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Research paper

Energy-Biological Agricultural Complex

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Abstract

When conducting modern farming on an industrial basis, there is a need to grapple with carbon dioxide surpluses in some premises, for example, it concerns livestock sheds- in order to improve the microclimate for raising productivity of animals, on the other hand there are production facilities that, according to the technology, require artificial carbonation of their space, for example, in greenhouses the process is used to increase the crop.
The paper gives an overview of existing methods of supplying carbon dioxide to a greenhouse, which primarily provides higher crops of plants when they are cultivated under glass. The air supply variant of gas saturated with carbon dioxide from the livestock shed has been proposed.

Keywords: *carbon dioxide, energy-biological complex, greenhouse, livestock shed, ,..*

1. Introduction

Agriculture is one of the leading industries in Ukraine. It is a basic component of Ukrainian agrarian sector. Agriculture consists of plant production and live stock breeding.
In recent years the greenhouse economy in Ukraine has been developing dynamically, but is not yet saturated. Its feature is that, the right approach to cultivation and marketing, makes this industry highly profitable even during the overproduction season.
The main technical task of the greenhouse economy is to provide the optimal climatic conditions for cultivating vegetables and greenery throughout the year. At the same time, the climatic and agro-cultural optimization, which is achieved in greenhouses, intensifies production manifold, which allows obtaining from the area unit the harvest much larger than on the field, and, the main thing, all year round.
For intensive and profitable greenhouse management, there is a certain concentration of carbon dioxide in the air, since carbon is the main building material for plants, which becomes a dry substance in the photosynthesis proces, and therefore the productivity and viability of cultivated crops depend directly on the CO_2 availability in the air. The natural carbon dioxide background in the outside air is, on average, 0.03 ÷ 0.04% by volume. Increasing the concentration to 0.2-0.6% [1] accelerates the photosynthesis process, which leads to an increase in the crop yield and helps to accelerate their afterripening.
In order to increase the yield of cultivated crops, the carbonate fertilization must be carried out during the growing season, beginning with the seedling growing . Especially high crop increments are observed during the flowering and fruiting plants. Assimilation processes under CO_2 optimum content in the air and sunlight, in addition, depend on the air temperature.

2. Main body

2.1 Overview of the latest research and publications

In the premises for the livestock management it is necessary to provide for the air exchange to remove excess heat, moisture, harmful gases and other substances. The air exchange organization is carried out using ventilation systems with natural, artificial or combined excitation [2].
The carbon dioxide fertilization is effective in winter when seedlings are grown with additional lighting. With the increased content of carbon dioxide in the air, plants in greenhouses use light energy more economically.
Carbon dioxide belongs to the 4th grade of danger according to GOST (all-Union State Standard) 12.1.007-76 by the degree of influence on the human body. Carbon dioxide is non-toxic and non-explosive, therefore, in accordance with the regulations [1], the air enrichment in greenhouses is acceptable.
In modern greenhouses, the following methods of supplying carbon dioxide to greenhouse modules are used (Fig. 1):
• Use of CO_2 from cylinders or gas collectors with liquid carbonic acid vented in cultivating premises through perforated pipes;
• carbonic anhydride use in solid form (dry ice), which is enclosed in small lattice boxes;

