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An Overview of Cryogenic System and Applications

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Abstract: *The development in cryogenic system in various operation of cryogenic instrumentation in industrial raises the level of mission complexity, risk and associated cost. Any application must then be justified on the basis of its specific return. In this paper is represents overview of cryogenic scientific missions, the cryogenic detectors and applications related technologies, and the mission objectives, offering unmatched performance and unique advantages. In the case of other applications, such as telecommunications, the advantages offered by various industries produced devices need to be evaluated against their development and operating costs, and compared with alternative technologies.*

Keywords: *Cryogenic System, Cryogenic Freezing, Cryogenic refrigerant, Gas Turbines, NASA, ISRO.*

1. INTRODUCTION

Cryogenics" stems from Greek and means "the production of freezing cold";however the term is used today as a synonym for the low-temperature state. Cryogenics is the study of how to attain low temperatures and how materials behave when these low temperatures and how materials behave when these low temperatures are attained. Temperatures are attained. What cryogenics is not: It is not the study of freezing and reviving people. This is known as Cryonics, a confusingly similar term.

Cryogenics deals with low temperatures, from about 100Cryogenics deals with low temperatures, from about 100 Kelvin to absolute zero. Kelvin to absolute zero.

2. BACKGROUND

Cryogenic technology involves the use of rocket propellants at extremely low temperatures. Combination of liquid oxygen and liquid hydrogen offers the highest energy efficiency for rocket engines that need to produce highest energy efficiency for rocket engines that need to produce large amounts of thrust. Celsius and hydrogen at below minus 253 ° C. Cryogenics is the science that addresses the production and effects of very low temperatures. The word originates from the Greek words 'kryos' meaning "frost" and 'genic' meaning "to produce." Under such a definition it could be used to include all temperatures below the freezing point of water (0 C).

However, Prof. Kamerlingh Onnes of the University of Leiden in the Netherlands first used the word in 1894 to describe the art and science of producing much lower temperatures. He used the word in reference to the liquefaction of permanent gases such as oxygen, nitrogen, hydrogen, and helium. Oxygen had been liquefied at -183 C a few years earlier (in 1887), and a race was in progress to liquefy the remaining permanent gases at even lower temperatures.

The techniques employed in producing such low temperatures were quite different from those used somewhat earlier in the production of artificial ice. In particular, efficient heat exchangers are required to reach very low temperatures. Over the years the term cryogenics has generally been used to refer to temperatures below approximately -150 C.

History of Cryogenic Technology:

- The United States was the first country to develop cryogenic rocket engines, registered its first successful flight in 1963with RL-10 engines, registered its first successful flight in 1963 and is still used on the Atlas V rocket and is still used on the Atlas V rocket.
- The Japanese LE-5 engine flew in 1977 French HM-7 in 1979, Chinese YF-73 in 1984.
- The Soviet Union, first country to put a satellite and later a human in space, successfully launched a rocket launched a rocket with a cryogenic engine only in 1987.

2.1 Cryogenic technologies: Cryogenics is the science that addresses the production and effects of very low temperatures. The word originates from the Greek words 'kryos' meaning "frost" and 'genic' meaning "to produce." Under such a definition it could be used to include all temperatures below the freezing point of water (0 C).

2.2 **Cryogenic Freezing:** Cryogenic Freezing is a special type of freezing designed to do just that. Freeze living objects. It is a process developed to safely freeze and thaw living objects so they can be revived to the exact condition they were in when they entered the freezing process.

2.3 **Cryogenic refrigerant:** It is a gas that is used in the process of cooling materials that acts as the key component in the process of cryogenic freezing. This process turns gases that would otherwise remain gaseous at natural temperatures into liquids, making them easier to transport in large quantities.

3. EXISTING SYSTEM

Working of Cryogenic engine:

It involves a complicated 'staged combustion cycle' to increase the engine efficiency.

- Hydrogen is partially burnt with a little oxygen in a gas generator.
- The hot gases drive a turbo-pump and are then injected at high pressure into the thrust chamber where the rest of oxygen is introduced and full combustion takes place.
- Before going to the gas generator, the incredibly chilly liquid hydrogen is used to cool the thrust chamber where temperatures rise to over 3,300 ° Celsius when the engine is fired.

