547-54

N91-28110 28

MARS SURFACE BASED FACTORY: PHASE II - TASK 1C COMPUTER CONTROL OF A WATER TREATMENT SYSTEM TO SUPPORT A SPACE COLONY ON MARS

Dr. John Fuller, Warsame Ali, and Danette Willis
Department of Electrical Engineering
Prairie View A&M University
Prairie View, Texas

ABSTRACT

In a continued effort to design a surface based factory on Mars for the production of oxygen and water, the Design Group at Prairie View A&M University made a preliminary study of the surface and atmospheric composition on Mars and determined the mass densities of the various gases in the Martian atmosphere. Based on the initial studies, the design group determined oxygen and water to be the two products that could be produced economically under the Martian conditions.

Studies were also made on present production techniques to obtain water and oxygen. Analyses were made to evaluate the current methods of production that were adaptable to the Martian conditions. The detailed report (Phase 1- Mars Surface-Based Factory: A Preliminary Design) was contained in an Interim Report submitted to NASA/USRA in August of 1986.

Even though the initial effort was the production of oxygen and water, we found it necessary to produce some diluted gases that can be mixed with the oxygen produced to constitute "breathable" air.

In Phase II - Task 1A, The Prairie View A&M University team completed the conceptual design of a breathable air manufacturing system, a means of drilling for underground water, and storage of water for future use. The design objective of the team for the 1987-88 academic year (Phase II-Task 1B), was the conceptual design of an integrated system for the supply of quality water for biological consumption, farming, residential and industrial use. The design has also been completed.

Phase II - Task 1C is the present (1988-89) task for the Prairie View Design Team. This is a continuation of the previous task.

The continuation of this effort is the investigation into the extraction of water from beneath the surface and an alternative method of extraction from ice formations on the surface of Mars if they are accessible.

In addition to investigation of water extraction, a system for computer control of extraction and treatment will be developed with emphasis on fully automated control with robotic repair and maintenance. It is expected that oxygen and water producing plants on Mars will be limited in the amount of human control that will be available to man large and/or isolated plants. Therefore, it is imperative that computers be integrated into plant operation with the capability to maintain life support systems and analyze and replace defective parts or systems with no human interface.

MARS SURFACE BASED FACTORY: PHASE II - TASK 1C COMPUTER CONTROL OF A WATER TREATMENT SYSTEM TO SUPPORT A SPACE COLONY ON MARS

Introduction

The Design Group at Prairie View A&M University is designing a computer control system for a water treatment plant to support a colony on Mars. The system is being developed with emphasis on fully automated control, robotic repair and maintenance. It is expected that the water producing plant on Mars will be limited in the amount of human control that will be available to man the plant. Therefore, it is imperative that computers be integrated into plant operation with the capability to maintain the water system and analyze and replace defective parts or systems with no or limited human interface.

Methods to extract water from beneath the surface of Mars are also being investigated. It is believed that water exists on Mars in polar ice deposits and in permafrost layers (ground ice). There is also evidence that water exists underneath the permafrost zone. The Prairie View Design Team is investigating ways of extracting and treating the water for human consumption and protein production. To carry out the described task, teams were formed to investigate problems, and design necessary equipment and implementation procedures for the four areas of drilling for water, plant control, computer interface and maintenance. Figure 1 shows the structure of the design team as developed for the 1988-89 academic year. The project will be completed in the summer of 1989. As this project continues, the focus will shift to the production of proteins for human consumption.

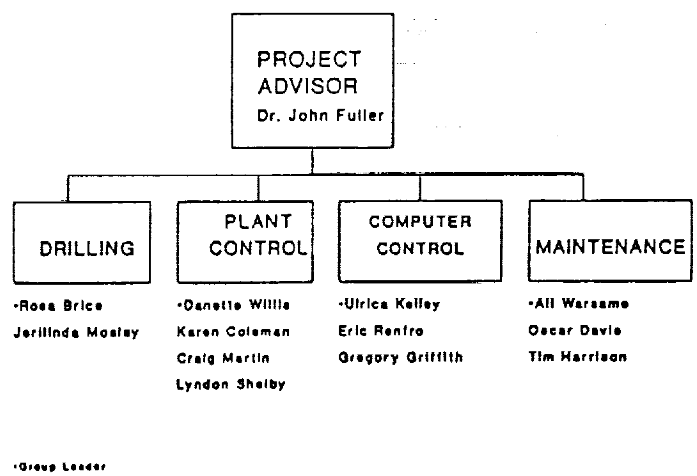

Figure 1

Drilling for Water

The success or failure of any attempt to colonize the planet Mars will largely depend on the availability of the most important life sustainer, water. Not only is water important for life but also any meaningful self-sustained technological advancement on Mars will be based on water as a process fluid. It is therefore imperative that every attempt be made to locate an adequate supply of water on Mars.