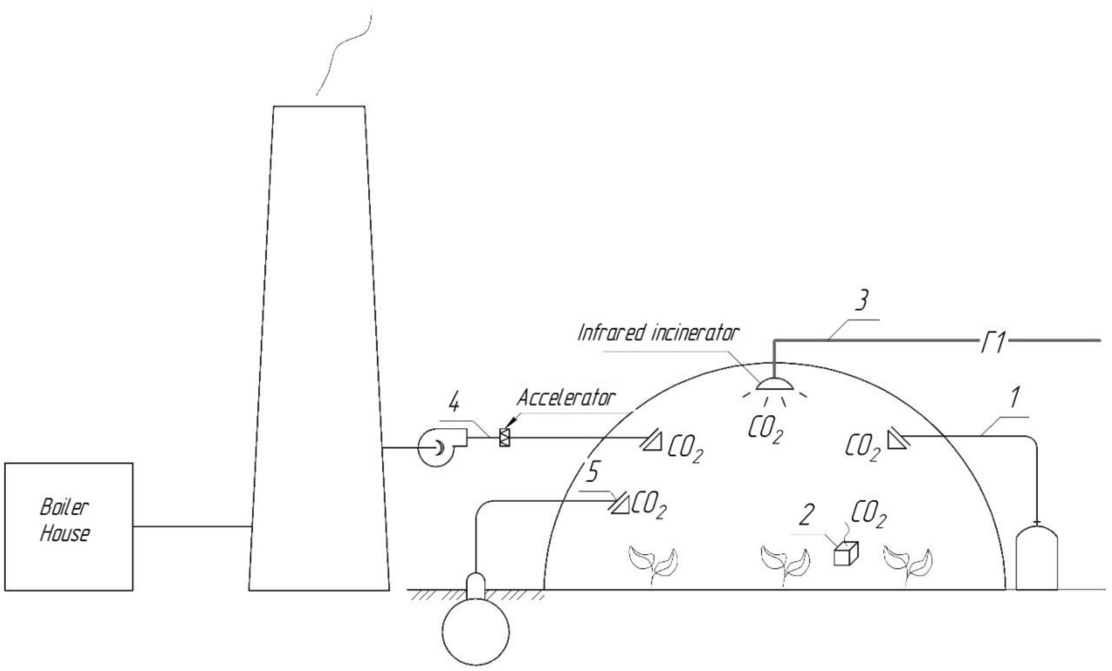

Fig. 1: Options for supplying carbon dioxide to the greenhouse: 1 – from cylinders with liquid carbonic acid; 2 – carbonic anhydride in solid form; 3 – from combustion of natural gas in infra-red incinirators; 4 – application of boiler exhaust gases; 5 – from storage container (gas collector)

• natural gas combustion in generators, which contributes to the CO_2 formation with small sulfur dioxide additives;• plant nuitrition by carbon dioxide due to the use of boiler flue gas emissions.

1. Cylinders. The use of liquefied carbon dioxide in cylinders is one of the simplest but expensive ways to fertilize plants with carbon dioxide. Nutrient carbon dioxide does not contain any harmful to plants additives, does not affect the greenhouse temperature regime. 60-80 kg CO_2 in cylinders (one cylinder contains about 25 kg of CO_2) are used per day for saturate air with carbon dioxide in 1000 m^2 greenhouse. For uniform nuitrition carbon dioxide from cylinder to plants is supplied through perforated rubber hose or polyethylene pipes with 4-5 mm diameter holes at a distance of 6-8 m apart.
2. Fertilizing with solid carbon dioxide (dry ice). The advantage of this method is that when heated in hot weather, the air temperature in the greenhouses decreases. Solid carbon dioxide is delivered in pieces of 25-35 kg in isothermal vans. 15-20 g of dry ice are used for the carbon dioxide air saturation for 1 m^3 of greenhouse. Dry ice is broken into small pieces weighing about 1 kg and evenly put in the greenhouse into boxes, mounted on flats or suspended on wire frames at 1,7 ÷ 2 m height.
3. Carbon dioxide fertilizing by gas and natural gas combustion. In the protected ground practice the fertilization through natural gas or sulfur-free gas combustion in special generators is the most popular. 1 m^3 of methane gives about 1.9 kg of CO_2. In this case infrared incinerators are used, which, in addition, allow maintaining high temperature indoors.
4. In comparison with gas generators, the boiler waste gas use has several advantages: the fertilization period of plants is prolonged for 2-3 months; the range of concentration of carbon dioxide is more widely regulated in the automatic mode. This nutrition system principle is the following: a part of exhaust gases is taken from the boiler house catalyzer with the help of high-pressure fans, and after cleaning from the carbon monoxide in the catalytic device, it is delivered through the main pipeline into the distribution pipelines, from which the polychlorovinil distribution hoses of 50-70 mm in diameter are bent to the greenhouse. The system works in manual and automatic modes.
5. Fertilizing with carbon dioxide from the storage container (gas collector) which should be periodically filled. This is not the cheapest way, since refueling is expensive.

2.2 General problem selection

This work is carried out to study the possibility of combining into one agricultural plant production facilities for different purposes and assessing such modulation economic components.

2.3 The work purpose

This work purpose of this is to reduce capital and operational costs to provide the necessary conditions for cultivation of plants in greenhouses [3, 4, 5].

2.4 The main material

In order to preserve energy resources and reduce the cost of supplying the greenhouse complex with energy resources, as a variant, we shall consider the method of CO_2 supplying with the air that is delivered from the livestock shed to the greenhouse, i.e., the energy-biological agricultural plant organization using both the heat of the air removed from the livestock shed and carbon dioxide contained in this air for using to intensify the production of plant origin product [7, 8 ,9, 10].

