that they use are technically different. There are two types of dust elimination systems that are commonly used. These; electro static and dust (bag) filter. The working principles of both filters are different from dust holding capacities, environmentally harmful gas emissions and investment costs. With the result of the topsis method used in this study, the cement factory aimed to reach investors in terms of cost and environmental sensitivity while making technological equipment selection.

KEY WORDS: cement factories, environmental pollution, topsis method, optimization, cost efficiency, cement production

Supervisor: Prof. Berna Dengiz, Başkent University, Department of Industrial Engineering.

ÖZ

ÇİMENTO FABRİKALARINDA ÇEVRE KİRLİLİĞİ VE MALİYET AZALTICI EKİPMAN SEÇİMİ

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Bu çalışmada, çimento üretim sürecinde etrafa salınan toz partikülleri ve çeşitli zararlı gazları minimize edecek teknolojik ekipman seçimi yapılabilmesi amaçlanmıştır. Çalışmayı sonuca taşıyacak yöntem olarak da "TOPSIS Metodu" kullanılmuştır. Metotta kullanılan veriler, Türkiye'de aktif üretim yapan 6 ayrı çimento fabrikasının tozsuzlaştırma sistem raporlarından alınmıştır. Veri alınan fabrikaların klinker üretim kapasiteleri birbirleriyle aynıdır; ancak kullandıkları tozsuzlaştırma sistemleri farklıdır. Yaygın olarak kullanılan iki tür tozsuzlaştırma sistemi vardır. Bunlar; elektro ve torbalı filtredir. Her iki filtrenin çalışma prensipleri toz tutma kapasiteleri, çevreye zararlı gaz salınımları ve yatırım maliyetleri birbirlerinden farklıdır. Bu çalışmada kullanılan topsis yönteminden çıkan sonuçla, çimento fabrikası yatırımcılarını teknolojik ekipman seçimi yaparken maliyet ve çevreye duyarlılık açısından optimumum sonuca ulaştırmayı amaçlamıştır.

ANAHTAR SÖZCÜKLER: çimento fabrikaları, çevre kirliliği, topsis yöntemi, optimizasyon, maliyet verimliliği, çimento üretimi
Danışman: Prof. Berna Dengiz, Başkent Üniversitesi, Endüstri Mühendisliği Bölümü.

CONTENTS Page

FIGURES LIST

TABLE LIST

Page

SYMBOLS VE ABBREVIATIONS LIST

A-	Negative Ideal Solution
A*	PositiveIdeal Solution
Al	Aluminium
C*	AbsoluteIdeal Solution
Ca	Calcium
CO	CarbonOxides
Cr	Chromium
D	Distance
EU	European Union
Fe	Iron
K	Potassium
Mg	Magnesium
NO	Nitrogen Oxides
P	The Variable
S*	Ideal Distance
SO	Sulfur Oxides
TS	Turkish Standards
V	The Weighted Normalized Matrix
W	Weights
X	Variable value

BAT	Best Available Technologies
BREF	BAT reference documents
CAP	Common Agricultural Policy
CIEU	The Cement Industrial Employers' Union
EIA	Environmental Impact Assesment
EPA	Environmental Protection Agency
EPD	Environmental Protection Departmant
IARC	The International Agency for Research on Cancer
LCA	Life Cycle Analysis

MoEF	Ministry of Environment and Forest
SNCR	Selective Non Catalystic Number Reduction Combination
TÇMB	The Turkish Cement Manufacturers' Association
TOPSIS	Technique for Order Preference by Similarity to Ideal Solution
WHO	The World Health Organization

1. INTRODUCTION

The presence of internal migration from the villages to the metropoles indicates that the urbanization will continue at a rapid pace. Urbanization is not only a population movement but also it triggers the big changes in the social and economic sphere in the society. Moreover, with these big alterations the construction of industrial facilities has become a priority in order to meet the urbanization needs. It is the cement plant which is one of the industrial structures that is the issue of my research. In Turkey, there are 70 cement factories, including 52 integrated facilities and 18 grinding as well as packaging facilities. The sector provides about 15 thousand employees [1]. Although these facilities have a proactive role in the national development, it may bring some environmental problems on the surface. Carbon emissions into the atmosphere during the burning of fossil fuels in industrial facilities have caused human health problems and other environmental problems [2].

The annual coal requirement of cement factories is around 6 million tons [3] and trying to meet the increasing demands for cement needs more coal as well as it creates environmental fatal consequences. It is predicted that in 2023, cement production will reach 99.8 million tons as infrastructure and construction activities will continue to increase cement demand. Unfortunately, due to the fact of the cement necessities has on rise toxic, heavy metals that particles carry has also increase. Moreover, released gases emitted from chimneys contains nitrogen oxides, sulphur oxides and carbon dioxide. When all these pollutant gas emissions come together, deterioration of both human health and environment occurred. Some filtration technologies like dust and electrostatic filter can be effectively used to remove dust from dusty gases so diminish the deterioration levels.

In this study, it is aimed to be able to select the technological equipment to minimize the dust particles and various harmful gases released during the cement production process. "TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) Method" is used as a method to carry out the work.

2. CEMENT

Cement is one of the most important industrial inputs of a country and is a critical product for hundreds of thousands of constructions projects. Cement is an important component of concrete and a binding material used to hold a concrete mixture together. Concrete mixture consists of sand, gravel, brick, briquettes etc.)

Although cement industry is the realm of high concentration of energy consumption and various gas releases, they have a contribution in economic development of a country. Concrete used in the construction of houses, roads, dams, airports, bridges and thousands of other infrastructural facilities cannot be considered without cement. Cement, which is the building material of modern civilization.

The cement word used today is derived from the word "caementum" which is meaningfully carved stone in Latin. Although the materials such as lime and gypsum were used as binding materials since the fire was found, the first reinforced concrete structure was built in 1852. Ancient Greeks and Romans realized the hydraulic properties of mixtures of "lime" and "puzolan" [4].

While cement is mainly defined as a hydraulic binder material obtained by grinding natural limestone stones and clay mixture after they are heated at high temperature, the definition in TS EN 197-1 Standard; "The cement is in the form of inorganic and finely milled, hydraulic binder which, when mixed with water, forms a settling and hardening paste due to hydration reactions and processes and protects its stability and stability even under water after curing" [5].

Generally, the diameter of the cement pellets is between 1 and 100 microns [5]. The cement is called hydraulic binder since it gains the binding action after entering the reaction with water. The proportions of alkaline and hydraulic items determine the nature of the binder.

The main component of cement is clinker and clinker is mainly composed of limestone (limestone), clay, marl and iron ore. 27 different types of cement are produced in five main cement types by adding gypsum and puzzolonic materials (blast furnace slag, fly ash, andesite, and similar additives) to the clinker.

2.1. Cement Production Process

Cement consist of limestone, clay, iron ores, and sand. These materials brought from the mines are crushed in the crushers, milled on the mill. Then the classified raw materials are classified to be mixed to obtain a homogeneous mixture (mixture called farin). Raw material reduced to the desired size in the mills are baked in rotary kilns until they become incandescent at 1400-1500 ° C [6]. The semifinished product from the furnace is called clinker. As a result of grinding the clinker with a mixture of gypsum, cement is obtained.

