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Effect of Candles Burning on Ventilation of Premises

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Abstract. At present, the use of different candles in the house has increased significantly to create a pleasant environment. At the same time, from an energy point of view, it is an attempt to reconstruct and create buildings as densely as possible to provide the least heat loss due to uncontrolled ventilation. Is it safe to use a home candle in this regard? The article is a brief documented history of candles, the principle of combustion and the effect of burning candles on the internal environment. The purpose of the article is to indicate how the burning of candles affects the need for ventilation of the room. Experimental measurements were made to achieve this aim Measuring of the production of carbon dioxide at flames of candles is the subject of this study. Experimental investigations have been carried out and the results of research are presented in figures and analytic equations. Measurement took place in three stages with order to some methods There have been measured both internal and external air parameters that are documented in figures From the given data, it can be argued that the greatest increase in the concentration of carbon dioxide occurred during the second stage of measurement, when the person was in the room when the candle burned. Effect of candles burning on the environment is presented. For example, some candles emit dangerous substances for human health and are pollutants in the air. Burning of candles process has been analyzed and a chemical scheme of a burning candle is presented. From measured and calculated data it can be argued that the flame of candles during an experimental measurement causes an increase in the concentration of carbon dioxide by 76 %, as in the case of human being.

Key words: candle, room, carbon dioxide, ventilation, air flow rate.

Introduction. Candles are used as a light source for thousands of years. Historians have found evidence that many early civilizations developed candles using waxes from available plants and insects. People used candles to illuminate their homes, help night wanderers and religious ceremonies. In the Middle Ages candles were made of animal fat and beeswax. Later they began to be made of fatty whales. In the 19th century a modern candle was growing. The first paraffin was isolated from beech wood resin in 1833 by C. Reichenbach in Blansko near Brno [1]. Paraffin as a petroleum product was put into production in the 1950s. One of the pioneers in Europe who was involved in oil refining was the pharmacist and inventor Jan Jozef Ignatius Lukaszewicz (1822-1882), who in 1850, in Lviv, Poland, first received an oil kerosene by means of distillation. Paraffin was produced as a byproduct [2]. From the archival reports of the Kralupsk Refinery, Lederer et al. Founded in 1900, 5 kg of paraffin was obtained from 100 kg of Borislav oil, among other products [3]. In Europe, oil refineries for kerosene and paraffin were built during this period. With the introduction of production of light bulbs, the production of candles began to decline. The popularity of the candle began to increase significantly since the mid-1980s, when the candles were interested in decorative elements. They began to produce candles of different sizes, shapes and colours. There is a great interest of

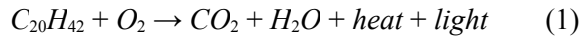
consumers in sparkling candles. At present candles are not used more as the main source of light, but as a life and social holiday [4].

Burning of candles. Waxes of animal, vegetable or oil origin are mainly hydrocarbons. Paraffin is the most commonly used candle wax.

Bees are also used in wax, soy wax, palm wax, gels, synthetic waxes and wax blends. Known candlesticks use only high-quality waxes [4]. Paraffin, which is a by-product of oil production, is most often used for the production of candles. This is a white mixture of higher saturated aliphatic hydrocarbons. It is no taste and no smell. It is insoluble in water. It is obtained by distillation of crude oil or crystallization by de-browning brown coal. It is also produced by catalytic synthesis. The paraffin melting temperature is from 42 °C (soft paraffin) to 65 °C (solid paraffin) and above. The boiling point is approximately 300 °C [5].

All waxes are hydrocarbons and consist of hydrogen (H) and carbon (C). Paraffin wax is a combination of carbon and hydrogen, whose chemical formula is C_nH_{2n+2} , where $n \geq 16$ [6]. After sparking the candle, the wax melts around the wick. Liquid wax is a capillary force drawn into the flame of a candle, where it turns into warm gas and begins to decompose on the atoms of hydrogen (H) and carbon (C). Hydrogen (H) and carbon (C) molecules react with oxygen (O) from the ambient air during combustion, forming light, heat, water va-

por (H_2O) and carbon dioxide (CO_2). Chemical scheme of a burning candle:



When burning a candle flame (fig. 1), we see a blue area in the lower part of the flame, dark orange to a brown color above it, and a large yellow area of the flame above it, which is most visible. The blue zone of flame is rich in oxygen. In it, the molecules of hydrocarbons evaporate and begin to decompose on hydrogen and carbon. Here, water vapor and carbon dioxide [4] begin to form. Measuring the production of carbon dioxide at flames of candles is the subject of this study.



