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Effect of Gases Emitted from Cutting Wood with CO_2 Laser on Air Quality

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Abstract: In this study, the effect of gases released during CO_2 laser cutting of different wood materials such as birch plywood, beech wood, medium density fiberboard (mdf) and chipboard (Particleboard), which are widely used in the woodworking industry on air quality. For this purpose, Arduino Uno microcontroller development board, ESP8266 wifi module and MQ135 air quality sensor module were used to measure the gases released during wood cutting with a 150 watt CO_2 laser cutting device. In addition, air quality index measurement was measured in real time with a microcontroller development card, and IoT (Internet of Things) technology was used for remote monitoring of instant data. Four different wooden materials were cut with a CO_2 laser cutting machine for 5 minutes each, and the air quality index measured using the microcontroller development board and ESP8266 wifi module was instantly sent to the channels on the IoT platform Thingspeak web address. The effect of the gases released during cutting on the air quality index was determined by averaging these data. The data was tracked both on the Thingspeak IoT platform and the Thingview android application. This study aims to examine in detail the effects of gases released as a result of CO_2 laser cutting of four different wood and wood-based materials on air quality.

Keywords: CO_2 laser, air quality, IoT, Thingspeak, wood material

CO_2 Lazerle Ağaç Kesiminden Yayılan Gazların Hava Kalitesine Etkisi

Özet: Bu çalışmada, ağaç işleme endüstrisinde yaygın olarak kullanılan huş kontrplak, kayın ağacı, orta yoğunlukta lif levha (mdf) ve sunta (Sunta) gibi farklı ahşap malzemelerin CO_2 lazerle kesilmesi sırasında açığa çıkan gazların hava kalitesine etkisi incelenmiştir. Bu amaçla Arduino Uno mikrodenetleyici geliştirme kartı, ESP8266 wifi modülü ve MQ135 hava kalite sensör modülü kullanılarak 150 watt CO_2 lazer kesim cihazı ile ahşap kesimi sırasında açığa çıkan gazlar ölçülmüştür. Ayrıca mikrodenetleyici geliştirme kartı ile hava kalitesi indeks ölçümü gerçek zamanlı olarak ölçülmüş, anlık verilerin uzaktan izlenmesi için IoT (Nesnelerin İnterneti) teknolojisi kullanılmıştır. dört farklı ahşap malzeme CO_2 lazer kesim makinesi ile 5'er dakika kesilerek mikrodenetleyici geliştirme kartı ve ESP8266 wifi modülü kullanılarak ölçülen hava kalite indeksi anlık olarak IoT platformu Thingspeak web adresindeki kanallara gönderildi. Kesim sırasında açığa çıkan gazların hava kalitesi indeksine etkisi bu verilerin ortalaması alınarak belirlendi. Veriler hem Thingspeak IoT platformunda hem de Thingview android uygulamasında takip edildi. Bu çalışma, dört farklı ahşap ve ahşap esaslı malzemenin CO_2 lazer kesimi sonucu açığa çıkan gazların hava kalitesine etkisinin detaylı olarak incelenmesini amaçlamaktadır.

Anahtar Kelimeler: CO_2 lazer, hava kalitesi, IoT, Thingspeak, ahşap malzeme

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1. Introduction

Wood has become an indispensable material for humanity throughout history [1]. Today, although they are used in many areas from furniture to construction, from art to industry, products made of wood are preferred in home decoration and other areas due to their rich style and elegant appearance. With technological developments, new methods have emerged in processing and shaping wood. One of these methods is the CO_2 laser cutting process. Laser cutting is a kind of flexible non-contact machining process, which has the advantages of high machining precision, narrow cutting width, and requiring only small space while maintaining low operating costs. Compared to traditional processing methods, the cutting speed of laser

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processing is faster. Perform local operations on parts, complex shapes, and small parts. Additionally, the combination of laser and computer technology facilitates rapid production. [2].

Laser cutters produce high-intensity infrared light beams that reach power densities of several hundred watts/cm2 for cutting and engraving materials such as glass, metals, polymers, and wood [3]. High-intensity light beams cause melting, vaporization, and evaporation of materials, producing emissions from gases, chemical vapours, and particles, so-called laser-generated air pollutants [4]. The type of gas released during laser cutting depends on several factors, including the material used, the operating speed and power, and the cutting time. [5]. Gases released during laser cutting of wood may vary depending on the chemical components of the wood, the parameters of the laser and the processing conditions. However, it is generally known that harmful gases may be released during laser cutting of wood. Carbon dioxide (CO_2), water vapor (H_2O), methane (CH_4), hydrogen (H_2), carbon monoxide (CO) Other Volatile Organic Compounds (VOCs), aldehydes and ketones are known as acidic gases. Because many of these gases can be harmful to human health and the environment, it is important to use appropriate ventilation and emission control systems when laser cutting wood. However, it is necessary to conduct special experimental studies to determine exactly in what quantities and conditions these gases occur. Because many of these gases can be harmful to human health and the environment, it is important to use appropriate ventilation and emission control systems when laser cutting wood. However, it is necessary to conduct special experimental studies to determine exactly in what quantities and conditions these gases occur. Additionally, these gases have a significant impact on air quality [6].