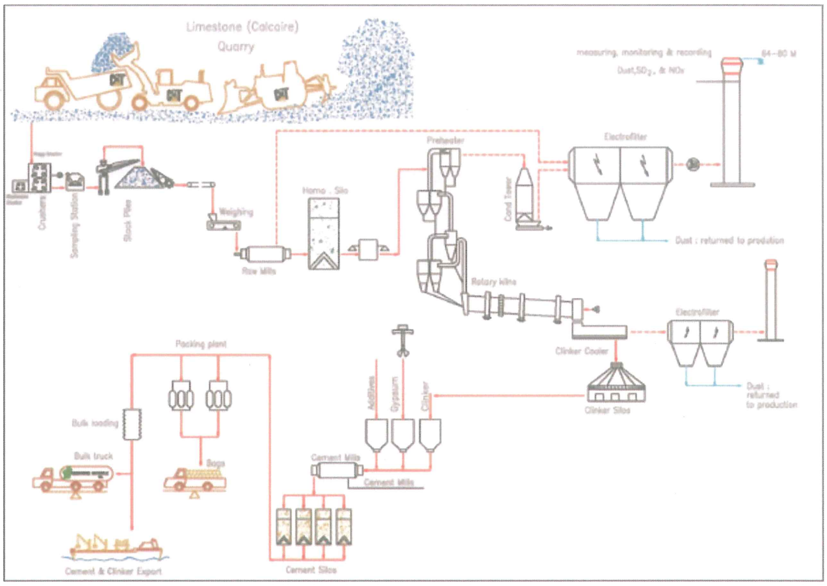

Figure 2.1 Cement production process [7]

1) Various raw materials extracted from blast furnaces by blasting are transported to crushers (crusher) for breaking by loading on conveying means.

2) Crushed raw materials in crushers are stocked separately.

3) Raw materials taken from the stocks are mixed at certain ratios and milled in the farina mills.

4) The mixture which is named Farin is stocked in farin silos to be cooked.

5) The farin, which is passed through the preheaters and sent to the rotary kiln, is cooked at about 1400-1450 degrees.

6) The melted hot material poured out of the rotary kiln and cooled down becomes semi-finished when it goes out without cooling. This material is called clinker and the clinker is stocked in the stockhole. Gypsum is ground in the cement mills with the admixtures of gypsum and the type of cement to be produced.

7) According to the types of cement, it is offered for sale as cement, baggy and bulk cement stocked in separate silos.

2.2. Turkish Cement Industry

The first cement factory of our country was established in 1911 in Darıca with a capacity of 20.000 tons [3]. Following the establishment of this plant, in 1912, Eskihisar Cement Factory was taken into operation. With the foundation of the Republic, new factories have been put in place, thus importing to meet the increasing demand for cement on the one hand while increasing production on the other.

Nowadays, the sector uses completely domestic resources in terms of raw materials and it can meet the cement requirement of our country by its production [3]. The Turkish cement sector, which produces cost-cutting modernization investments and complying with EU norms, is a sector that has entered the growth trend with the construction sector as it concentrates on urban transformation projects in our country.

The cement sector is one of the most important industrial sectors in Turkey. Production at high rates and consequently the use of fossil fuels in large quantities brings with it large dust emissions and hence air pollution.

The chemical compositions of the inputs and outputs used in the production of cement, the use of solid wastes as alternative fuel, the chemical compositions of the cement powders before and after the dust holders, the distillation systems used for the separation of the dust, the main dust sources in the cement plants. And rotary kiln flue gases will be useful for measures taken in the name of environmental sensitivity during cement production.

To realize cement production in Turkey, the annual coal requirement of cement factories is around 6 million tons [3]. Efforts are being made to spread the use of various solid wastes as alternative fuels in order to reduce the harm they give to the environment.

In the cement industry, for the waste to be used as an alternative fuel and for the emissions of the flue gas to be generated as a result of the use, the flue gas emissions should be below the emission limit values by making trial burning according to the principles of "Communiqué on General Rules to be Complied in the Use of Waste as Additional Fuel" dated 22.06.2005 It is necessary to obtain a license.

Figure 2.2 Turkish cement factories [8]

In the Turkish cement sector, there are a total of 70 cement factories, including 52 integrated facilities and 18 grinding and packaging facilities. The sector provides about 15 thousand employees [1]. The total cost of the sector is 38% fuel and 21% electricity.

In addition to having a relatively high level of energy yachts domestically, the fact that Iran is in advantageous position from the important competitors limits the competitiveness of the Turkish cement sector. Achieving full energy is not developed in the Turkish cement sector. While the energy rate obtained from Europe is around 30%, this rate is 3% in Turkey.

2.3. Worldwide Cement Industry

In recent years, cement production, which has maintained its upward trend in emerging countries has declined due to the weakness in the construction sector in EU economies, which have yet to overcome the effects of the global crisis. In the United States, which performs better than other developed economies, cement sector tends to grow.

China is in the first place in cement production, where infrastructure spending is of great importance in economic growth. China has achieved 1.6 cents of total cement urea min. In the 20th century of the US only in the period 2012-2014. India is another country with a high population reaching 300 million tons in 2010-2014 with an average annual growth rate of 8.1%. Cement production in India, another country with a high population, Brazil and Turkey are among the important producers of the sector. Brazil, the fifth largest breeder in the world, is thought to be a captain in Turkey due to its economic growth performance, which is expected to continue its weak course in the coming years. On the other hand, it is estimated that Iran, which cannot provide reliable data on the amount of cement production, has a production close to that of Turkey.

2.4. Turkish Institutions In The Cement Sector

There are two main companies operating in the cement sector. The Cement Industrial Employers' Union (CIEU), which mainly operates in the field of industrial relations from these establishments. The Institution has 58 member cement factories and responsible for protecting and developing their common economic and social rights and interests within the framework of existing legislation, providing mutual assistance among them, helping the establishments established and being established in the business line to work efficiently and harmoniously, representing its members, concluding collective bargaining agreements, and creating a safe working environment.

The Turkish Cement Manufacturers' Association (TÇMB), which is another roofing organization of the sector, mainly operates in technical fields and operates in the sector. TÇMB, which represents a total of 67 establishments, 49 of which are integrated and 18 of which are grinding plants in Turkey, provides solutions to the sectoral problems with better quality product, more efficient service understanding and social, environmental, legal and ethical values of the Turkish cement sector a non-governmental organization founded in 1957 with the aim of finding an association.

2.5. Cement and Environment

The cement sector is included in the category of very dangerous class of cement manufacturing (Code 23.51.01) in the Communiqué on Workplace Hazard Classes Concerning Occupational Health and Safety, which was published in the Official Newspaper dated 26.12.2012 and numbered 28509 [6].For this reason, there is significant occupational health and safety hazards in the production process. Because of the products produced and the raw materials used, "dust" in the production of cement comes out as one of the important problems. This problem arises at various points in the production chain, which requires measures in the sense of both the environment and occupational health and safety. According to this, in the cement production, the powder is to be transported from the raw material to the trucks to start from the raw material quarries, to be broken in the crusher to reduce the raw material to the desired dimensions, to be stored in the silos, to be crushed in the farin mills, baked in the oven, to be sold in the cement mills together with clinker, is spreading to the working environment and surrounding area. These powders are raw materials, farin, coal, clinker, gypsum, additives, cement powders and ground coal dust used in rotary kiln or drying processes. These dusts can cause health problems. Apart from the aforementioned sources, there may also be dust problems in the cement factories where materials are transported and unloaded.

Figure 2.3 Cement factory in Turkey

2.6. Cement Plants and Air Pollution

Almost all of the relevant academic studies, articles and sectoral informations for the last five years have been shown that the cement industry is responsible for 10% of the annual CO2 emissions in Turkey. When gas emissions combined with the dust emission, it triggers detrimental consequences. Especially, small particles (PM10 and PM 2,5) released from cement factory floors and polluting the air cause diseases and deaths [9]. As the amount of particles increases, disease and deaths also increase. The diameter of the particles is related to the health effect. These contaminating particles can be even more dangerous because they carry toxic and cancer-causing heavy metals. Those with particle diameters smaller than 10 micrometres cause more health problems because they can breathe to the lungs. Since small particles adversely affect health even at very low concentrations, it is intended to keep the amount of small particles in the air as low as possible [9].

WHO; the World Health Organization (WHO) reported that 7 million premature deaths in 2012 (one out of every eight deaths) were associated with air pollution, which they identified as the most important environmental risk [9]. Numerous scientific studies have shown the relationship between air pollution and sickness and death. Air pollution, especially respiratory and circulatory system is affected. Air pollution threatens life by not adversely affecting human health but negatively affecting all living things and ecosystems. In the history of the world, the experiences of air pollution, which cause thousands of people to lose their lives, still maintain their freshness in memory.