Millennium of progress in cryogenics:

- Invention of the helium liquefier which could be manufactured commercially (Sam Collins).
- Discovery of superconductivity by Kamerlingh Onnes (mercury) in about 1908.
- HTSC
- MRI
- SMES (Roger Boom)
- Cryogenic food freezing using liquid nitrogen and cryogenic carbon dioxide.
- Commercial use of products of air (oxygen, nitrogen, argon).
- Basic oxygen furnace for steel making.
- Space flight using liquid hydrogen and liquid oxygen propellants.
- Cryopreservation of blood and body parts.
- Deep space communication using cryo electronics.
- Superconductivity theory (John Bardeen).
- Infrared imaging (using cryogenic cooling)

Cryogenic Liquids:

- Commonly used gases, in their liquid form, are nitrogen and helium. These are the common cryogenic liquids.
- Liquid Helium and Nitrogen are usually Liquid Helium and Nitrogen is usually stored in vacuum insulated flasks called Dewar.
- Nitrogen condenses at -195.8 C (77.36Nitrogen condenses at -195.8 C and freezes at -209.86 C (63.17 Kelvin).
- Liquid nitrogen is used in many cooling systems.
- Helium boils at -268.93 C (4.2 Kelvin) and Helium boils at -268.93 C (4.2 Kelvin) and does not freeze at atmospheric pressure

Cryogen	Triple point [K]	Normal boiling point [K]	Critical point [K]
Methane	90.7	111.6	190.5
Oxygen	54.4	90.2	154.6
Argon	83.8	87.3	150.9
Nitrogen	63.1	77.3	126.2
Neon	24.6	27.1	44.4
Hydrogen	13.8	20.4	33.2
Helium	2.2 (*)	4.2	5.2

(*): λ Point

Table.1: Characteristics of temperatures of cryogenics

4. PRAPOSED SYSTEM

Cryogenic Technological system involves various operations such as

CONSTRUCTION:

1. The major components of a cryogenic rocket engine are the combustion chamber (thrust chamber), pyrotechnic igniter, fuel injector, fuel cryopumps, oxidizer cryopumps, gas turbine, cryovalves, regulators, the fuel tanks, and rocket engine nozzle.
2. In terms of feeding propellants to combustion chamber, cryogenic rocket engines (or, generally, all liquid propellant engines) work in either an expander cycle, a gas-generator cycle, a staged combustion cycle, or the simplest pressure-fed cycle.
3. The cryopumps are always turbo-pumps powered by a flow of fuel through gas turbines . Looking at this aspect , engines can be differentiated into a main flow or a bypass flow configuration.
4. In the main flow design, all the pumped fuel is fed through the gas turbines, and in the end injected to the combustion chamber. In the bypass configuration, the fuel flow is split; the main part goes directly to the combustion chamber to generate thrust, while only a small amount of the fuel goes to the turbine.

PROCESS FLOW:

1. Pressure of liquid nitrogen is increased from 0.7MPa to 2.9MPa using turbo-pumps.
2. Some of liquid nitrogen is utilized in cooling engine.
3. In gas form, nitrogen occupies a volume, 700 times than that in liquid form.
4. The engine's nozzle is 121 in (3.1 m) long with a diameter of 10.3 in (0.26 m) at its throat and 90.7 in (2.30 m) at its exit.

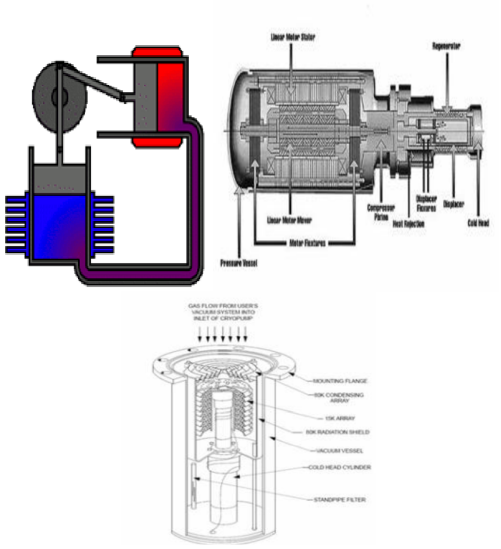

Figure.1: Cryogenic Devices

CRYOGENIC Technology used in various fields:

Cryogenic Engines in Aerospace:

