Internet of Things Based Combustible Ice Safety Monitoring System Framework

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Abstract. As the development of human society, more energy is required to meet the need of human daily lives. New energies play a significant role in solving the problems of serious environmental pollution and resources exhaustion in the present world. Combustible ice is essentially frozen natural gas, which can literally be lit on fire bringing a whole new meaning to fire and ice with less pollutant. This paper analysed the advantages and risks on the uses of combustible ice. By comparing to other kinds of alternative energies, the advantages of the uses of combustible ice were concluded. The combustible ice basic physical characters and safety risks were analysed. The developments troubles and key utilizations of combustible ice were predicted in the end. A real-time safety monitoring system framework based on the internet of things (IOT) was built to be applied in the future mining, which provide a brand new way to monitoring the combustible ice mining safety.

1. Introduction
As the development of human society, more energy is required to meet the need of human daily lives. Compared with traditional energies, new energies generally have the characteristics of less pollution and large reserves. New energies play a significant role in solving the problems of serious environmental pollution and resources exhaustion in the present world. At the same time, many of the new energies are well-distributed, which are also very meaningful to solve the war caused by energy problem.

Combustible ice is essentially frozen natural gas – a natural gas hydrate, and is one of the newest energy sources to be discovered, which has been found in high altitude frozen plateaus as well as underwater in marine sediments. Natural gas hydrates are essentially just frozen methane and water and can literally be lit on fire bringing a whole new meaning to fire and ice. One cubic meter of combustible ice contains 164 cubic meters of regular natural gas and is considered to have few impurities, meaning it can burn cleaner with less pollutant.

While reserves of combustible ice have been found around the world, China’s discovery is big and estimates say that there is enough energy frozen in the tundra to provide the country with energy for 90 years. Natural gas, which is not a zero emission fuel, can only be considered a “cleaner” energy source compared to oil, but given the alternative of it just being released from melting, it might be wise to continue research on this new energy source.

This paper analysed the advantages and risks on the uses of combustible ice. By comparing to other kinds of alternative energies, the advantages of the uses of combustible ice were concluded. The combustible ice basic physical characters and safety risks were analysed. The developments troubles and key utilizations of combustible ice were predicted in the end. To deal with all the safety risks
during the mining, a real-time safety monitoring system framework based on the internet of things (IOT) was built to be applied in the future mining, which provide the a brand new way to monitoring the combustible ice mining safety.

2. The advantages and risks of combustible ice

2.1. The basic parameters of combustible ice
China organizes launching the previous research to natural gas hydrate since 1997. [1] In 1999, Ministry of Land and Natural Resources started the reconnoitring at sea of natural gas hydrate, launched the investigations of 18 voyages, find the intersection of north and land slope, the South China Sea of China, have very natural gas hydrate to compose and deposit the terms, and obtained a series of geophysics, geochemistry, geology, biology, etc. obvious evidence. [2-3]

At the end of December of 2003, the marine geological investigation bureau of Guangzhou was in the South China Sea area in the north for the first time, utilizing the sea floor to make a video recording, technology has found the ashen blocky deposition material of group in deep sea floor of 3000 meters, analyse that is thought, such ashen blocky material of group is after the combustible ice in the deep department stratum is decomposed, the coastal bottom of methane gas ruptures and gushes out to overflow the sea floor, take shape. [4-5]This conclusion gets the approval of the authoritative expert of international combustible ice. [6-7]This discovery verifies there is combustible ice in the sea area of the north of the South China Sea of China. Combustible ice is clean new energy with the burning results only with water. The burning combustible ice burning flame as showed in Figure 1.

![Image of combustible ice burning flame](image)

**Figure 1.** Combustible ice burning flame [8]

To form combustible ice there are three basic conditions. First of all, the temperature cannot be too high, may produce above the zero degree, from 0 to 10 centigrade for suitable, the most altitude limit is about 20 centigrade. The temperature will be again high to decompose combustible ice. The second pressure must suffice, but cannot be too big. In zero centigrade and above 30 atmospheric pressure conditions, it produces on the possibility. [9]

2.2. Safety risks of combustible ice
Although the development prospect of combustible ice is considerable, the mining difficulty is great. On the one hand is the combustible ice is located at the vast ocean base or on the high and cold dangerous far tundra, which are development difficultly. On the other hand, combustible ice owns some physical characters, also enables the combustible ice mining to be beset with difficulties.