The chromium concentrations of airborne particles in the Büyükçekmece lake basin are well above the limit values. The cement factory is also shown as a source of chrome which is concentrated in this region. The study takes into account the pollutant effect of the plant, which is remote from the cement factory, which is the most important source of atmospheric chromium, showing that it affects the Büyükçekmece lake drinking water basin and causes the chromium transport to the basin [10].

Sulfur oxides and nitrogen oxides, the emissions of cement plants, react with water and other components to form acidic components. These acidic components are the basic component of acid rain. Briefly; cement plant emissions cause acid rain. Acid rain also damages whole nature and destroys forests [11].

Dust is an important component of air pollution and at very low levels it causes health problems [11]. The most important dusts originating from the cement production process, both dusty and end product are spread around the environment, which is used in raw materials, dust, farina powder, coal dust, clinker dust, gypsum powder, additive powder, cement powder, rotary kiln or drying [11].

Figure 2.4 Cement plant and air pollution [11]

The auditing report of the 55 cement factories operating in 44 provinces by the Labor Inspection Board of the Ministry of Labor and Social Security in 2006 is worthy of showing dust effect. According to the report; 18.1% of the workplaces did not measure dust, and 27.3% did not measure personal dust exposure. In 52.7% of the workplaces, there are some poorly isolated sections bearing the risk of spreading dust to the working environment. This suggests that more than half of the cement factory workers are at risk because of the toxic dust in the environment [11].

Figure 2.5 Cement plant and air pollution [11]

The pollutants emitted from the blast as an emission of the cement plant can be transported for kilometers away with the effect of prevailing winds. Thus, pollution can also occur in places far away from where the factory is located. This contamination may be due to the location of the plant and meteorological phenomena, such as natural areas, agricultural land, residential areas, or overhead drinking water sources that feed the area.

2.7. Cement Plants and Soil Pollution

The dust released from the rotary kiln flues in the cement factories not only create air pollution but also negatively affects the growth of the plants with the destruction of the soil structure [13]. It is proven that the olive trees in Muğla has been affected by cement dust. According to this; the structure of the olive tree leaves in contact with the powder has changed, the growth and development of the leaf have been adversely affected, and the number of fruits has deteriorated as well as the yield has been lost [15]. This effect of the cement plant chimney dust on plants; the accumulation of dust on the leaves inhibits the light transparency required for photosynthesis, leading to the loss of chlorophyll pigments with superficial pH change. Negative effect was also seen in olive trees 500 meters from the factory. On the negativity that researchers have identified in their work; "Although it has been stated in the authorities that there are filters in the chute, it seems that this is not enough" [13]. The negative impact of pollution of the cement industry on chlorophyll and photosynthesis activity in plants has been shown recently and in other geographical regions [13]. It is obviously showen that factories should be away from the agricultural areas.

Figure 2.6 Industrial Plant, Karabash [14]

The pollutant cement disrupts the physicochemical structure of the soil with the pulp content and increases the amount of heavy metal. The pollution of the cement factory in the wind direction of the chimney emissions has been evaluated in a number of studies. Heavy metal pollution in areas under the influence of cement plant emission; iron (Fe), aluminium (Al), chromium (Cr), calcium (Ca), magnesium (Mg), sodium (Na) and potassium (K) contamination brought out surface [16]. Similar cadmium contamination in Turkey has been shown for the cadmium concentration in the soil and plants near the cement plant, which is shown for cadmium production. It has been shown that the cadmium concentration decreases as the plant moves away from it [16].

Figure 2.7 Industrial Plant, Karabash City [14]

2.8. Other Output Gases

The most important environmental problems related to cement production are pollutant gas emissions to the atmosphere. Large quantities of emissions include nitrogen oxides (NOx), sulfur oxides (SOx) and dust. The generated wastewater is usually limited to surface runoff and cooling water, which does not have a significant effect on water pollution. But; It is a potential source of contaminants in the open space where fuels are stored and in the contamination of wastewater, soil and groundwater that occurs during loading and unloading.

Figure 2.8 Other output gases [14]

2.9. Dust

“Airborne particulate matter ranging in diameter from 10 to 50 microns, generated by activities such as cutting, crushing, detonation, grinding and handling of organic and inorganic matter such as coal, grain, metal, ore, rock, wood. Their presence in upper atmosphere can cause either a net warming or a net cooling effect, depending upn their surface color. Dust particles with black upper and gray or white lower surface would cause warming, whereas those with opposite color arrangement would cause cooling. Industrial dust (generated by cutting, drilling, grinding or sawing) can pose health risks if inhaled and (because such particles usually are less than 10 microns in diameter) would be more hazardous due to its ability to embed deep into lungs and other issue [16].”

During the cement production processinorganic dust is relased. Inorganic dusts tend to accumulate in the lungs. Among these, dusts that create fibrosis (hardening of lung tissue) cause chronic lung diseases by causing tissue disorders in alveoli, which are air sacs in the lungs.

- Metallic powders (iron, copper, zinc dust, etc.)

- Non-metallic powders (sulfur, coal dust)

- powders of chemical compounds (zinc oxide, manganese oxide etc.)

- Powders of natural compounds (minerals, killer, mineral ores, etc.)

* Minerals: Powder containing Silica Dust Asbestos Fibers in a breathable, crystal structure

Man-made mineral fibers (MMMF)

2.10. Impacts

The adverse effects of cement factories on the environment are: materials and storage (particles), grinding (particulate matter), oven and clinker cooling fumes (particles or "oven dust", combustion gases containing carbon monoxide and carbon dioxide, hydrocarbons, aldehydes, ketones, oxides) processes. Water pollution is caused by water leaks (high pH, precipitated solids, dissolved solids) or cooling of machine equipment in wet systems.

In summary, the most important environmental effects of cement plants are the reduction of the final air quality due to emissions of flue gas and dust, material storage, material furnaces, in-plant routes and particulate matter emissions from transportation, waste water production from wet systems and especially material removal, it is the generation of noise from the breakers. Potential adverse effects from cement plants are as follows:

- Crusher (crusherunit), pre-homogenization and raw material stocking unit, raw material mill (farin) unit, farin stock and homogenization unit, calcined preheater- rotary kiln and clinker cooling unit, coal grinding unit, cement grinding and drying units, material storage and loading, atmospheric particulate matter emission from vehicle traffic;

- Kiln gas (SOx and NOx) emissions due to fuel burning

- Air pollution (electrical interruption, fluctuations such as carbon monoxide up take) that may result from failure of electrostatic filters;
- Water pollution from leaks from liquid wastes or waste piles;
- Air pollution (no electrostatic precipitator) during the initial start-up of the oven;
- Atmospheric diffusion of toxic air pollutants (metals such as incomplete combustion products or lead) resulting from the burning of hazardous wastes or the substitution of waste oils for fuel;
- The risk that the possession and storage of hazardous wastes will ocur to the environment;
- Degradation of transit structures, hazards created by heavy trucks carrying raw material, fuel or cement to the plant;
- Risk of erosion / sedimentation in surface waters from raw material removal and transport,

Cement factories may also have positive impacts on the environment in waste management. The technology and process are suitable for reuse of various waste materials (wasteoil, steelslag, scale, power plant slag waste and ashes, marble quarry pickling waste) including rotary kilns, including some hazardous materials.

Figure 2.9 Emission of hazardous gases [14].

2.11. The Mitigation Precautions

Cement production includes all operations from the raw material to the production of semifinished clinker and packaging the final product, cement. The most important environmental adverse effect at these stages is particulate emissions. Electrostatic or bag filters are the most commonly used methods for controlling furnace dust and other particulate matter generated in the process. The control of the dust resulting from the transport of the materials is more difficult. Raw material storage piles, conveyor belts and factory roads have more negative impact on the quality of the air. Mechanical dust collectors, crushers, conveyors and loading facilities can provide effective control in such places. In addition, through the recycling of collected dust, expenditure is reduced and solid waste generation is reduced the most [17]. Factory routes should be cleaned using vacuum sweepers and / or rogers (to block traffic and wind-up dust). The top of the storage stacks should be closed as much as possible. Trucks that bring materials to the plant must be covered with tarpaulins and speed limits should be provided to the vehicles.

