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Study on Development and Application of Microwave Technology

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ABSTRACT Microwave technology in just a few decades has penetrated into all walks of life, to social development and people's life had a profound impact. On the basis of the development of the microwave, the details of the mechanism of microwave heating and microwave sterilization of both technologies, and microwave heating conditions and characteristics of clarification, in addition, also includes microwave technology is widely used in various fields, while microwave technology for the existing problems are analyzed, and the prospects for the development of microwave technology is also discussed.

KEYWORDS

Microwave technology

Microwave heating

Microwave sterilization

1. Introduction

Microwave is a very short wavelength electromagnetic wave. The wavelength is range between 0.1 mm to1 m, so because its value is the longest wavelength shorter than the wavelength of ultra-short minimum value, so called microwave. Microwave has a very high frequency, which range between 300 MHz to 3000 GHz, so microwave also referred to as "ultra-high frequency electromagnetic waves". Microwave overall range between infrared and FM, depending on the wavelength of the microwave range, but also the microwave into decimeter, centimeter wave, millimeter and sub millimeter wave.

With the development of science, microwave technology has been widely used, especially in the communications industry, such as microwave satellite communications, microwave scattering communications, analog microwave communications and digital microwave communications. To avoid mixture of frequency between microwave communications industry, medicine, science and frequency interference, the frequency of the microwave communication with other uses of the microwave frequency used separately. Currently, industrial, medical and scientific are commonly used microwave frequencies such as 433 MHz, 915 MHz, 2450 MHz, 5800 MHz and 22125 MHz, where 915 MHz and 2450 MHz are commonly used in industrial heating.

2. Development of microwave technology

Development of microwave technology depends largely on the application and development of microwave devices. In the early 1900s, researchers have begun to explore the microwave theory and experimental research related. But then the smaller power signal generator coupled with signal receiver sensitivity was poor, so the experiment was failed to achieve substantive progress [2]. In 1936, the further development of techniques for the study of microwave waveguide technology provides reliable theoretical and experimental conditions. American Telephone and Telegraph Company George C. Southworth. The waveguide used as a broadband transmission line and patented the same time, ML Barrow MIT completed the ATC transmission of electromagnetic waves experiments, these work rules waveguide laid the theoretical foundation to promote microwave technology for further development [3]. In the 1940s, during World War II, the emergence and use of radar raises Microwave Theory and Techniques of attention, and developed a lot of microwave devices, in this period, and has been the rapid development of microwave technology in practical applications recognition. However, conditions at the time of war, countries are busy with practical application, the study of microwave theory still is lacking, so make microwave theory lags behind practice. From 1945 to 1965, the pace of development of microwave technol-

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ogy has been significantly improved, while its wider range of applications. In the past 20 years, gradually opened up a new microwave band and formed a series of new fields of science radio meteorology, radio astronomy, microwave spectroscopy and the like. More systematic and complete establishment of a set of microwave electronics theory, for the further development of microwave technology has laid a theoretical foundation. After 1965, the microwave equipment toward miniaturization finalized and when the direction of the development and application of microwave integrated circuits and microwave solid state devices. At present, the microwave equipment are in a higher frequency band, wideband, high power, digital, high reliability, miniaturization and other aspects of development, monolithic integration and millimeter, sub-millimeter-band microwave development has become the focus of the research stage technology direction [4].

3. Two kinds of commonly used microwave technology

3.1. Microwave heating

3.1.1. The principle of microwave heating

Microwave heating is a polar dielectric material by absorption of microwaves so that the electromagnetic microwave energy into heat medium to achieve. Polarization is closely related to the transformation process and the dielectric material inside the molecule. Specific works as follows: When the material containing polar molecules placed in a microwave electromagnetic field in the dielectric material in the polar molecules produce hundreds of millions of times per second violent rotation at high frequency alternating electromagnetic field, and with the high frequency alternating electromagnetic field direction rearrange, polar molecules such regular periodic movement must overcome the interference and obstacles between neighboring molecules, resulting in an effect similar to friction. The results showed that the effects of microscopic electromagnetic energy into microwave energy within the dielectric material, while macro that is manifested as increased body temperature to be heated [5-6].

3.1.2. Realize the conditions of microwave heating

Because microwave heating is a material loss by itself in electromagnetic fields and conducted electromagnetic energy heated, the thermal effect is based on the absorption of polar molecules dielectric material for microwaves generated, so that microwave heating to be achieved, requires the material itself must capable of absorbing microwave [5].

