BEYOND 60 DAYS

BY PROMETEO TEAM

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Section 1: Summary

The “Beyond 60 days” Project is an uninterruptible power supply system that will keep the different devices that are part of the exploration missions to Venus in operation.

The challenge is to keep the exploration platforms energized for a minimum of 60 days in hostile conditions with high surface temperatures of Venus of around 460 C and an atmospheric pressure of 94 bar.

The implementation of an analogous energy system is proposed, made up of a set of thermocouples that supply 24 volts to different instruments of the rover, which will be interconnected to a high-performance batteries pack cover with a thermal insulation.

Venus being an inner planet closer to the sun with respect to the earth, its study will allow the collection of data on its atmosphere, geological evolution and its internal structure, the importance of carrying out Venusian missions of more than 60 days with systems adapted to the infernal environment and relentless of Venus is a challenge.

This system consists of:

4 thermocouple plates.

1 battery pack

1 Rover

Section 2. Explaining the solution

2.1. Power Supply Components

2.1.1. Thermocouple

The thermocouple type N (Ni – Cr – Si) – (Ni – Cr – Mg) is composed of positive wire 14% chrome, 1.4% silicon and 84.6% nickel; and the negative thread of 0.4% silicon and 95.6% nickel. Protected with beryllium oxide insulation and a molybdenum and tantalum jacket. (See figure 1)

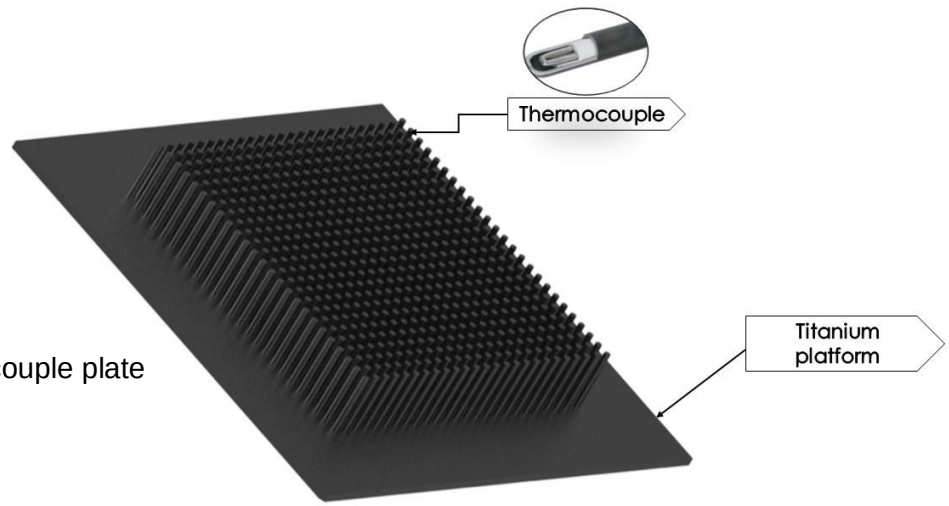

Figure 1:Thermocouple plate

2.1.2. Thermocouple plate

Each plate has 850 thermocouples that generate a total of 12 volts at an average temperature of 450ºC.

Thermocouple			**Totals**	
º C	mV	Quantity (q)	q * mv	**Volts**
100º C	2.774mV	850	2357.90	**2.36v**
200º C	5.913mV	850	5026.05	**5.03v**
300º C	9.341mV	850	7939.85	**7.94v**
400º C	12.974mV	850	11027.90	**11.02v**
450º C	14.846mV	850	12619.10	**12.62v**
500º C	16.748mV	850	14235.80	**14.23v**

Chart 1: Range of expressed values in celsius /volts

Two plates are connected in series adding up to a total of 24 volts. As a redundant energy system, 2 thermocouple plates are added in parallel. (See figure 2).

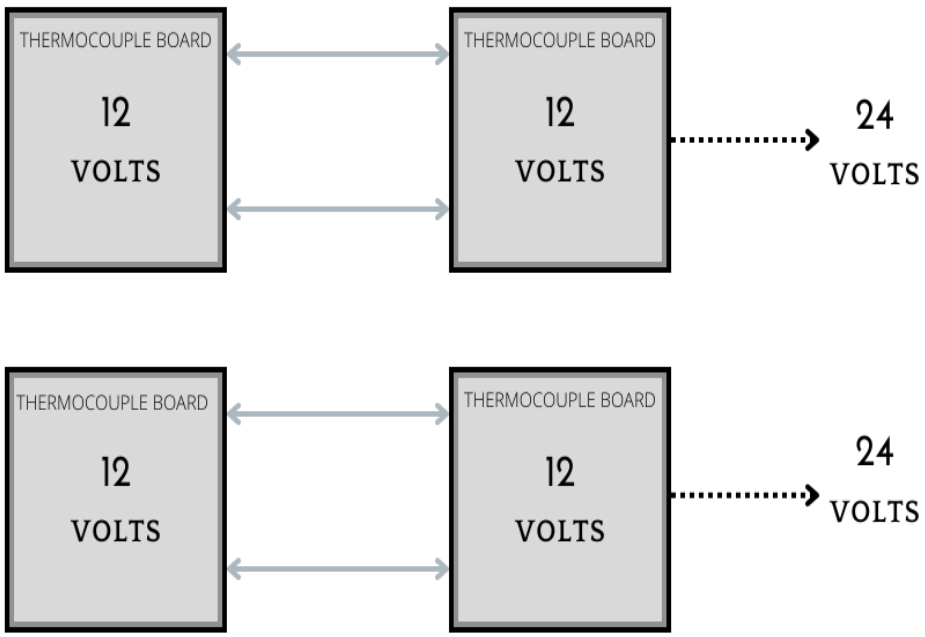

Figure 2: Thermocouple plate assembly

2.2. Energy storage system components

2.2.1. Batteries

Several high temperature batteries have been developed for electric vehicle applications. Three successful batteries that can work between 250°C and 450°C are: LiAl-FeS2, Na-S and Na-metal chloride. These batteries offer a relatively high specific energy compared to aqueous rechargeable batteries and also a good specific power. Therefore, the batteries are very suitable for long-term missions on the surface of Venus. The Sodium-Nickel Chloride Battery (Na-NiCl2) has been selected because it allows a temperature of up to 500 ºC