Mitigation measures and potential adverse effects can be matched as follows:

• Atmospheric particle emission from all factory operations, crushing-screening, grinding, oven and clinker coolers, material storage and packaging: control of particles with bag filters and electrostatic precipitators, control of oven particle diffusion by humidification for dry process operations;

• Air pollution that may occur if the electrostatic and bag filter are not working: the operation of the unit to which electrostatic filtration is connected is not operated, the automation is provided, the parallel part collector is designed, the part of the collector is damaged while the other part is used;

• Dust emissions from dust-emitting equipment: covering or closing of conveyors, crushers, materials, transfer points, storage areas; installing mechanical dust collectors or bag filters where necessary; asphalting roads; vacuuming factory roads; sprays for factory roads and storage piles; reduction of these emissions by use of pre-curtained short rotary kilns; modification of the combustion system;

• Atmospheric diffusion of toxic air pollutants (metals such as incomplete combustion products or lead) resulting from the burning of hazardous wastes or the substitution of waste oils for fuel. Analysis of hazardous wastes and waste oils before they are burned, ensuring oven operating efficiency. disposing);

• Risk to the environment from the possession and storage of hazardous wastes: compliance with hazardous waste storage procedures and development of possible state plans.

3. LITERATURE SURVEY

TOPSIS application has a wide application area in every sectors. The TOPSIS method has been used to develop many production or service systems. The use of method is not only limited to academic work, but has also proved its applicability in practical applications. In any sector that wants to develop or compare a system, it gives satisfactory results when sufficient data are reached.

Since the aim of the study was to select the filter according to the investor's importance criteria among the dust elimination filters used in the cement plants, the methods used for the multiple criteria selection were first investigated. While other researchers were seeking out new solutions to find the worst and the best for their studies, they utilized Fuzzy Set and Triangular Fuzzy Number, Grey Relational Analysis, The Fuzzy Grey Multi Criteria Decision Making Model [18]. In their studies, they developed a district heating system because of their concerns about economic and environment. Their studies integrated the Fuzzy Set Theory and Grey Relational Analysis method because the Multiciriteria Decision Modelling of District Heating System is a typical problem with uncertain information. When all models are integrated, uncertainities have become disappeared [18]. When they arrived a conclusion, they reached the best and the worst District Heating System.

When making literature survey in the realm of device and technological equipment selection, there are lots of various subjects can be studied by Multi Criteria Decision Making Models. For example, Maridi, Atabi, Nouri and Yarahmadi have studied about the selection of optimized air pollutant filtration technologies for petrochemical industries through multiple decision making [19]. Secondly, Hede, Nuras, Ferreina and Rocha have studied in incorporating sustainability in decision making for medical device development. Thirdly, Özşahin, Uzun, Musa and Şentürk have evaluated nuclear medicine imagining devices using Fuzzy Preference Ranking Organisation Method for Enrichment Evaluation Method [19]. Forthly, Canon, Batanau and Vermahave developed decision support system for multi criteria machine selection for flexible manufacturing systems [21]. Last but not least, Wang, Li and Su have studied electricity monitoring system with fuzzy multi objective linear programming integrated in carbon footprint labeling system for manufacturing decision making [21]. All these studies can be shown as a proof of multidecision criteria models have a wide application area. Besides, multi criteria decision making models have been also used in the realm of environmental management system selection, equity portfolio, humanitarian aid, health technology assessment, enterprise resource planning system selection, logistic strategy selection, policy optimization, information technology selection and green supplier selection.

In this study, Multi Criteria Decision Making Models used in order to make equipment selection in cement industry by using TOPSIS and it has never been applied before. Instead of equipment selection, researchers have studied different cement industry subjects. Ertuğrul, Karakasoğlu have studied performance evaluation of Turkish cement firms with fuzzy analytic hierarchy process and TOPSIS methods [23]. Moreover, Amrina, Ramadhani and Vilsi have developed a fuzzy multi criteria approach for sustainable manufacturing evaluation in cement industy [24]. Other application was about financial performance evaluation of Turkish cement firms with fuzzy analytic hierarchy process and TOPSIS methods by Ertuğrul and Karakasoğlu [23].

When litereature surveyed, there are some studies about making equipment selection by using Multi Criteria Decision Making Methods. However, in the realm of the cement industry and equipment selection considering environmental facts, studies are not found using any kind of Multi Criteria Decision Making Models. That's why, this paper can be took a pro active role in order to highlight environmental consequences of cement industry and immediate precautions must be taken.

4. DUST CONTROL IN THE CEMENT SECTOR

The procedures and principles regarding the subjects such as how to make the risk assessment in the workplace, the qualifications of the persons and organizations to be evaluated and the principles are defined in the Regulation on Risk Assessment of Occupational Health and Safety published in the Official Newspaper dated 29 December 2012 and numbered 28512. Risk assessment; identifying and analyzing risks, initiating risk control measures, documentation, updating the work done and, if necessary, renewing the steps to start from the design or establishment phase for all workplaces [25]. When employees are involved in the risk assessment work, they are allowed to participate in the process at each step needed to get their views. Employees at work, employee representatives and employees coming to work from other businesses and their employers; health and safety risks that may arise in the workplace and corrective and preventive measures.

4.1. Dust Control: Technologic Alternatives

Reducing the mass load emitted from unavoidable emissions and decreasing environmental particle levels are priorities of the cement sector. It is necessary to recycle and collect the dust in the furnace gases, which leads to increase operational efficiency and reduce atmospheric emissions. At dust collection process, electrostatic precipitator and bag filters have a pro active role on emission control, worker protection, measures and control for public health and environmental quality.

In power plants or other solid-fuelled power plants, small ash particles called fly ash drift together with the flue gases and go towards the boiler. If these measures are not taken, the damage to the environment is considerable. However, in all plants operating with solid fuel, it is absolutely necessary to place an ash holder before the fans that allow the gas-ash fragments to be thrown out of the boiler in the boiler [26].

In the precipitation cells, the ash retaining efficiency is 70% and it is not used in modern facilities. The yield in wet ash is about 80%. In cyclone ashes, the yield reaches 90% [27]. Dust filters are a very old method and their efficiency results are very good. It is the reason of why cement industry prefer dust and electrostatic filters.

Figure 4.1 An example of the chimney with filter and without filter

4.2. Electrostatic Filters

Flue gases are one of the most important causes of air pollution, and unfiltered release into the environment negatively affects the environment. Various filtering methods have been developed to reduce these adverse effects. One of the filters that provide high efficiency with low pressure loss and air pollution control in cement plants is electrostatic filtration.

Due to lower energy consumption, lower spare parts costs and minimum maintenance requirements than other filter types, electrostatic filters offer high efficiency by reducing operating costs [27]. Electro filters are used for dust removal without putting an obstacle in front of dusty gas. They can be effectively used to remove dust from dusty gases with high temperature and high humidity.

4.3. The Working Principle of Electrostatic Filters

The working principle of electrostatic filter is different from other dust holding systems. Electrophoresis is based on the principle that ash particles are collected by electrical charging and removed from the system.