Mars is presently too cold to support oceans or any form of stable liquid water on its surface. The mean ambient temperature is -25 degrees Celsius. It is believed that there are ice deposits or permafrost beneath the surface of Mars. The thickness of the zone containing ground ice is about 10 to 30 cm. More water may exist underneath the permafrost zone.

In order to assess the amount of water on the planet other than by mere estimation, some form of drilling must be done.

The study of the composition of the Martian soil is very important in determining its drillability. A survey of the Martian soil has been conducted through the exploration by the Viking Landers. The soil is composed of different elements such as silicon, iron, phosphorus, calcium, aluminum, thallium, and sulfur. The debris analyzed by the Viking Landers showed silicon oxides in abundance of approximately 45 percent by weight.

One other important factor to consider in the design of the drilling unit is the drilling rate. The drilling rate is a function of several variables, the most important of which are the rock drillability, the weight on the bit and the extent of cleaning the hole. The effect of the weight on the bit is of great importance to our design since the gravity on Mars is substantially less than that on Earth.

The drilling process will involve boring a hole by using a rotating bit to which a downward force is applied. The bit is supported and rotated by a hollow stem composed of high-quality steel, through which a drilling fluid is circulated. The fluid leaves the stem at the bit, thereby cooling and lubricating the cutting structure. By flowing across the cutting surface, the drilling fluid drags cuttings from the hole stem annulus. This process will form the basis for the design of the drilling unit.

Plant Control and Computer Control

The integrated water treatment plant consists of several processes, such as a suspended solids removal unit, ultrafiltration unit, and reverse osmosis unit, which have parameters that need to be monitored or controlled. These parameters include flow rate, temperature, pressure, and conductivity. Therefore, devices such as sensors, transmitters, and control valves must be employed.

To facilitate the need of automated control, a personal computer would be used to maintain and run the entire water system. The electronic sensors, transmitters, and control valves along with analog to digital and digital to analog converters will communicate with the personal computer.

Through the use of one or more microprocessors, RS232 serial cables and/or fiber optics along with analog to digital converters, the above devices will be integrated with each other.

The purpose of the A/D and D/A converters will be to interpret the analog signals being sent from the sensors and convert them to digital signals to be analyzed by the computer. If an adjustment needs to be made within a process, the computer will send a signal to a valve (actuator) to make the proper adjustment. The microprocessors that are being investigated are the Intel 8086, Motorola 68000 and the Z80.

Maintenance

The initial habitation of Mars will require machining and maintenance for space applications. Machining and maintenance on Mars is complicated due to the following factors: the absence of atmosphere, light is not diffused or scattered, the natural space environment consists of intensive light and dark periods, small number of persons, and the lack of machining parts. The factory communication network system will consist of an industrial microcomputer cell control, computer interface units, a robotic controller, vision, and a computer numerical control machine (CNC lathe).

Robotics for space applications have been proposed for increased productivity, improved reliability, increased flexibility, higher safety and for the performance of automating time consuming tasks. If a malfunction takes place within the system, it takes almost twenty minutes to receive a signal from Earth. This signal instructs the machine on how to recover from the fault. So, it is necessary to have an emergency plan that can start automatically right after the shutdown of the plant.

Vision/sensing is projected to include the fusion of multi-sensors ranging from microwave to optical with multi-mode capability to include measuring capability for position, attitude, recognition and motion parameters. [1]

The objective of using a CAD/CAM system on a CNC lathe machine is to produce machine parts on Mars, and it is planned to modernize the computer numerical control (CNC) lathe by developing a software system on a personal computer. The CAD/CAM system is able to take all the data from design programs and convert the information to numerical control (NC) programs which are used on the CNC lathe.

The design programs are written in Basic language on a personal computer. The CAD/CAM software system is developed in Fortran language. By using software packages the need of punched tape for the CNC lathe and blueprints of the design drawings are eliminated. As a result, the complete automation from design to manufacturing for the CNC lathe is achieved. The sample design program is shown in Figure 2, the sample of a manufactured work piece is shown in figure 3, its horizontal tool path cutting is shown in Figure 4, and its NC program is shown in Figure 5.