Air pollution is a factor that greatly threatens the health and quality of life of living things and should be constantly monitored because it causes many harmful effects. The most effective way to monitor is to know the source and origin of pollution. When measuring the level of air pollution, some air pollutant gases that pollute the air are taken into consideration [7]. Studies have shown that poor indoor air quality causes some discomfort. In Building-Related Disease due to inadequate ventilation of the building, building occupants complain of symptoms such as cough, chest tightness, fever, chills, muscle aches, Legionnaires' disease, and pneumonia [8]. Air pollution poses a major challenge to global health. According to a study conducted by the World Health Organization (WHO) in 2012; One in 8 deaths worldwide is caused by air pollution. Again, according to statistical data published by the World Health Organization, 4.6 million people die every year due to various diseases directly caused by poor air quality. Among the parameters affecting indoor air quality; Substances such as carbon monoxide, carbon dioxide, volatile organic compounds, particulate matter, silica dust (silica), cigarette smoke, ozone, asbestos, radon, lead, nitrogen dioxide, sulfur dioxide, chemicals, cleaning products and disinfectants are included. These substances can cause air pollution and negative effects on employee health. When evaluated in terms of occupational health and safety, indoor air pollutants in working environments play an important role in employee health and constitute an agent that causes occupational diseases and even premature deaths globally [9,10].

Measurement of the harmful formaldehyde gases released from furniture produced from wood-based boards is important to determine occupational health safety and air quality of indoor environments. Flooring and furniture used in buildings are factors that affect air pollution. Unnaturalness of the materials used, chemical-based coatings used in flooring, coatings made of cheap and durable materials are among the factors that determine indoor air quality due to the chemicals they contain [11].

The effects of plate thickness, processing time and temperature on formaldehyde emission were investigated for wood-based boards obtained from particleboard (Particleboard) and medium density fiberboard (MDF), which are used extensively in interior environments. The boards were analyzed for formaldehyde emissions at 65% relative humidity content, and a significant increase in formaldehyde emissions was detected in all board types as the temperature increased. As a result, the temperature and thickness of wood-based boards significantly affect the amount of formaldehyde and affect the air quality in indoor spaces [12].

In the literature review, no information was found regarding air quality measurement due to the gases released by cutting wood and wood-based boards with a CO_2 laser machine. Additionally, costly devices are used to measure air quality. In this study, internet-based real-time measurements were made with low-cost microcontrollers and sensors.

2. Material and Method

Wooden material; It has superior properties compared to other industrial materials due to its hygroscopic, heterogeneous and anisotropic structure. These superior technological properties of wood enable it to have a wide range of uses [13]. When wood material burns, it produces two main pollutant gases such as CO and NOx, as well as substances harmful to health such as benzene, aldehydes, respirable particulate matter and other free radicals [14]. In this study, birch plywood, beech, mdf and chipboard wood materials were burned in the same ways with a CO_2 laser cutting device, and the air quality index was measured and compared using the microcontroller development card and MQ135 air quality sensor. Wooden materials were prepared in 3x100x250 mm dimensions and placed in the CO_2 laser-cutting device. The ventilation was reduced at the same rate in all 4 materials, the materials were burned for 5 minutes each, and the same shapes were processed. The CO_2 laser-cutting device used to burn materials are shown in Figure 1.

Fig 1. CO_2 laser cutting device used in the study

Materials ready to be processed with the CO_2 laser-cutting device (birch plywood, beech, MDF and chipboard) are shown in Figure 2, respectively.