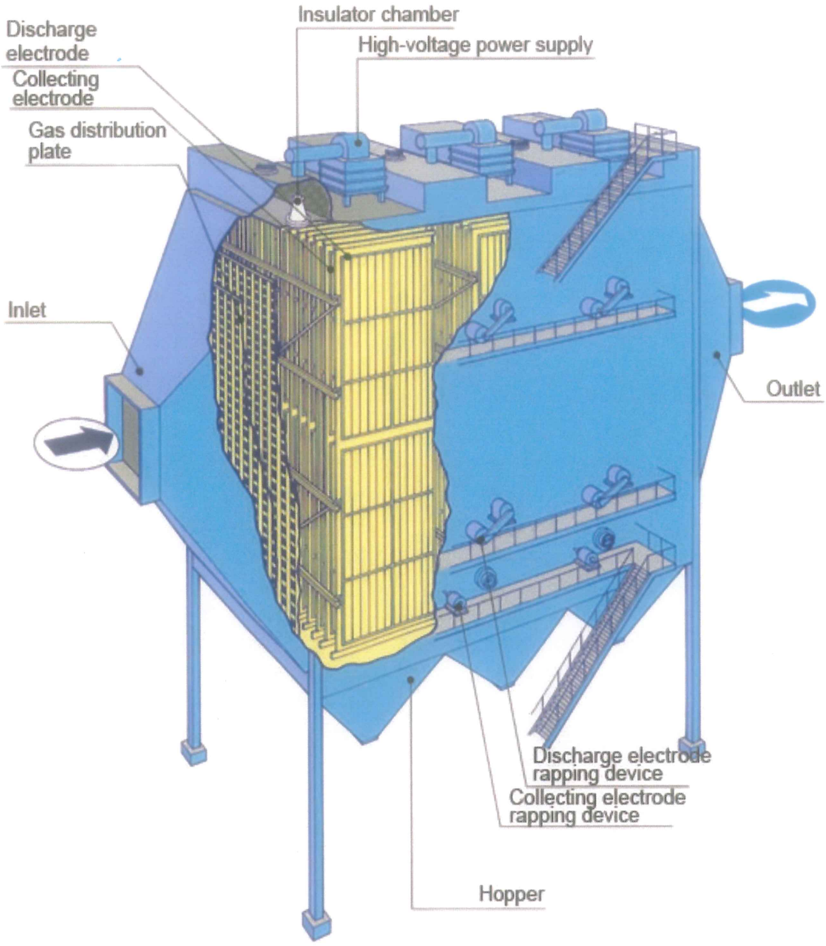

Figure 4.2 Electrostatic filter [28]

If the voltage is high enough, a light ring is formed around the discharge electrode. This shows that the voltage is high enough to spread into the gas around the electrons. On the one hand, these electrons are held by the gas molecules and brought to the negative ion cell, while positive ions on the other hand collide to a certain degree. Negative ions, positive collector electrodes; positive ions also enter the negative collecting electrodes. The particles entering the field quickly gain a negative charge and move towards the positive electrode in the field. When they hit the electrodes, they lose their negative charge and combine with other particles there to form larger particles and the dust collected in the collecting electrodes are collected by mechanical hammering and shaking method and returned to the system [28]. Electro filters can be used for both liquid and solid particles. In the electro filter, there are many plates parallel to each other in the vertical position. Flue gases pass through these plates. Charging electrodes are placed between the plates to create an electric field between the plates.

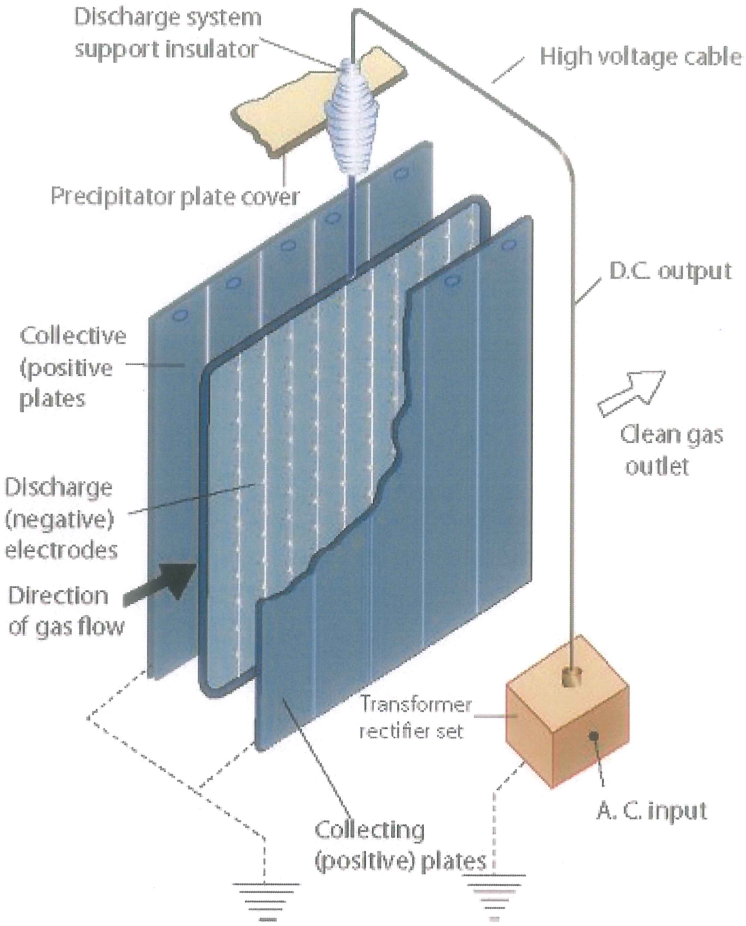

Figure 4.3 Single stage electrostatic filter [28]

Collecting plates are electrically grounded. It also forms positively charged electrodes. The discharge electrodes between the plates are usually connected to a DC source between 60kV-75kV and negative polarity. For this reason, an electric field occurs between the discharge electrodes and the grounding surfaces [28]. As the flue gases pass through this area, the ash fragments are loaded negatively. These ash particles that are loaded are drawn by the collecting surfaces and spread to the surface by turning towards that side. Chemical properties of ashes affect their ability to be electrically charged.

In electro filters, the average gas flow rate is 1-3 m / s. The ash particles collected on the plate surfaces accumulate to form a layer [28]. These plates need to be discarded periodically. For this reason, "shrinking" is applied by shooting with the most special mechanism. These collected ashes are then emptied from time to time and transported to the ash field from the plant site.

Figure 4.4 Airman plant electro filter

4.4. Dust Filter

Bag filter, another dust removal system, is also used extensively as an alternative to electro filters to clean industrial process gases. These filters are found in the optimum number within the steel structure. The bags, pressure air system, air lock, conveyor unit, automatic control system and fan are selected according to the quality of the dust particles.

Dust filter features are best price quality ratio, carbon steel or stainless steel filter body option, high filtration efficiency, easy maintenance and replacement of filter elements, multifunctional, modification of toolless filter element, increased durability, reduced maintenance costs, filters that meet hygiene requirements according to food norms, increased work security, low operating costs, optional electronic differential pressure gauge.