- First operational Cryogenic Rocket Engine is 1961 NASA designed RL-10 LOX LH2 rocket engine.
- The second-stage Pratt & Whitney RL10B-2 engine is based on the 30-year heritage of the reliable RL10 engine At Mahendragiri in Tamil Nadu, is the LPSC. The system involves materials working at 23K and pumps at speeds of 40,000 rpm.
- Complex metering, monitoring, integrating technologies involved. The engines required to fire for 700 seconds during the final stage of a launch providing 7 tones of thrust Engine works on 'Staged Combustion Cycle' with an integrated turbo pump running at 42,000rpm.
- Also equipped with two steering engines developing a thrust of 2 kN each to enable three-axis control of the launch vehicle during the mission Closed loop control of both thrust and mixture ratio, which ensures optimum propellant utilization for the mission

Cryosurgery: Cryosurgery- Use of extreme cold produced by liquid nitrogen (or argon gas) to destroy abnormal tissue. Used to treat external tumors, such as those on the skin. For internal tumors, liquid nitrogen is circulated through a hollow instrument called a Cryoprobe. Used since many years in the treatment of skin cancer

Cryogenics in manufacturing field: Cryogenic treatment works on Reamers, Tool bits, Tool punches, Carbide Drills, Carbide Cutters, Milling Cutters, Files, Knives, Reciprocating Blades, Dies and cutting tools.

- Stress relieved ferrous and non ferrous castings and forgings for enhanced dimensional stability and surface finish

Cryogenics in electronics field:

- Super conducting electronic devices like SQUID (Super conducting quantum interference device) are used in sensitive digital magnetometers and voltmeters
- Zero friction bearings use magnetic field instead of oil or air, derived from the Meissner Effect associated with super conductivity.
- Super conducting electric motors are constructed approaching zero electric loses

Nuclear Magnetic Resonance Spectroscopy (NMR)

- Most common method to determine the physical and chemical properties of atoms by detecting the radio frequency absorbed and subsequent relaxation of nuclei in a magnetic field. Strong magnetic fields are generated by supercooling electromagnets.
- Liquid helium(BP 4K) is used to cool the inner coils. Cheap metallic superconductors can be used for the coil wiring. So-called high-temperature superconducting compounds can be made to superconduct with the use of liquid nitrogen(BP 77K)

Magnetic Resonance Imaging (MRI) :

Complex application of NMR where geometry of the resonances is deconvoluted and used to image objects by detecting the relaxation of protons that have been perturbed by a radio-frequency pulse in the strong magnetic field. Mostly used in health applications

Electric Power Transmission: Superconductors could be used to increase power throughput. Require cryogenic liquids such as nitrogen or helium to cool special alloy-containing cables to increase power transmission. Field is the subject of an agreement within the International Energy Agency.

Frozen Food: Transportation of large masses of frozen food. Food is freezed in war zones, earthquake hit regions, etc. Cryogenic food freezing is also helpful for large scale food processing industries Forward looking infrared (FLIR) Many infra-red cameras require their detectors to be cryogenically cooled

Blood banking: Certain rare blood groups are stored at low temperatures, such as −165 °C

Special effects: Liquid nitrogen and CO2 has been built into nightclub effect systems by Kryogenifex to create a chilling effect and white fog that can be illuminated with colored lights.

5. RESULT

The liquid portion is usually distilled to produce liquid oxygen, liquid nitrogen, and liquid argon. Other gases, such as helium, are used in a similar process to produce even lower temperatures, but several stages of expansion are necessary. Cryogenics has many applications.

APPLICATION OF CRYOGENICS:

- Aerospace-cryogenic engines
- Medical Field
- Manufacturing field
- Electronics Field
- Fuels research.

Advantages:

High Energy per unit mass: Propellants like oxygen and hydrogen in liquid form give very high amounts of energy per unit mass due to which the amount of fuel to be carried aboard the rockets decreases.

- Clean Fuels Hydrogen and oxygen are extremely clean fuels. When they combine, they give out only water.
- This water is thrown out of the nozzle in form of very hot vapour. Thus the rocket is nothing but a high burning steam engine
- Economical Use of oxygen and hydrogen as fuels is very economical, as liquid oxygen costs less than gasoline.

6. CONCLUSION

This research concludes that this approach to field of cryogenics has made remarkable progress over the last 15 years, moving from laboratory prototypes to commercial applications in several areas. Such progress, coupled with the advanced performance offered by cryogenic and superconducting devices, has triggered a virtuous cycle of ever growing initiatives and new applications.

In this article we have discussed the dominant engineering trends and which cryogenic technologies are expected to develop in the next 10 years. The importance assigned to it by the leading various organizations indicates that cryogenics is going to play a strategic role for many future every missions

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