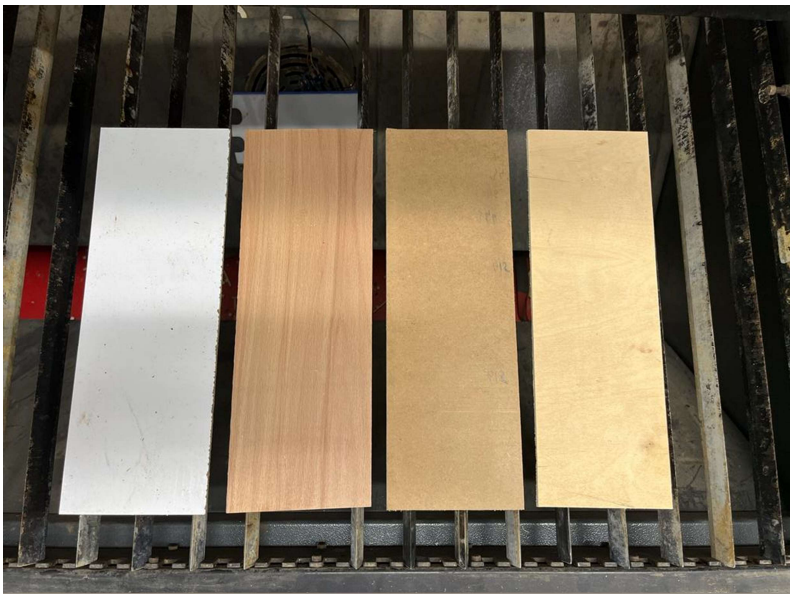

Fig 2. Materials used in the study

For woodcutting, the cutting feed rate was set at 15mm/min and the cutting power was set at 40% watts. The focal length for cutting was determined as 6 mm and cuts were made as in Figure 3.

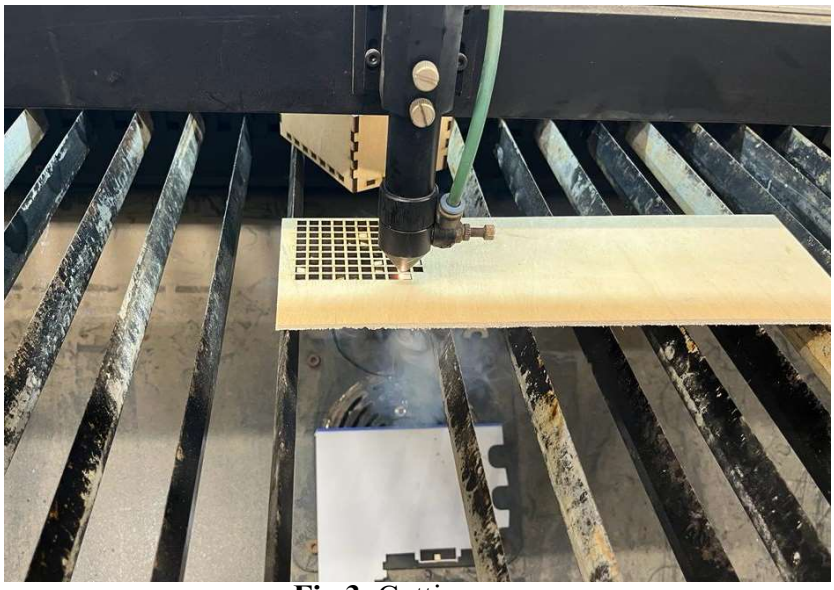

Fig 3. Cutting process

2.1. Air Quality Index

Air pollution; It can be defined as the increase of pollutants such as water vapor, gas, dust and smoke in the atmosphere to a level that is harmful to all living and non-living beings [15]. Air quality index is an index used to report daily air quality. It provides information about how polluted or clean the air is in our area. The air pollution index also indicates the health effects that may occur when exposed to polluted air. AQI is an indicator chart prepared between 0-500 values. As the AQI value increases in the table, air pollution increases. An AQI value above 300 indicates that the air quality is poor and dangerous for health. An AQI value of 100 corresponds to the national air quality standard. When the AQI value is below 100, air quality is considered good, and when it exceeds 100, the risk of affecting vital functions increases [16]. The interpretation of the air quality index is shown in Table 1.

Table 1. Air Quality Index Values

AQI	Index	Result
0-50	Good	Green; It means the air quality is good.
51-100	Middle	Yellow color; It indicates an average air quality. In general, there is no alarming value, but there may still be health concerns.
101-150	Sensitive	Orange color; It means air quality is sensitive. People with respiratory problems may be negatively affected.
151-200	Unhealthy	Red color; He states that the weather conditions are unhealthy. Not only sensitive groups but all people can be negatively affected by the color red.
201-300	Bad	This category, highlighted in purple, means bad air quality. This weather condition, which is extremely dangerous for health, threatens the health of all citizens.
301-500	Dangerous	The last class, identified by brown, calls for a state of alert. Brown; It states that the level of health concern has reached dangerous levels.