Sodium-Nickel Chloride (Na-NiCl2) Batteries	
Characteristic	Na-NiCl2
Operating Temp Range, °C	250–500
Open Circuit Voltage, Volts	2.58
Theoretical Specific Energy, Wh/kg	800
Specific Energy for Cells, Wh/kg	100–130
Specific Energy for Batteries, Wh/kg	90–110
Energy Density for Cells, Wh/l	150–190
Energy Density for Batteries, Wh/l	70–130
Cycle Life, cycles	>2000

Chart 2: Datasheet Sodium-Nickel Chloride (Na-NiCl2) Batteries

2.2.2 VOLCANIC WOOL / AIRGEL

It is proposed to cover batteries with All-Ceramic SiC Airgel and stone wool fiber to overcome the high temperatures that they will be subjected to.

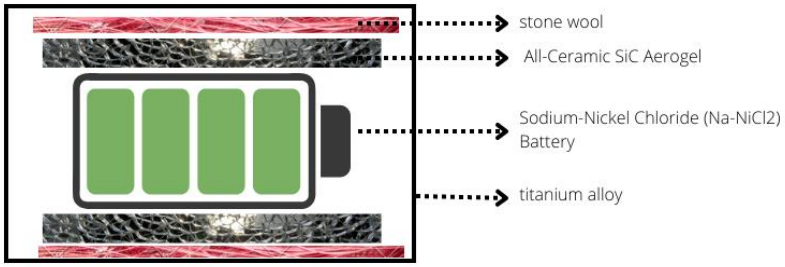

Figure 3: Battery heat protection diagram

2.3 Equipment and operation

The proposal is to equip the automaton rover (See figure 4) with the uninterruptible power source based on the set of thermocouples connected in series (See figure 2), which feed the batteries with a special coating (See figure 3).

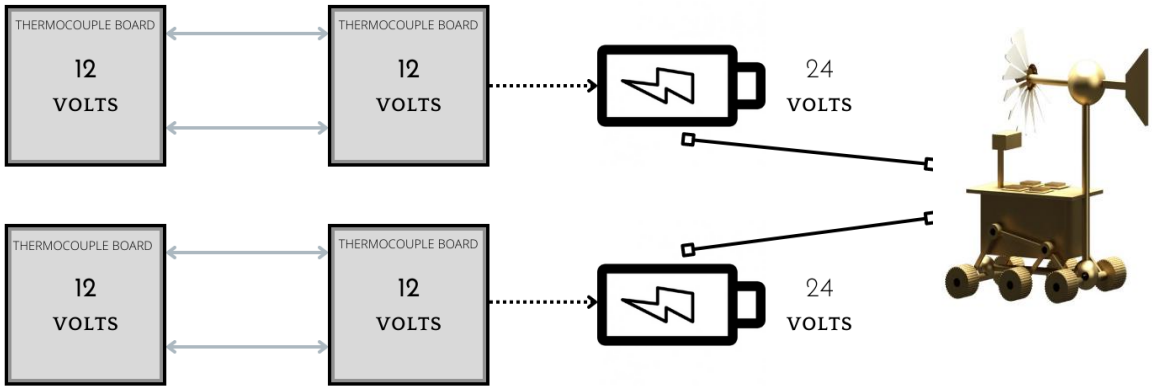

Figure 4: Power supply and battery system flow diagram

Venus has an average temperature of 460 °C, a hostile and infernal environment which is taken as an advantage to generate energy of 24 volts with 1500 thermocouples. It is expected that this energy could have redundancy in the power supply with 2 additional thermocouple plates in which additional 24 volts are generated in case of failure of the first set of thermocouples. Having said that, the total number of thermocouples is 300.

The advantage of using thermocouples as a primary energy source is due to the fact that it adapts to the mechanical system of the autonomous rover. Consequently, it is analogous, its manufacture does not generate high costs, it is easy to implement, and it is fed by the temperature of the atmosphere of Venus.

It is expected that with use of N-type thermocouples and the special coating on the Sodium-Nickel Chloride batteries, they could keep themselves running for at least 60 days on the surface of Venus.

In addition, an alternate energy system propelled by wind currents is incorporated. This system consists in a wind system. When the thermocouple primary energy system fails, the system is activated. Consequently, the electric motors are deactivated and the rolling of the rear wheels, which are driven and directed by the wind, are activated; the vane that is connected to the front wheels causes the turn according to the flow and orientation of the wind.

The tools used in the development of the project are:

- Autocad
- Office
- Filmora

- Google drive
- Photoshop
- 2 PCs I7 3.2ghz 16 ram ddr4
- 2 microphones
- 2 Laptops i5 2.4ghz 8 ram ddr4

Section 3: For the future.

Our system expects to implement improvements in the performance field to expand the capacity and stability of the load supplied for devices that are used in explorations not only in the hostile environment of Venus but also in other space environments.

Improvement of the resistance of electronic components at temperatures greater than 450 C°

Sources

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