(1) Dielectric material consisting of a polar molecule, the ability to absorb microwaves better. For example, the polarity of the water molecules is very strong, can well absorb the microwave, so whenever aqueous substance will be able to absorb microwaves, the aqueous substance will be achieved by microwave heating.

(2) A dielectric material consisting of non-polar molecules, absorb little or no absorption of the microwave, but it can pass through the microwave, so that such substances can be used as the microwave heating container, also it is used as a sealing material. For example, plastic products, glass, ceramics, bamboo containers, polyethylene, polytetrafluoroethylene and the like. The use of such substances as a heating vessel can only make the incident microwave heating of food, but the container itself does not heat.

(3) There is a special kind of material does not absorb microwaves, namely metal [4]. Similar exposure to light will be totally reflected in the mirror characteristics, when microwave irradiation to the metal surface, will be totally reflected, namely microwave metal does not work, so we can see, metal products cannot be used for microwave heating container.

3.1.3. The matters needing attention of microwave heating

(1) Since the metal does not absorb the microwave, and the microwave is irradiated to the metal surface will be totally reflected, so to avoid the metal film microwave packaging items or bags on the printed image of the article made of metal powder is heated, otherwise metal The following section will not have any heating effect [4].

(2) Avoid the mixing of metal sheet or a metal needle in the object to be heated. Not only can the heated metal surface requirements, but the same cannot be heated mixed metal object. This is because the metal tip of the microwave electric field of the most concentrated areas, not only cannot achieve normal heating, but also the formation of point discharge, thereby generating heat in the tip of a thin parts [4].

(3) The use of selective heating container. Material due to non-polar molecules plastics, ceramics, glass, bamboo utensils and other components do not absorb microwave energy through a microwave, so it is very suitable for use as a heating vessel. Under normal circumstances, plastic or ceramic microwave heating containers do best.

3.1.4 Microwave heating characteristics

(1) Instant of the microwave heating [7]. Because microwave heating is electromagnetic energy into heat, so for internal heating, no heat transfer process, and both inside and outside heating, uniform effect, instantaneously can reach high temperatures, time-saving convenience.

(2) Efficiency of the microwave heating [7]. In the microwave heating process, only the object itself absorbs the microwave to be heated and converted into thermal energy, and the microwave heating chamber wall does not absorb the microwave device is a metallic material, heating the container is hardly absorbed microwave non-polar material, therefore, the heating device heating the container itself and the corresponding almost no heat loss, so the thermal efficiency is very high.

(3) Selective microwave heating. Dielectric material consists of polar molecules and non-polar molecules, accord-

ing to the conditions and principles of microwave heating, the only substance consisting of polar molecules absorb microwave can achieve microwave heating. Thus, this feature can be used to achieve the microwave heating of the different components of the mixture or compound selective heating of different parts [7].

(4) Microwave heating safety harmless, no waste generation. Compared with a conventional method using fossil fuel combustion heating, microwave heating does not produce carbon dioxide, no environmental pollution [7].

(5) The lack of microwave heating due to internal heat dissipation, so that the internal temperature is higher than the outside temperature, the temperature gradient distribution presented, forming the driving internal moisture to penetrate the surface of the vapor pressure difference, so that the water evaporates faster. This feature microwaves sometimes make microwave heating of food taste changes. For example, the microwave heated bread poor taste and feel there is a fat coke, far less conventional heating bread soft and delicious. This is because microwave heating is by electromagnetic energy into heat energy to achieve, and not when heating water, and bread heated in the water will evaporate with increasing temperature, so that the bread in water less and less, so will lead to poor taste and the kind of fat coke feeling. The bread is generally conventional heating steam into the surface of the core through the bread, make the bread more and more moisture, so soft and delicious to eat, a lot of good taste will ever bread than microwave heating. The use of microwave heating enables this feature material internal moisture evaporation of migration, but also to achieve microwave drying using a microwave.

3.2. Microwave sterilization

Microwave sterilization is the use of microwave thermal effect and interaction of non-thermal effects of microorganisms in food to achieve the insect sterilization purposes. Microwave thermal effect is the use of microwave instantaneous reach high temperatures characteristic, is the destruction of the spatial structure of bacterial cells occurs, making it mutate the protein to achieve sterilization purposes. Non-thermal effects of microwave is also called biological effects, it is also the use of microwave heating of the transient characteristics of the material so that the physiological activity of microorganisms such as bacteria mutate and lead to abnormal growth and development until death, so as to achieve the purpose of sterilization preservation [4].