2.2. Design of Air Quality Measurement System

MQ135 air quality sensor is a sensor that can detect air quality according to the amount of NH_3, NOx, Alcohol Vapor, Benzene, Smoke and CO_2 gases in the atmosphere. This sensor is particularly capable of detecting gases such as ammonia, nitrogen oxides, alcohols, benzene, smoke and carbon dioxide. When this sensor is used with a microcontroller, it can measure gas concentrations in real time and analyze this data. In this study, the air quality index during the processing of 4 different wooden materials with a CO_2 laser cutting device was measured with the Arduino Uno microcontroller development board and MQ135 air quality sensor. In the designed system, the MQ135 air quality sensor was read from the analog output and the air quality index was calculated by writing codes in C language. ESP8266 wifi module has been added to the system so that the system can send data instantly and over the internet. By connecting the ESP8266 Wifi module controller to the internet, the air quality index values measured during cutting were sent to the Thingspeak internet address, which is an IoT (Internet of Things) platform. An account was opened on the Thingspeak website and the address of the channel was encoded in the microcontroller codes. The data was converted into instant graphs in the channels opened on the Thingspeak IoT platform. The image of the designed system is shown in Fig 4.

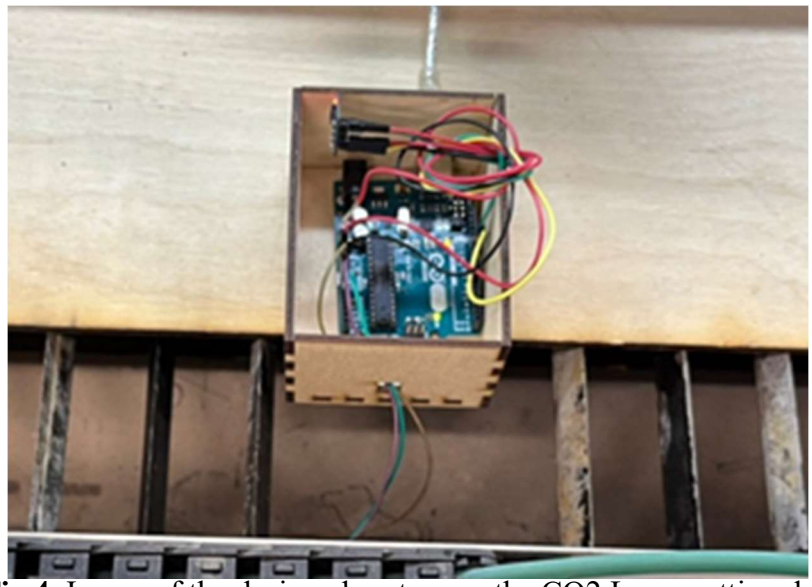

Fig 4. Image of the designed system on the CO2 Laser cutting device

2.3. Thingspeak IoT Platform

The Internet of Things is the ability of every object that the human mind can think of to communicate with other objects through the Internet [17]. Sensing provided by Wireless Sensor Network (WSN) technologies, which is the main usage area of IoT (Internet of Things), is encountered in many areas of today's life. This offers the ability to measure, infer and understand environmental indicators from sensitive natural resources to urban environments. The proliferation of these devices in a communicating network creates the Internet of Things (IoT). Here, sensors and actuators interact seamlessly with the environment and enable information to be shared between platforms to develop a common communication language. Fueled by the adoption of various wireless technologies such as RFID tags and embedded sensor and actuator nodes, IoT has evolved day by day from its inception [18,19]. Thingspeak is a web address used as an IoT channel. The data received through sensors and controllers can be sent to the Thingspeak platform, converted into instant graphics, and sensor data can be tracked. Additionally, Thingspeak is an open source Internet of Things application and API for storing and retrieving data from sensors using HTTP. It is an IoT analysis platform service that allows you to collect, visualize and analyze live data [20].

3. Research Findings

In this study, air quality index was measured from the gases released as a result of processing 4 different materials with a CO_2 laser cutting device. Measurement of air quality index was provided by microcontroller development card and MQ135 air quality sensor. In addition, by adding an ESP8266 wifi module to the system designed for easier tracking of measured values, the system was connected to the internet and the data was instantly sent to the Thingspeak IoT platform via this module. A graphical representation of the 4 materials processed in the Thingspeak channel is shown in Fig 5. Graphical representation of the air quality index during the processing of 4 materials in the Thingspeak channel.