The combustible ice is common product in the low temperature and the high-pressured. But the combustible ice “the hobby” may probably be much bigger than to the high pressure the low temperature. The people already discovered that under enough high pressure, combustible ice when 18℃, still might maintain “the ice” the nature, is one kind out-and-out “the high temperature ice”.

This has brought the very major difficulty for combustible ice's mining. If cannot guarantee that the enough high pressure and the low temperature, the combustible ice will melt rapidly for the water and the methane, if cannot carry on to the methane collects well, the massive methane will enter the atmosphere directly, the global climate will face a disaster.
Carries on mining to the ocean deep place's combustible ice, besides faces the similar environmental protection difficult problem, but also possibly causes the seabed to soften, presents the large-scale seabed landslide, the destruction seabed project facility situation.

At present develops mainly faces three problems: First, in the technical stratification plane has the difficulty, our country mines the natural gas the technology to be quite mature, but develops combustible ice to compare to development natural gas many procedures. Moreover develops improper, will create the natural gas revelation. Second, in the cost aspect, actually to mine is worthwhile. If the oil price reduces, whether to increase the development cost, also will be worth considering. Third, environment question, if will develop will create the very big destruction to the environment, then its development will also not have the significance. In fact all energy mining can the varying degree create the harm to the environment, but along with science's and technology's development, combustible ice can in control under the condition develops is feasible. But did not have the effective solution at present, the concrete solution is exploring.

2.3. The advantages of combustible ice

Combustible ice, known as the new energy that can be used 1000 years by human is the first choice of the future alternative to oil, coal and other traditional energy sources. One cubic meter of combustible ice can be released from 160-180 cubic meters of natural gas. Its energy density is 10 times that of coal. After combustion no residue and exhaust was produced.

The recent discovery marks the first time that exposed methane hydrate deposits have been found in Japanese waters. Methane hydrate, which is normally found several hundred meters beneath the ocean floor, is a sherbert-like substance that burns when exposed to flame. It forms when low temperature and high pressure under the ocean floor causes methane molecules to become trapped inside frozen water molecules.

Scientists from the University of Tokyo, the Japan Agency for Marine-Earth Science and Technology (JAMSTEC), and the National Institute of Advanced Industrial Science and Technology (AIST) are working together to collect samples from two points located at depths of 800 to 1000 meters (2600 to 3300 feet), about 30 kilometres (19 miles) offshore. They are using unmanned submarines to collect the ice. Based on the high electrical conductivity of the ground beneath the ocean floor, the scientists suspect the existence of large underground columns of methane hydrate. [10-12]

While methane hydrate is being hailed as a potential source of fuel in the future, methane is a greenhouse gas. Methane is generated when organic matter in deep layers of sedimentary rock breaks down due to heating. The methane moves into upper layers, where it accumulates and forms methane hydrate. As the temperature rises and pressure falls, methane hydrate dissociates into methane and water. The resulting methane concentration in the surrounding seawater ranges from dozens to thousands of times higher than normal.

3. System framework

To improve combustible ice mining safety, combustible ice mining monitoring system (CISMS) aims to monitor the combustible ice mining safety anytime, anywhere, which is based on the internet of things (IOT). The entire system datum are acquired by all kinds of wireless sensors, processed by the cloud computing platform, and then broadcasted to the terminals either on PDA or the clients.

CISMS is based on the internet of things (IOT) which is under the security technology and management concept generally.

