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P5_11 Can Volcanoes Make Venus Habitable?

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Abstract

This paper dives into the uses of converting Carbon dioxide (CO_2) into Oxygen (O_2). The aim of this paper is to examine if Venus' atmosphere could be terraformed to allow humans to breathe on the surface of the planet. What was found was that using power generated from 37 volcanoes known to be on Venus, it would take 186,666 MOXIE machines 1.38×10^{15} hours to convert Venus' atmosphere to 20% O_2

Introduction

For this paper we will be using a MOXIE machine [1] (Mars Oxygen In-Situ Resource Utilization Experiment), a machine that can convert CO_2 into O_2. a MOXIE machine is designed for terraforming, it uses a reasonable amount of power of 300W to produce 10g per hour (as a maximum) of O_2 [1].

Humans require an atmosphere minimum of 19.5% O_2 to breathe [2], we will assume a minimum of 20% O_2 in this paper. Venus is used for this paper as 96.5% of the atmosphere is CO_2, which is favorable for two reasons. Firstly, a MOXIE machine can only be used to convert CO_2 to O_2, which there is plentiful on Venus. Secondly, humans can breath comfortably in an atmosphere mostly containing CO_2[3].

The volcano being used for this paper on Venus is Maat Mons [4], but for the lack of information on this active volcano, it will be modelled off of Yellowstone volcano, as will any volcano being mentioned in this paper. Yellowstone has a magma chamber temperature of 800 °C [5].

The power generation will be based off of Icelandic deep drilling to access these magma chambers in volcanoes as a way to generate electricity[6].

Finally, the assumptions that are being made for this paper are that the equipment needed to convert Venus' atmosphere can easily be taken to Venus, when breathing Venus' atmosphere there are minimal harmful gases allowing this paper to ignore them and all volcanoes are similar to the Yellowstone volcano. The sole purpose of this paper is to understand the possibility of turning CO_2 to O_2 in Venus' atmosphere, ignoring atmospheric obstacles that would effect machine or human.

Theory and Equations

A MOXIE machine needs 300W of power to convert CO_2 into 10g of O_2 per hour. Hence to power MOXIE for an hour it will take approximately 1.08×10^6J.

We know Venus' atmosphere is 4.8×10^{20}kg [7]. So take make Venus' atmosphere breathable, 20% of 4.8×10^{20}kg has to be O_2. The MOXIE machines are set the task of converting CO_2 from the atmosphere into 9.6×10^{19}kg of O_2. To find how long this would take, equation (1) gives the

formula required to calculate it.

$$h = 9.6 \times 10^{19}\text{kg}/(10 \times 10^{-3}\text{kg} \times n) \quad (1)$$

In equation (1), h is the number of hours it would take to convert Venus' atmosphere to be 20% O_2, 9.6×10^{19}kg is the O_2 needed, 10×10^{-3}kg is a single MOXIE machine's output and n is the number of MOXIE machines being used. For a single MOXIE machine to output 9.6×10^{19}kg of O_2 , it would take 9.6×10^{20} hours.

Yellowstone's magma chambers get up to 800 °C, thus using ratios of 500 °C generating 35 MW of electricity from deep drilling vents[6], increasing the temperature to 800°C results in 56×10^6 MW of electricity. This is equivalent to 2.106×10^{11} J h^{-1}, which would allow for a total of 186.666 MOXIE machines to run at once. These machines would produce 1,867 kg h^{-1} of O_2. These 186,666 MOXIE machines working 24/7 would take 5.14×10^{16} hours to convert 20% of Venus' atmosphere into O_2.

On Venus, there is expected to be a total of 37 active volcanoes [8]. Thus, this would increase the production of O_2 by 37 times, translating to 69,079 kg h^{-1}, reducing the time to terraform Venus' atmosphere to 1.38×10^{15} hours.

Conclusion

This paper tries to understand the practicality of terraforming Venus to allow humans to breathe on the surface. This paper finds that to get Venus' atmosphere to be breathable by humans it would take 9.6×10^{20} hours to convert the atmosphere using one MOXIE machine and 1.38×10^{15} hours using 186,666 MOXIE machines (powered by all 37 volcanoes). However, this is a loose estimate, based on 37 active volcanoes. Although this process shows it is not feasible today, without taking into account building and transporting these machines, it is a good approximation to how long it would take to make Venus' atmosphere breathable for humans. However, it is possible for this technology to advance in the future and decrease the total conversion time.

References

[1] https://mars.nasa.gov/mars2020/spacecraft/instruments/moxie/ [Accessed 1 December 2020]

[2] https://sciencing.com/dangers-argon-5443798.html [Accessed 1 December 2020]

[3] https://bit.ly/2VyOuPb [Accessed 1 December 2020]

[4] https://photojournal.jpl.nasa.gov/catalog/PIA00106 [Accessed 1 December 2020]

[5] https://www.nps.gov/features/yell/ofvec/exhibits/eruption/heat/oven.htm#:~:text=It%20is%20estimated%20that%20the,other%20places%20on%20Earth's%20continents. [Accessed 1 December 2020]

[6] https://www.sciencemag.org/news/2014/02/could-volcanoes-power-world [Accessed 1 December 2020]

[7] https://nssdc.gsfc.nasa.gov/planetary/factsheet/venusfact.html [Accessed 15 December 2020]

[8] https://www.smithsonianmag.com/smart-news/researchers-discover-what-may-be-37-active-volcan [Accessed 14 December]