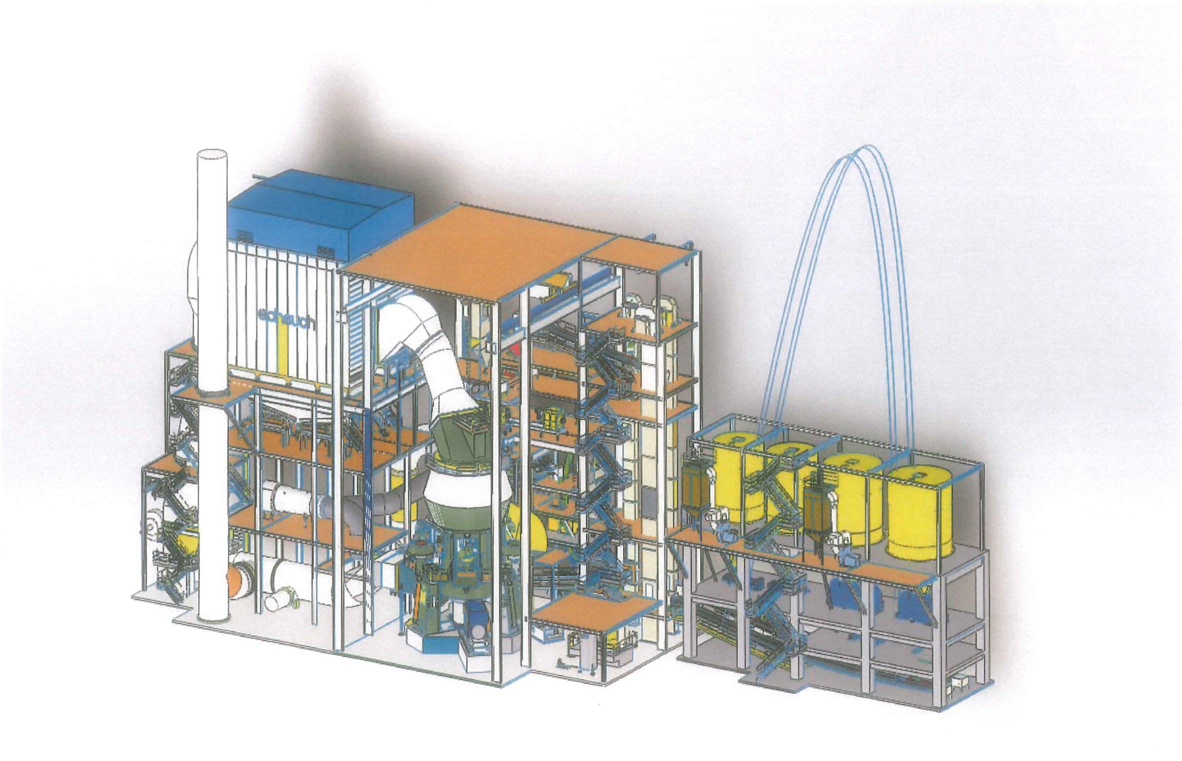

Figure 4.5 Dust filter (sintek.co)

4.5. The Working Principle of Dust Filters

Dust filters are used in industrial facilities to keep dust in the air. The bagged filters come in bags, air bags, airlocks, conveyor units, automatic control systems and fendant tubes, all of which are selected in the steel structure in an optimum number and in accordance with the nature of the dust. Gases or air under pressure or vacuum, enter the system from the bottom of the filter body. Since the flow direction is towards the filter bag, it leaves the pollutants in the air (gas) on the outer surface of the filter bag. Fresh air passing through the filter cage passes through the venture section, reaches the clean section of the filter and exits the system with the help of the exhaust system. The pores of the filter element deteriorate as the dust accumulates on the empty surface of the filter element during dusting. By controlling the pressure difference in the clean and dirty gas zone of the filtration and monitoring this pressure difference, the differential pressure is reduced and kept between the permissible limits

Figure 4.6 Dust filter

Over time, dust adhering to the bag will accumulate on the surface of the bag, causing pressure loss. Because of this, it is necessary to shake the bags at certain intervals. These shaking patterns can be of different types. The most commonly used is shake with high-pressure shock air. The dust dropped from the bags is returned to the system [29].

5. HEALTH IMPACTS OF CEMENT PLANTS

As long as you do not pay attention to the solution methods mentioned, the health problems that will be out of the way can not be prevented. Parallel to the industrialization that started in our country since the 1970s, the negative effects of industrialization to the environment and human health have reached important dimensions. The fact that these facilities are located close to fertile land, access roads and residential areas lead to significant health and environmental problems in these areas. In addition to physical pollution, poisonous flue gases and particles that they secrete to the environment lead directly to negative health effects to human health as well as to irreversible serious health problems when taking into account the harmful effects on agricultural land and groundwater.

Although cement is necessary for industrial production and economic development, it causes environmental pollution due to the use of intense energy and production of sulfur oxides, oxides of nitrogen, particulate matter and carbon dioxide, and adversely affects human health [30].

Air pollution is listed by the International Agency for Research on Cancer (IARC) in 2013 as a list of the causes of cancer. The World Health Organization (WHO) reported that air pollution leads to lung cancer and increases the risk of bladder cancer [31].

Rising production technology is expected to change the environmental impact of cement factories. Different at each stage of cement production pollutants emerge. From raw material removal process, transport, production of the required energy in the recycle (large irreversible fossil in the majority fuel is used) and cement as the product. In the process of getting pollutants are a major problem. From all these stages then the final product, cement is itself an important polluter. Cement dust contains arsenic, cadmium, chromium, cobalt, copper, manganese, nickel, thallium, tin, vanadium, zinc, beryllium, selenium, tellurium and mercury [31].

Cement plant emissions are important source in terms of organic, inorganic chemicals and metals. Atmospheric emissions from other combustion processes Similarly, the particulate matter PM, nitrogen oxides (NO_x), carbon monoxide (CO), carbon dioxide (CO2), hydrogen sulphide (H2S), volatile organic compounds (VOCs), sulfur oxides (SO_x), hydrofluoric acid (HF) and hydrochloric acid (HCl), mercury (Hg), arsenic (As), cadmium (Cd), lead (Pb), zinc (Zn), dioxine, and furan [30]. Cement industry is responsible for 5-6% of carbon dioxide emission. It will be noticed that this ratio is quite high considering all human activities and the CO2 emission industry. As a result; the cement industry is polluted during the entire production process from raw material to final product [32].

Cement factories also causes respiratory system diseases with the emission of the cement product. Cement plant emissions sulphur dioxide (SO2), irritating to the eye. Workers are more likely to be affected by sulphur dioxide. Inhaled sulphur dioxide affects the respiratory system and disrupts lung function. The resulting respiratory system inflammation; increased cough, increased sputum, increased asthma attacks, and increased susceptibility to chronic bronchitis and respiratory system infections [32]. Sulphur dioxide is easily confused with the blood circulation from the lungs. It may be fatal in the short term if high levels of sulphur dioxide are present. When high levels of health and non-smoking miners are affected, nose and throat burns, difficulty in breathing, severe airway narrowing [33]. Asthmatics also suffer from very low levels of sulphur dioxide. It is thought that children are more affected than by adults, because the respiratory system and defence mechanisms are not fully developed, and because they are so mobile that they require more breathing.

Recent studies indicate a strong relationship between cardiovascular diseases such as internal and external air pollution, stroke and ischemic heart disease. According to the World Health Organization, 40% of deaths due to air pollution are caused by heart disease and 40% by stroke [33].

There is no consensus that the cement factory emissions of dioxin and furan are an important threat to human health. Dioxin causes impairment of all types of cancer, immune system, nervous system, endocrine system and reproductive function. At the same time, dioxin and furan are known as "secretion". The secretion is distorted fertility, fetal development, the factors that disturb the secretions responsible for the reproduction and development of the body. Dioxins and furans, as well as heavy metals such as lead, mercury, cadmium, which are also emissive in the cement plant, are among the secretions. It has been suggested that the blindness causes mental functions, increased aggression, hyperactivity, congenital abnormalities, prostate, breast cancer [32]. Cement plant pollutants cause chromium VI skin-associated dermatitis, tenderness and injury, adversely affecting the kidney and immune system [32]. Chromium VI causes sperm damage and reproductive system disorders in male laboratory animals [35]. The cadmium level in the blood of people living close to the cement plant is higher than those living away from the factory. The biological half-life of cadmium (19-38 years) is long in the body since it is long. It causes diseases such as bone erosion, tooth decay, kidney diseases, lung and prostate blood-lineage, constant headaches, dizziness, nausea, vomiting, insomnia, asthma [35].

Many years ago, similar complaints were associated with cement factory welded pollutants. In Germany, people living close to the cement factory showed increased levels of thallium in the urine and some associations such as polyneurotic complaints, sleep disturbances, headache and fatigue. Recently, cement powder has been shown to be a risk factor for cervical cancer such as cigarette, alcohol, and asbestos, as well as early preterm birth [36].

6. FILTER EQUIPMENT SELECTION FOR CEMENT FACTORIES

In order not to have the health problems, many methods can be developed to reduce the environmental damage to minimum levels. The filters referred to as dust retention and emission reduction alternatives can be assumed to be inventions of green technology. The TOPSIS method was used in this study to decide between the two and determine the technological equipment that provides optimum efficiency.

All systems in development process, reach the most appropriate structure though exchange, due to the mission of their being. Organizations involved in the production and service sector follow the same development processes and seek out new solutions to reach certain targets with various constraints. Solutions of abstract models of these systems also help decision makers. When the topsis method reaches at the end, the result will help industrial sectors to realize how technological equipment choices important for environment and monetary issues. Moreover, they realise the inevitability of the development process because it affects all living and non-living systems.