At the same time, the energy-biological agricultural plant will be a combination of objects of two types, namely, a greenhouse module and a livetock shed (Figure 2).

As an example for the calculations let us consider a greenhouse complex consisting of individual modules of 7.6 × 36 m area, and a livestock shed - a standing for 263 young cattle heads. Young cattle is over a year old, the average weight of an animal is 350 kg. Constructive scheme - a complete carrying frame in the form of a rack-beam system with keramzite concrete cladding panels.

Construction area is the village of New Tagamlyk, Mashivka district, Poltava region. Average temperature of the coldest five days is $t_{ext5} = -23\,^{o}C$, the coldest day is $t_{c.d} = -26\,^{o}C$ The heating period for the young cattle premises begins at $t_{ext} = +2\,^{o}C$. The heating period duration is $T_{h.p} = 3087$ h. Average temperature during this period is $t_{h.p.} = -4.7\,^{o}C$.

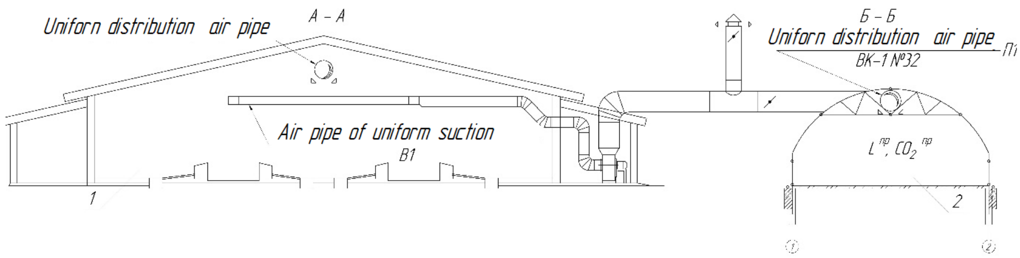

Fig.2: CO_2 supply principal scheme of with exhaust air from the livestock shed,

1 – livestock shed module; 2 - greenhouse module

Young cattle is kept in the stall; relative air humidity the premise is $\varphi \leq 75\%$ (normal humidity-mode). The premise filling with animals is less than 80 kg of live weight per 1 m^2 of floor. The amount of carbon dioxide emitted from all cattle is determined by the formula [6]:

$$A_{CO_2} = n \cdot a_{CO_2} \quad (1)$$

where a_{co_2} is the amount of carbon dioxide per animal, l / h, n is the number of cattle.

Then, the A_{co_2} hourly amount is 28,152 m^3/h .

The greenhouse module volume is calculated according to the formula:

$$V = \frac{1}{2} \cdot \pi \cdot R^2 \cdot H \quad (2)$$

where R is the arch design curvature radius of the greenhouse module;

H is the greenhouse module length;

$$V = \frac{1}{2} \cdot 3{,}14 \cdot 3{,}75^2 \cdot 37 = 817 m^2$$

To calculate the greenhouse module provision with carbon dioxide, we set the necessary carbon dioxide concentration of 0.6% in volume. In this case, the required CO_2 consumption for 1000 of greenhouse modules volume is 6 m^3 /h . Accordingly, to provide a given concentration of one greenhouse module, it is necessary 4.9 m^3 /h of carbon dioxide. Therefore, the number of modules that can provide the livestock shed is

$$n = 28{,}152/4{,}9 = 5{,}74 \approx 6 \text{ modules}.$$

Comparison of CO_2 normative value provision variants in the premises of greenhouse modules is carried out. The results of the comparison of operating costs are shown in Fig. 3.

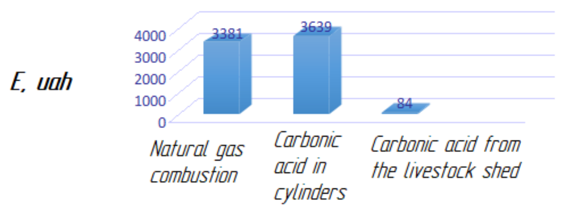

Fig. 3: Comparison of operating costs for providing a greenhouse complex consisting of six modules, with carbon dioxide during 24 hours, UAH

3. Conclusions

Carrying out this method of carbon dioxide delivering to the greenhouse complex, we get a number of advantages:

1. Providing CO_2 concentration necessary level in the greenhouse air, which has a positive effect on the yield of cultivated crops.
2. Possibility to use the heat of air released from the livestock shed for heating greenhouse modules during the cold season.
3. The saving of fuel and energy resources in the creation of agricultural energy-saving complexes.

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