Fig. 1. Paraffin burning and size (Source: author's archive)

Effect of candles burning on the environment. Today candles are mainly used to improve the feelings in the room. For this reason, candlesticks are trying to produce candles with the smell that suits consumers. Scientists at universities and research laboratories around the world experiment with candles to learn more about burning candles and their effects on the environment in buildings.

For example, according to the authors of R. Masudi and A. Hamidi [7], some candles emit dangerous substances for human health and are pollutants in the air. In the period from 2008 to 2010, several types of paraffin candles were investigated and it was found that candle samples produce various hazardous products, including benzene, toluene and alkenes. Their conclusion was that the studied paraffin candles are dangerous to the human body in confined spaces.

Scientific group Derudi et al. [8] During their studies, the emission factors for pollutants, in particular for VOCs, which the EU identifies as priority pollutants in the room from the burning of scented candles, have been identified.

Climate engineering [9] argues that air in the average economy contains two to five times more pollutants than external air – which, of course, depends on the method of ventilation, and so on. In article "How to improve indoor air quality" [9] there are 9 ways to improve the air quality in the room, which, besides proper ventilation, mainte-

nance of the air conditioner, etc., recommends that you do not smoke indoors and avoid the use of sparkling candles.

For more information on how candles affect indoor air quality, we can find it on various other sites. such as Safe Air Environmental Inc. In the article "Candles affect the quality of air indoors" [10] states that the burning of some aromatic or aromatherapy candles in the apartment can be compared to smoking cigars.

Christian Seacher (Denmark) concluded [11] in his review that burning candles and cooking is the largest source of pollution in households.

The aim. The aim of the article is to indicate how the burning of candles affects the need for ventilation of the room. Experimental measurements were made to achieve this aim.

Experimental measurement. Experimental measurements were carried out in an office located on the second floor of a five-story building. The office has the following dimensions: length 5.63 m, width 3.4 m and height 2.72 m. The room has one open window with a height of 1.75 m and a width of 1.1 m. The internal volume of the room is 52.07 m^3 . The measurements are performed in winter.

The measurement took place in three stages with order to method [12-15]. During the first stage of the measurement in the office there was one person, and the candle did not fire. During the second stage of the measurement, one person was in the office, and a paraffin candle 22 mm in diameter was burnt all the time (fig. 1). During the third stage of the measurement there was no person in the office, and a 22 mm paraffin candle was constantly burned. During all three measuring stages, the window and the door in the room were closed.

Results of experimental measurements. The course of the concentration of carbon dioxide from all three stages of measurement is shown in Fig. 2.

From Fig. 2 we can observe:

- during the first stage of measurement from 7:29 am to 7:59 am, the concentration of carbon dioxide increased from 653 ppm to 781 ppm;
- during the second measurement step from 8:41 am until 9:10 am the concentration of carbon dioxide has increased from 719 ppm to 944 ppm;
- during the third measurement step from 10:00 am to 10:30 am, the concentration of carbon dioxide increased from 590 ppm to 659 ppm.

From the given data, it can be argued that the greatest increase in the concentration of carbon dioxide occurred during the second stage of measurement, when the person was in the room when the candle burned. The concentration of oxide in the room increased by about 7.5 ppm/min.