3.1. The sensor layer of CISMS

Sensor layer is the core data acquiring component and the basic layer in the CISMS. Different kinds of sensors, such as the temperature sensor, pressure sensor, position gas sensor etc., are applied to acquire the combustible ice mining data. The sensors are mostly wireless sensors, which typically consist of a large number of low-cost, low-power, and multifunctional sensor nodes that are deployed in a region
of interest. These sensor nodes are small in size, but are equipped with sensors, embedded
microprocessors, and radio transceivers, and therefore have not only sensing capability, but also data
processing and communicating capabilities.

These sensors communicate over a short distance via a wireless medium and collaborate to
accomplish a common task. Compared with traditional wireless communication networks, for example,
cellular systems and MANET, sensor networks have the following unique characteristics and
constraints:

- **Dense Node Deployment.** Sensor nodes are usually densely deployed in a field of interest. The
  number of sensor nodes in a sensor network can be several orders of magnitude higher than
  that in a MANET.
- **Battery-Powered Sensor Nodes.** Sensor nodes are usually powered by battery. In most situations,
  these sensors are deployed in a harsh or hostile environment, where it is very difficult or even
  impossible to change or recharge the batteries.
- **Severe Energy, Computation, and Storage Constraints.** Sensor nodes are highly limited in
  energy, computation, and storage capacities.
- **Self-Configurable.** Sensor nodes are usually randomly deployed without careful planning and
  engineering. Once deployed, sensor nodes have to autonomously configure themselves into a
  communication network.
- **Application Specific.** Sensor networks are application specific. A network is usually designed
  and deployed for a specific application. The design requirements of a network change with its
  application.
- **Unreliable Sensor Nodes.** Sensor nodes are usually deployed in harsh or hostile environments
  and operate without attendance. They are prone to physical damages or failures.
- **Frequent Topology Change.** Network topology changes frequently due to node failure, damage,
  addition, energy depletion, or channel fading.
- **No Global Identification.** Due to the large number of sensor nodes, it is usually not possible to
  build a global addressing scheme for a sensor network because it would introduce a high
  overhead for the identification maintenance.

3.2. *The network layer of CISMS*

The network layer includes the remote control, VPN, M2M wireless access, wireless sensor network,
heterogeneous network integration and the fourth generation network. The network layer bridges the
sensor layer and the application layer.

The network layer is responsible for routing system packets delivery including routing through
intermediate routers, whereas the data link layer is responsible for media access control, flow control
and error checking. The network layer provides the functional and procedural means of transferring
variable length data sequences from a source to a destination host via one or more networks while
maintaining the quality of service functions.

The network layer of CISMS makes it possible to monitor the combustible ice in anywhere on
anytime. Its networks are partitioned into sub networks and connect to other networks for wide area
communications. Networks use specialized hosts, called gateways or routers to forward packets
between networks. This is also of interest to mobile applications, where a user may move from one
location to another, and it must be arranged the messages. Version 4 of the internet protocol (IPv4)
was not designed with this feature in mind, although mobility extensions exist. IPv6 has a better
designed solution.

3.3. *The application layer of CISMS*

The application layer is the top level of the CISMS structure. Basically it is based on the support
service platform, information platform and the cloud computing platform to accomplish the CISMS
functions through public middleware, intelligent recognition and the industrial monitor.
The cloud computing platform deals with the entire sensors layer datum transferred by the network layer, which is a technology that uses the internet and central remote servers to maintain data and applications. Cloud computing allows users to use applications without installation and access personal files at any computer with internet access. This technology allows for much more efficient computing by centralizing storage, memory, processing and bandwidth. The information platform is mainly to promote, share and exchange information on the combustible ice monitoring issues in different regions. The information platform aims to illustrate the combustible ice monitored datum graphically, which are calculated after the cloud computing platform. The support service platform provides the concerned support service to the CISMS users. All the system problems can be solved online on time. Any errors or abnormal behaviours are logged in the server.

4. Conclusions

Combustible ice, also called natural gas hydrate, with giant reserves and high energy density. It is a kind of new type green energy source which has a good prospect. According to comparative analysis of two kinds of development ideas, it presents that both international cooperation and independent technology innovation can promote developing more green and low cost recovery technology of combustible ice.

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