Microwave sterilization compared with traditional sterilization, and has many incomparable advantages. In general, the conventional method of sterilization of more than at least 100 °c, and longer when used, ranging from ten to several tens of minutes. The microwave sterilization temperature 70–90 °c can, with time short, usually 3 to 5 minutes [8]. Microwave sterilization and more thorough, safe and reliable, can extend the shelf life, but some of the material after microwave sterilization taste will be poor. Weili Feng compared the fish and other microwave sterilization and heat sterilization: Experiment 1: the role of 850 W continuous power microwave sterilization 135 s; Experiment two: 60 min heat sterilization in a water bath of 98 °c; the results showed that: two experimental to destroy E. coli was 100% effective; the protein content in the fish, two experiments were similar, but the fish in the water content, microwave sterilization lot worse than the water bath [9]. It led to microwave sterilization after the fish poor taste.

4. The application of microwave technology

4.1. Application of microwave technology in agriculture field

The use of microwave technology can be hydrolyzed corn cob. Corn cobs are a renewable resource and are use very extensive. Previously, people often burned as fuel or discarded as waste, causing a great waste of resources, and environmental pollution. The use of microwave technology can be hydrolyzed corn cob, to take advantage of its preparation of food additives and chemical raw materials, make full use of corncobs been [10]. Using microwave technology can be sweet potato slices [11], pepper [12], carrot [13] and honeysuckle [14] was dried, but also for oil seed oil [15]. The use of microwave technology can also soften the wood, to improve the performance of impregnated wood, thus simplifying wood stain, immersion treatment and other processes. Microwave technology can also be used for product quality testing, such as material defect detection, wood product moisture content testing and Formaldehyde emission testing [16].

4.2. Application of microwave technology in the medical field

The active ingredient can be detected using microwave technology medicine, herbal extracts [17], but also to use its dried carry out pills [18]. In addition, the microwave technology can also be used in clinical treatment, now it has been widely used in gynecology, ENT, physiotherapy, oncology surgery [19].

4.3 Application of Microwave Technology in Environmental Protection

The use of microwave technology for treating wastewater [20], gaseous pollutants [21], solid waste [22], etc. can either simplify the procedure, turning waste into treasure, nor secondary pollution. The use of microwave radiation may be dried animal dung, manure can improve efficiency, increase farm income, but also kill pathogens, reduce agricultural pollution. In addition, the use of microwave extraction and microwave digestion technology for environmental monitoring, etc. [22]. In short, the microwave technology has the energy-saving and environmental protection aspects, the pollution, high efficiency, can signifi-

cantly reduce the hazardous waste on the environment, and its application in environmental protection gradually by the people's attention.

4.4. Application of microwave technology in other areas

In addition to the above microwave technology has important applications in many fields beyond, and its application in the food industry, chemical and materials industry is also more and more people's attention. Microwave technology can be used for crushing, grinding, ore pre-processing and mineral roasting [7] and so on. The use of microwave technology can be expanded aquatic products processing and digestion [9], can also be used to prepare activated carbon and regeneration [23].

With the further development of microwave technology and microwave devices, microwave applications in various fields will become more extensive, and its practical application will be a corresponding push Microwave Theory continues to mature.

5. Microwave technology problems and prospects

5.1. Problems

Traditional methods cannot, although widely used and microwave technology has many advantages over, but as a new technology, its development is still in its infancy, there are still many problems to be solved.

(1) Notwithstanding the microwave technology it has been widely used in various fields, but also a lack of systematic theoretical foundation, especially for microwave mechanism of action is still relatively superficial understanding of its interpretation only stay on an experimental basis, subject to the use of more detecting verified as accurate way. Therefore, we should strengthen the research on the mechanism of microwave technology, making it a more systematic and complete theoretical system [24].

(2) Compared with other countries, China is still the stability of microwave equipment is lacking [25]. Therefore, it should strengthen the development of microwave components and equipment to improve the adaptability and compatibility of microwave devices, in order to develop a stable, economical and efficient microwave equipment.

(3) At present, the microwave device is a device in the home based on the transformation was complete, and its application and promotion is limited, not economies of scale. It should pay attention to cross-link the microwave process system and major discipline problems, and strengthen engineering research, the progressive realization of microwave theoretical achievements in industrial production, economies of scale, promote their application in industrial areas.