Practical applications in terms of the theoretical development of the field of decision analysis are very fast with development and providing strong logic structure and success in decision making. While creating logic structure, optimization methods can be useful in order to maximize income and minimize losses. Every day, companies try to choose the best one in order to take the benefit from various alternatives and we must make various decisions while making these choices. Considering optimization results, companies may act towards more than one goal. In this paper, goals are minimizing equipment cost and environmental hazard by evaluating alternatives in topsis model.

TOPSIS, one of the methods used in the decision-making process, is a technique that allows the best selection among alternatives. TOPSIS is one of the multipurpose decision making (CAP) methods developed by Hwang and Yoon in 1981 [36]. The TOPSIS word consists of the initials of Technique for Order Preference by Similarity to Ideal Solution.

The TOPSIS method is a very simple method that does not involve complex algorithms and complex mathematical models. Because it is easy to understand and difficult to interpret the results, almost every field uses TOPSIS technology. The TOPSIS method utilizes many different areas such as supply chain management, supplier selection, logistics, engineering, production systems, business and marketing applications, human resources management, financial applications, energy management, chemical engineering and water resources management.

Although a limited number of TOPSIS programs have been developed, the Microsoft Office Excel program will be used in this section to solve problems related to the TOPSIS method.

It is quite easy to understand the output when the TOPSIS method receives a small number of input parameters from the user. When choosing with the TOPSIS method, it is expected that a selected alternative is close to ideal solution and away from ideal solution (negative ideal) [37]. If our aim is return, the ideal solution is the maximization of the term approximation, while the negative solution is the minimization of the cost. It is expected that the desired alternative will be far from the ideal ideal solution so far as the ideal solution approximation is expected. In other words, with TOPSIS, the solution which is ideal from the alternatives is chosen to be close to the ideal, the solution to the negative ideal. For example, two alternatives such as X and Y are shown below [24]; where the alternatives are the preference of X relative to Y, since the ideal solution is close to X and equally far away from the negative ideal solution. Y is far from the ideal solution to X and at the same time the negative ideal solution is close to Y, which is why Y is not preferred in terms of decision maker [37].

By using the TOPSIS method, the alternatives are sorted according to certain criteria. The first step of this method is the creation of the decision matrix. Then, the decision matrix is obtained by normalizing the decision matrix and the decision matrix is weighted. Ideal solving and negative ideal solving distances are calculated. Finally, the order of the alternatives is calculated by calculating the relative scores of each alternative. If these stages are examined with the order [38];

Step 1: Creating the Decision Matrix

The decision matrix is a matrix that must be created by the decision maker. The generated matrix will be an mxp-sized matrix. The decision-making rows show the decision points, while the columns contain the factors. This matrix can be represented as follows;

factors

$$A_{ij}=\begin{bmatrix} a_{11} a_{12} & \cdots & a_{1p} \\ \vdots & \ddots & \vdots \\ a_{m1} a_{m2} & \cdots & a_{mp} \end{bmatrix} \quad \text{decision criterias} \qquad (1)$$

Step 2: Obtaining Normalized Matrix

After the decision matrix is formed, squares of each a_{ij} values are obtained, and column sums composed of the sum of these values are obtained and normalization is performed by dividing each column of the a_{ij} value by the square root. The notation for this process is shown below;

$$N_{ij}= \frac{a_{ij}}{\sqrt{\sum_{i=1}^{m} a_{ij}^2}} \text{ (i=1,.....,m and 1,.....,p)} \qquad (2)$$

Normalize matrix is obtained as follows;

$$A_{ij}=\begin{bmatrix} \mathrm{n}_{11} n_{12} & \cdots & n_{1p} \\ \vdots & \ddots & \vdots \\ n_{m1} n_{m2} & \cdots & n_{mp} \end{bmatrix} \qquad (3)$$

where a_{ij}; i=1,......p

j=1,......m

Step 3: Obtaining Weighted Normalized Matrix

Each value of the normalized matrix is weighted with a value such as wij. The weighting process reveals the subjective direction of the TOPSIS method. Because weighting is done according to the importance of the factors. The only subjective parameter of the TOPSIS method is the weight. Note that the sum of w_{ij} values is equal to 1. The weighted normalized matrix (V matrix) is obtained by multiplying the nij values obtained with the normalized matrix by the wij weights.

$$V_{ij}=\begin{bmatrix} w_1 n_{11} & \cdots & w_n n_{1p} \\ \vdots & \ddots & \vdots \\ w_1 n_{m1} & \cdots & w_n n_{mp} \end{bmatrix} \rightarrow V_{ij}=\begin{bmatrix} V_{11} & \cdots & V_{1p} \\ \vdots & \ddots & \vdots \\ V_{m1} & \cdots & V_{mp} \end{bmatrix}$$

where $w_j=1,\ldots\ldots p$ is (4)

$$\sum_{n=1}^{p} wj = 1$$

Step 4: Obtaining Ideal and Negative Ideal Solution Values

Once the weighted normalized matrix (V matrix) is obtained, the maximal values of each column are determined, provided that our goal is maximization, provided that it depends on the structure of the problem. These maximum values are our ideal solution values. Then, minimum values for each column are obtained again. This is the negative ideal solution value. If our goal is minimization, the values obtained will be the exact opposite. The notation for obtaining positive ideal and negative ideal solution values is shown below;

Positiveideal solution A^+has the form:

$$A^+=(v_1^+, v_2^+, \ldots v_n^-)=((\max v_{ij}j \in I),(\min v_{ij}j \in I)) \quad (5)$$

Negative ideal solution A^-has the form:

$$A^-=(v_1^-, v_2^-, \ldots v_n^-)=((\max v_{ij}j \in I),(\min v_{ij}j \in I)) \quad (6)$$

Step 5: Obtaining Ideal and Negative Ideal Distance Values

Euclidean distance is used when calculating ideal and ideal non-point distance values. In the coordinate plane, the distance between the two known x and y coordinates is found [37];

Here;

x_{ik}: i. Observe. Variable value

x_{jk}: j. Observe. Variable value

p: represents the variable number.

Ideal solution is tried to determine the distance between the nearest Euclidean distance and the negative ideal solution. If this formula is generalized to be able to calculate the ideal and ideal non-point distance, the following calculation method is used;

Positive Ideal distance

$$S_i^* = \sqrt{\sum_{j=1}^{n}(V_{iJ} - V_{J*})^2}$$

Negative Ideal distance (7)

$$S_i^- = \sqrt{\sum_{j=1}^{n}(V_{iJ} - V_{J-})^2}$$

Here the number of decision points will be S_1, S_2.

Ideal and ideal non-point spacing is used to calculate the ideal resolving relative proximity of each decision point. The ideal solution is symbolized by Ci* relative closeness. Where C_i^* is the value of $0<C_i^*<1$, and $C_i=1$ is the absolute resolution of the corresponding solution point, and $C_i^*=0$ is the absolute ideal solution of the corresponding decision point.

$$C_i^* = (S_i^-)/(S_i^- + S_i^*)$$

7. APPLICATIONS

Five different scenarios were implemented in this study, which was created using the TOPSIS method. The reason of different five scenarios were different is related to the the desire of some cement plant investors are more environmentally sensitive, some investors are more caring about the cost issues.

In the first scenario, two types of filtration systems, namely electrostatic and bag filter's maintenance and repair activity times in a year, life, ease of installation, emissions of CO, NO, SO2, TOC informations have received from cement plants.

In the decision matrix, the alternatives to be used in order to decide rows, and in columns the criteria to be used for comparison. The matrix A, shown table 1, is the initial decision matrix generated by the decision maker.

The rows indicate the number of decision points and the columns indicate the number of evaluation factors.

FILTERS	MAINTENANCE AND REPAIR ACTIVITY	LIFE	EASE OF INSTALLATION	COm	NOxm	SO2m	TOCm	Dust
	TIMES (IN A YEAR)	YEAR	MONTH	mg/Nm3				
Electrostatic Filter	1.0	25.0	7.5	434.7	1363	6.9	28.0	66.4
Dust (Bag) Filter	1.0	25.0	5.5	290.3	635	46.9	22.9	2.0

Table 1 Average values of filter

Using the data in Table 1, a standard decision matrix was formed by applying the formula 2 and 3. The standard decision matrix is obtained by the initial decision matrix (A) and the normalization formula shown in the second and third equation shown below. The standard decision matrix (R) is shown in Table 2.