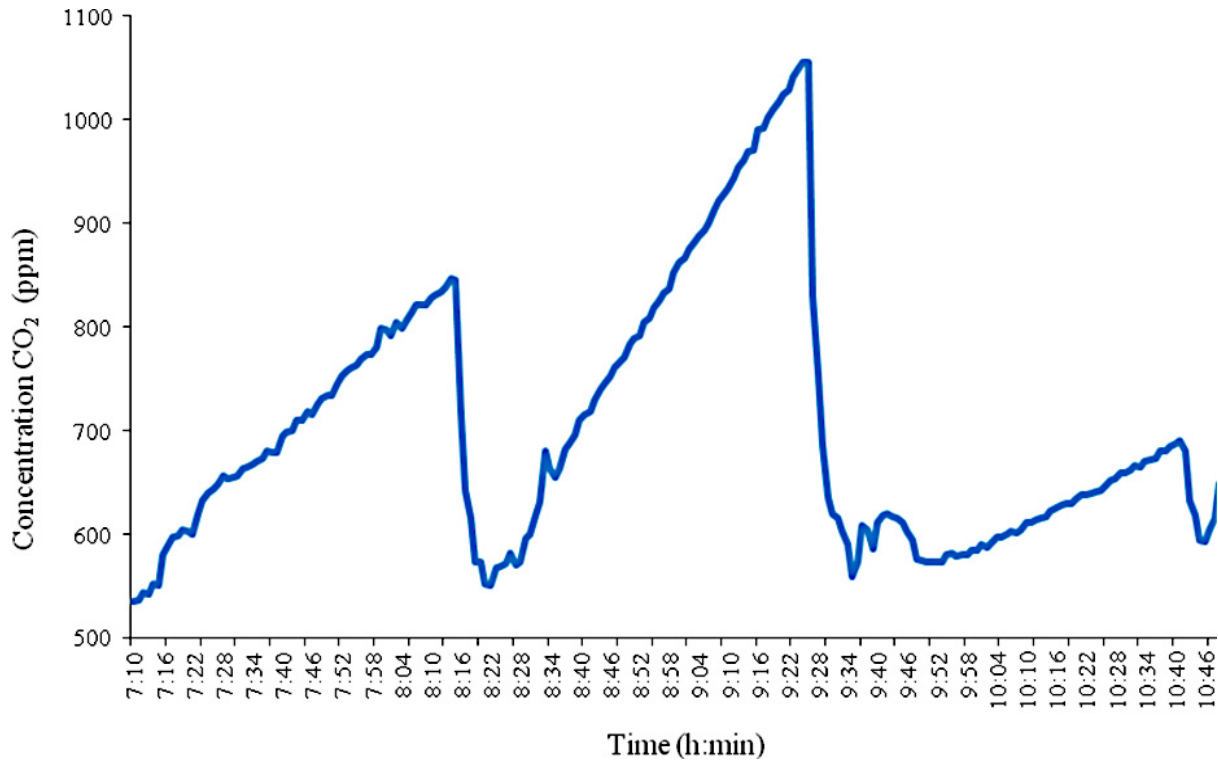


Fig. 2. Measurement of carbon dioxide concentration

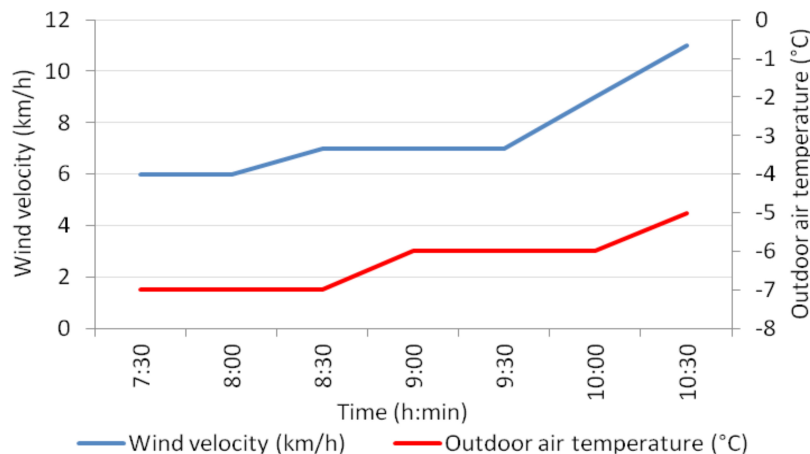


Fig. 3. Outdoor air parameters

The slightest increase in the concentration of carbon dioxide occurred during the third stage of measurement, when there was no man in the room, and the candle was burned. The oxygen concentration in the room increased by about 2.3 ppm/min. During the first phase of the measurement, when the person was indoors and the candle did not light up, the oxygen concentration increased to about 4.3 ppm/min.

The increase of the concentration of carbon dioxide in the room is strongly influenced by the intensity of ventilation resulting from the leakage of the construction structures, which also depends on the weather – mainly on wind speed and air temperature. Measured external air parameters are

documented in Fig. 3.