The computer graphics method using basic language to generate CNC program offers the following advantages:

1. It is safer. A problem, such as the cutting tool colliding with the chuck of an engine lathe, would provide a genuine hazard to a user trying out a CNC program. With the CAD/CAM program, the problem is eliminated.

2. It is economical. Besides saving all of the scrap work that would have been produced in the actual situation, CAD/CAM program allows the limited machine tools to be utilized.

3. It is psychologically more satisfying. The major advantage of using this CAD/CAM system is to generate a CNC program.

Recommendations for Future Research

The following are recommended areas for future development:

1. Develop the CAD/CAM software package of the CNC lathe for threading operation.

2. Comprehending all errors and malfunctions that can take place between the personal computer and the CNC lathe.

3. Testing the system by a set of design programs to produce mechanical parts.

4. Design a plant prototype with simulation of all system parameters.

5. Study the Martian moon, Phobos, as an alternate source of water.

6. Raise fish on the planet Mars for life support.

References

1. Kumar, Krishen; "Space Robotic Vision System Technology." International Conference and Exhibit, Houston, Tx. October 16-21, 1988.

2. Ali, Warsame; "Development of a CAD/CAM System on An EMCO-5 CNC Lathe", Master Thesis at Prairie View A&M University, December 1986.

3. EMCO-5 CNC Lathe Manual, 1986.

4. Haberle, Robert; "The Climate of Mars."


```
10  ' piece of iron ================================
20 SCREEN 1,0 :CLS : KEY OFF : DEFINT A-Z
30 LINE (48,39)-(132,39),1
40 LINE (48,39)-(48,121),1
50 LINE (48,,121)-(132,121),1
60 LINE (132,39)-(132,121),1
70 LINE (132,50)-(155,50),2
80 LINE (132,110)-(155,110),2
90 LINE (155,50)-(155,110),2
100 LINE (155,57)-(199,57),3
110 LINE (155,103)-(199,103),3
120 LINE (199,57)-(199,103),3
122 LINE (132,39)-(132,50),1
124 LINE (132,121)-(132,110),1
126 LINE (155,110)-(155,103),1
128 LINE (155,50)-(155,55),1
130 LET X1=48 : X2=199
140 LET Y=80
150 FOR I=X1 TO X2 STEP 21
160 LINE (I,Y)-(I+10,Y),1
170 LINE (I+15,Y)-(I+16,Y),2
180 NEXT I
190 END

Ok
█
```

Figure 2

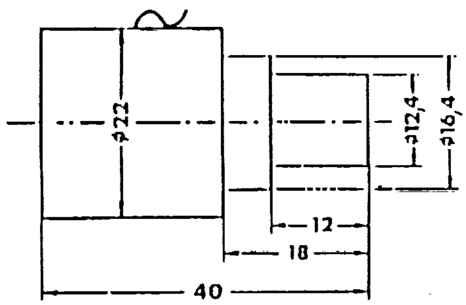

Figure 3

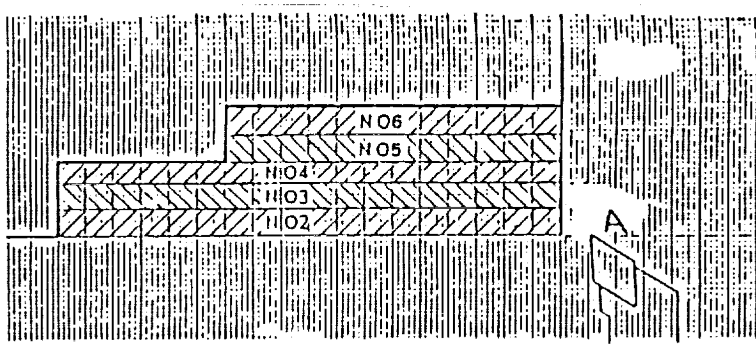

Figure 4

N	G	X (BLU)	Z (BLU)	F (mm/min)
00	00	-500		
01	01	00	-400	
02	84	-100	-1900	400
03	84	-200	-1900	400
04	84	-280	-1900	400
05	84	-380	-1300	400
06	84	-480	-1300	400
07	22			

BLU=0.01 mm

Figure 5