FILTERS	MAINTENANCE AND REPAIR ACTIVITY	LIFE	EASE OF INSTALLATION	COm	NOxm	SO2m	TOCm	Dust
	TIMES (IN A YEAR)	YEAR	MONTH	mg/Nm3				
Electrostatic Filter	0.05	0.13	1.84	0.83	0.90	0.14	0.77	0.99
Dust (Bag) Filter	0.05	0.13	1.35	0.55	0.42	0.98	0.63	0.02

Tablo 2 The standard decision matrix

CRITERION WEIGHTS	MAINTENANCE AND REPAIR ACTIVITY	LIFE	EASE OF INSTALLATION	COm	NOxm	SO2m	TOCm	Dust
	0.014	0.034	0.000	0.216	0.235	0.038	0.201	0.259

Tablo 3 Criterion weights

In the next step, the values of the columns of the R matrix are multiplied by the evaluation weight valuesand the columns of the V (Weighted Standard Decision Matrix) are calculated as shown in formula 4.

FILTERS	MAINTENANCE AND REPAIR ACTIVITY	LIFE	EASE IF INSTALLATION	COm	NOxm	SO2m	TOCm	Dust
	TIMES (IN A YEAR)	YEAR	MONTH	mg/Nm3				
Electrostatic Filter	0.001	0.005	0.000	0.18	0.21	0.00	0.15	0.2
Dust (Bag) Filter	0.001	0.005	0.000	0.080	0.046	0.254	0.10	0.0

Tablo 4 Weighted standard decision matrix

In step 4, the largest value in each column of the V matrix for the A * set, the smallest value in each column of the V matrix for the A set is selected, and the sets are obtained as in table 5.

A*	0.001	0.005	0.000	0.080	0.046	0.006	0.104	0.000
A-	0.001	0.005	0.000	0.180	0.214	0.254	0.156	0.260

Tablo 5 Ideal positive negative solution set

The ideal discrimination measures for the decision point were found as in Table 6 using the 7th formulation.

S1*	0.32
S2*	0.24
S1-	0.24
S2-	0.32

Tablo 6 Ideal discrimination measures

In the last step, using the values in table 6, the ideal solution closeness values for 2 decision points were found.

C1*	0.43
C2*	0.56

Tablo 7 Ideal solutions closeness values

When these values are introduced in the order of magnitude, the bag filter is relatively more close to ideal ideal solution compared to the electro filter and the bag filter should be selected depending on the conditions in this scenario.

In the second scenario, cost factors are added in addition to scenario 1. Also in this scenario, the criterion weights are designed as a filter selection of an environmentally responsible investor. The factors in the selection are given the scores 1 for the least important, 10 for the most important. Criterion weights were found by normalizing these scores.

The second scenario investor was thought to attach importance to environmentally sensitive. According to this, the relative closeness of the electrostatic filter was found to be 0.59 and the bag filter was found to be 0.40, with a score of 10 for the maintenance factor, 5 for the life factor, 5 for ease of installation, and 10 for other environmental factors. All measurement values show that the electro filter is the closest choice to the ideal solution relative to the bag filter.

The third scenario is designed so that if the investor is not sensitive to the environment and gives importance to the ease of installation, the maintenance, the repair and the cost factors. In this case, the cost, the ease of installation, the life and the maintenance and repair factors were given 10 points, other environment factors were given 3 points and normalized. As a result, the electro filter (0.62) was found to be the closest to the ideal selection according to the bag filter (0.37).

In the fourth scenario, the investor is calculated as one who minimizes the dust release and ignores nitrogen release, cost and other installation factors. According to results, relatively the closest value to ideal solution is bag filter option with 0,51.

The fifth scenario was created for investors who are committed to keeping costs and maximum dust. 10 points for cost and dust holding; maintenance and repair activity, life, ease of installation, C0 factors were given 5 points; NO, TOC factors were 9;6 points were given to the SO2 factor. In this scenario, the bag filter 0.52 was the filter that should be chosen with the closeness value to the ideal result.

When all scenarios are considered, accurate result can not be obtained from a topsis method that has been introduced without significant cost factors and has not been normalized. Before making an investment, the investor should investigate all the factors and make their importance ranking. When the importance order is done, the result table is as follows.

	COST	MAINTENANCE AND REPAIR ACTIVITY	LIFE	EASE OF INSTALLATION	CO	NO	SO2	TOC	DUST	IDEAL RESULTS
2.SCENARIO	3	5	5	5	10	10	10	10	10	ELEC. F.
3.SCENARIO	10	10	10	10	3	3	3	3	3	ELEC. F.
4.SCENARIO	3	5	5	5	8	9	6	9	10	DUST F.
5.SCENARIO	10	5	5	5	5	9	6	9	10	DUST F.

Table 8 Criterion ranking points according to investors' priorities and result

8. CONCLUSION

Increasing population, urbanization, and subsequent changes in the needs of people have put societies alive among industrial facilities. Even if the industrial facilities are established far from the people's settlements, the ground waters have always been contaminated by dusts and effect people's health. Especially, cement plantsare important pollutants among other industrial facilities.

Cement production is concentrated in certain countries of the world, including Turkey. Nowadays, cement production need has on rise so it triggers the increasing amount of establishment of new cement factories. The cement industry is polluting, so it is necessary for the cement industry to educate and inform the public about the environmental and health effects of the cement industry.

Approximately 74 million tons of cement was produced in 2013 and 753 kg of carbon monoxide is produced in 1000 tons of cement production. All these results highlight the importance of worker health and safety trainings must be included in the factory as well as necessary protection material and supervision. **In this study, it is aimed to be able to understand the importance of technological equipment selection effects the minimize the dust particles and various harmful gases released during the cement production process.** The contribution of the electrostatic and bag filters from the dust elimination chimney systems on the project is seen in the seos reports of 6 same capacity cement factories active in Turkey. These seos report values used in the TOPSIS method which developed by Hwang and Yoon in 1981 in the project. The aim is to find a system that minimizes damage to the environment and low cost among the two options. TOPSIS method is the multi criteria decision making method that serves to find the worst and the best results by ranking options. Five scenarios were created for this study. In the first scenario, the two alternatives have 8 factors. These; breakdown maintenance within one year, equipment life, installation time, CO, NO, SO2, TOC and dust emissions. In the second, third, forth and the fifth scenarios, the equipment cost factor was added to the first scenario factors and a total of 9 factors were calculated.

In the first scenario, the aim is to choose the equipment that gives the least harm to the environment, the less faulty maintenance, the faster installation. Therefore, the minimum of the factors other than the lifetime factor was selected when constructing the positive ideal solution sets. In the first scenario, the selection of the bag filter option was seen as appropriate. According to the result of the first, forth and the fifth scenario, the dust (bag)filter is more close to relatively ideal solutions according to investors'priorites among factors. This project was designed according to the priority and the importance of the decision maker. As their factor rankings changed, the criterion weight values have changed with the optimum results.

Although the annual lives of the two filters are the same, they have some different features. Firstly, dust filter production in our country is more than the production of electrostatic filter. Thus, the installation times of the electrostatic filters are a few more months on average because supervisors are coming from abroad in order to start guaranteeing the equipment. Secondly, while electrodes of the electro filter create some problems, annual malfunction can be more, in bag filters, problems such as bag burning is encountered. All these illustrates that both filters serve the same purpose but some different problems. So, the investors' importance criterias can change the results.

To arrive a conclusion, to minimize the negative health effects of cement factories, it is imperative that the most advanced technology be used in accordance with the conditions of the day, which are less polluting in all circumstances and less affect human health. The choice of equipment must be made without forgetting that the important point is human and its health and well-being. The problem is scientifically clear and, as it is being acknowledged, determining regional and global action plans should be the main target.

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