From Fig. 3 shows that at the first stage of the experimental measurement, the average wind speed was about 6 km / h. In the second stage, the average wind speed was about 7 km/h, and in the third stage, the average wind speed was about 10 km/h. The temperature of the outside air during the entire measuring period was from minus 5 to minus 7 °C. It can be assumed that if the wind speed in the third stage was similar to the previous two stages, the increase in concentration would be about 3.2 ppm/min.

Conclusion. From measured and calculated data it can be argued that the flame of candles during an experimental measurement causes an in-

crease in the concentration of carbon dioxide by 76%, as in the case of human being. From the above results it can be argued that for this case, in the presence of a person in the room and the simultaneous burning of candles, it is necessary to provide almost twice the air exchange than if the

candle did not used. Also, when buying candles it is necessary to take into account the material from which they are made, so as not to harm the health.

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Вплив горіння свічок на вентиляцію

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Анотація. У даний час використання різних свічок у будинках значно збільшилося задля створення приємного середовища для людини. У той же час, з точки зору підвищення енергоефективності будівлі реконструюються та будуються якомога більш цільними, щоб забезпечити найменшу втрату теплоти через неорганізований повітрообмін. Чи безпечно користуватися в приміщеннях свічками? У роботі наведена коротка документальна історія свічок, принцип їхнього горіння та вплив спалювання свічок на внутрішнє середовище. Метою роботи є дослідити, як горіння свічок впливає на потребу вентиляції приміщення. Для досягнення цієї мети були проведені

експериментальні дослідження приміщення. Вимірювання кількості вуглекислого газу при горінні свічок є предметом даного дослідження. Результати досліджень представлені у числовому вигляді та у вигляді аналітичних рівнянь. Вимірювання відбувалося в три етапи: у присутності людини в приміщенні, те ж з горінням свічки та горіння свічки без присутності людини. Вимірювалися як внутрішні, так і зовнішні параметри повітря. З отриманих даних випливає, що найбільше зростання концентрації діоксиду вуглецю відбувалося на другому етапі вимірювання, коли людина перебувала в кімнаті, де горіла свічка. Найменше зростання концентрації діоксиду вуглецю спостерігалось на третьому етапі, при горінні свічки без присутності людини. Представлено вплив горіння свічок на навколишнє середовище. Наприклад, деякі свічки виділяють небезпечні речовини для здоров'я людини і забруднюють повітря. Проаналізовано процес горіння свічок і представлено хімічну схему горіння свічки. З вимірних і розрахункових даних можна стверджувати, що полум'я свічок під час експериментального дослідження викликає збільшення концентрації вуглекислого газу на 76 %, ніж людина. При горінні свічки слід збільшити повітрообмін у приміщенні близько двох разів.

Ключові слова: Свічка, приміщення, вуглекислий газ, вентиляція, витрата повітря.

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Влияние горения свечей на вентиляцию

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Аннотация. В настоящее время использование различных свечей в домах значительно возросло, чтобы создать приятную обстановку. В то же время, с энергетической точки зрения при реконструкции и строительстве зданий их делают максимально герметичными, чтобы обеспечить наименьшие потери теплоты из-за неорганизованного воздухообмена. Безопасно ли использовать при этом свечи? В статье представлена краткая документированная история свечей, принцип горения и влияние горящих свечей на внутреннюю среду. Цель статьи - показать, как горение свечей влияет на вентиляцию помещения. Для достижения этой цели были проведены экспериментальные исследования. Измерение количества углекислого газа при горении свечей является предметом данного исследования. Проведены экспериментальные исследования и результаты исследований представлены в числовом виде и в виде аналитических уравнений. Измерение проводилось в три этапа. Были измерены как внутренние, так и внешние параметры воздуха. Из приведённых данных можно утверждать, что наибольшее увеличение концентрации углекислого газа произошло во время второго этапа. измерения, когда человек находился в комнате, где горела свеча. Представлено влияние горения свечей на окружающую среду. Например, некоторые свечи выделяют опасные для здоровья человека вещества и загрязняют воздух. Проанализирован процесс горения свечей и представлена химическая схема горения свечи. Согласно измеренным и расчётным данным можно утверждать, что пламя свечей во время экспериментального измерения вызывает увеличение концентрации углекислого газа на 76%, как и в случае пребывания человека.

Ключевые слова: свеча, помещение, углекислый газ, вентиляция, расход воздуха

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