5.2. Prospects

Microwave technology is as an electromagnetic energy into heat special thermal way, not only in terms of widespread food heating, insect sterilization, drying preservation and other purposes, while also to catalyze chemical reactions, new materials development of microwave processing applications [26]. With the constant improvement of microwave technology development and deepening of microwave theory, microwave technology will gradually realize industrialization, its security, energy efficient, environmentally friendly and will also promote its advantages are widely used in all walks of life, to promote environment-friendly society The rapid development.

Conflicts of interest

These authors have no conflicts of interest to declare.

Authors' contributions

These authors contributed equally to this work.

References

1. Min, X. R., Tang, P. (2009). *Other Microwave Technology Base*. Beijing: Science Press.
2. Zhao, B. L., & Zhao, F. Microwave technology development and application of review. *China Science and Technology Information, 20*, 272–275.
3. Yang, X. X. (2009). *Microwave Technology Base*. Beijing: Tsinghua University Press.
4. Feng, P. S. (2009). *Microwave Technology in Industrial Production and Health*. Beijing: China Electric Power Press.
5. Shi, S. J., Cao, D. (2002). Microwave principle and its application in the food. *Shanxi food industry, 3*, 8–12.
6. Ning, Y. Z. (2006). Development and application microwave technology. *China Science and Technology Information, 18*, 142–143.
7. Cui, C., & Han, Y. (2006). New applications of microwave technology in the beneficiation. *Metal Mine, 4*, 29–32.
8. Yang, X. Q. (2008). *Microwave technology in China's food industry.* Application and development China Agricultural Machinery Institute 2008 Annual Conference Proceedings.
9. Duan, Z. H. (2008). Microwave technology in China aquatic products processing status of applied research. *Aquatic Science and Technology Information, 35*(1), 5–7.
10. Wang, C. F., & Zhao, G. H. (2010). Repair microwave technology in the hydrolysis of corn cob. *Chinese Food Additives, 3*, 203–206.
11. Jiang, Y. P., & Wang, J. (2009). Potato chip microwave drying characteristics and drying model. *Zhejiang Agricultural Sciences, 21*(4), 407–410.
12. Zhao, C. (2007). Pepper and other microwave drying characteristic. *Agricultural Machinery, 38*(3), 99–101.
13. Gulum, S., & Elif, T. (2005). Drying of carrots in microwave and halogen lamp-microwave combination ovens. *LWT, 38*, 549–553.
14. Ru, X. H., Wang, L. F., & Bing, W. J. (2001). Other research Honeysuckle drying microwave drying technology in the application. *Food Science, 1*(5), 41–43.
15. Yi, Y. X., Hu, T., Yin, Z. M. (2011). Microwave technology in the oil tea seed oil process. *Chinese Oil, 36*(2), 34–35.

16. Bin, S. H. (2012). Microwave technology in China's timber processing and product testing application. *Zhejiang Forestry Science and Technology, 32*(5), 75–78.
17. Liu, X. G., & Wang, X. (2010). Microwave technology application and development of the active ingredients in herbal extraction. *Guangming Chinese Medicine, 25*(8), 1544–1545.
18. Wang, H. Q., & Hai, S. J. (2011). Application of microwave technology and equipment in the pharmaceutical industry. *China Science and Technology Aspect, 20*, 340.
19. Qiong, Q. B. (2011). Microwave treatment works and clinical application. *Chinese Community Doctors ,13*(3) 120.
20. Wu, N. P. (2012). Super microwave technology in the oxidation reaction Research Progress Application. *Liaoning Chemical Industry, 41*(6), 607–609.
21. Wang, L. L. (2010). The application of microwave technology in energy conservation. *Guangzhou Chemical Industry, 38*(8), 17–18.
22. Sun, P. (2002). The application of microwave technology in the field of environmental protection. *Chemical industry environmental protection, 22*(2), 71–74.
23. Foo, K. Y., & Hameed, B. H. (2009).Recent developments in the preparation and regeneration of activated carbons by microwaves. *Advances in Colloid and Interface Science, 149*, 19–27.
24. Yang, C. C., & Ding, B. H. (2008). Advances microwave technology. *Chinese Ceramics, 10*, 3–5.
25. Jun, W. H. (2012). Current development of microwave technology and market prospects. *Changchun Normal University: Natural Science Edition, 31*(6), 44–46.
26. Chen, Y. Q. (2011). Discussion on principle Weibo micro blogging situation and development. *Guangdong Chemical Industry, 38*(11), 58–59.