Fig 5a. Birch plywood

Fig 5b. Beech wood

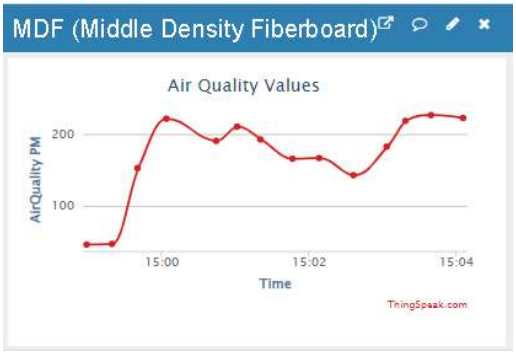

Fig 5c. Middle Desnsity Fiberboard

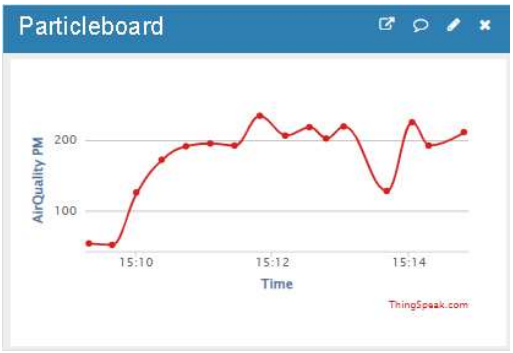

Fig 5d. Chipboard

The average air quality index of the gases released when processing birch plywood material with a CO_2 laser cutting device was determined as 192.42. The average air quality index measured as a result of processing the solid beech material under the same conditions and in the same environment was determined as 193.4. The air quality index resulting from the gases released as a result of the processing of MDF fiber board was measured as 170.78. The air quality index was measured as 176.06 due to the gases released as a result of the processing of the same size chipboard (chipboard) by the device. A graphical comparison of the average air quality indexes of these 4 materials in the thingspeak channel is shown in Fig 6.

Fig 6a. Birch plywood air quality

Fig 6b. Beech wood air quality

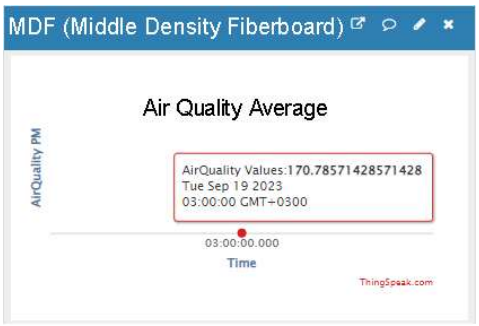

Fig 6c. Middle Desnsity Fiberboard air quality **Fig 6d.** chipboard air quality

The data obtained in the study can be tracked graphically on the Thingspeak IoT platform and the Thingview program, which is the Android software of the Thingspeak platform. Channel data was pulled from the Thingview program. The user will be able to instantly monitor the air quality index while processing wood materials from his android device. The image of the air quality index in the Thingview program is shown in Fig 7.

Fig 7a. Birch plywood air quality average **Fig 7b.** Beech wood air quality average

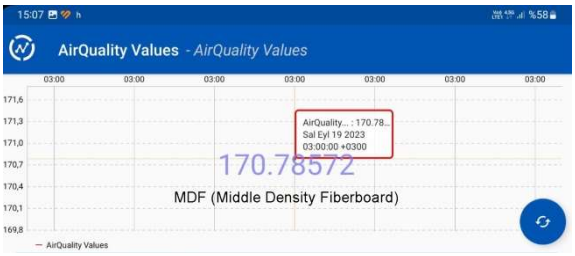

Fig 7c. Middle Desnsity Fiberboard air quality average **Fig 6d.** Chipboard air quality average

4. Results

Air quality is an important factor affecting human health. The level of air quality in workplaces, workshops and factories also affects the health and working efficiency of employees. In this study, the air quality index was measured from the harmful gases released as a result of processing 4 different materials (birch plywood, mdf, beech and chipboard) with a CO_2 laser cutting machine. Microcontroller development board and MQ135 air quality sensor were used to measure the air quality index. In addition, an ESP8266 wifi module was added to the controller and coded to send the measured air quality to the internet. The average of these 4 materials measured with the same number of data under the same conditions was taken on the Thingspeak channel. These 4 materials are compared graphically. As a result of the comparison, it was determined that MDF has the lowest air quality index and is less harmful among these 4 materials. It has been determined that beech wood material has the highest air quality index and reduces air quality compared to other samples. In addition, thanks to the device designed during the cutting that connects to the internet and sends instant data, the day-to-day and instant status of the data can be monitored remotely both from the Thingspeak internet address and with the Thingview android software. With this study, it can be concluded that the health of workers in wood workshops, production efficiency and environmental effects are directly dependent on the presence of these gases.

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