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Gas Stove with Embedded Controlling System to Stop Misuse of Natural Gas in Bangladesh

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ABSTRACT
Natural gas is the most essential resource in Bangladesh. Around 52% of energy supply of Bangladesh depends on natural gas. It is estimated that, approximately 20 TCF gas is reserved in Bangladesh. Though domestic users consume 12% of the gas supply, a big amount of this supplied gas is misused due to drying cloths, warming room and for other purposes during winter and rainy season. Through this research work, a microcontroller based embedded system (including arduino mega, ultrasonic sensor, servo motor) is designed to control this misuse and stop it. This embedded system will enable the gas flow through gate valve of gas stove whether there is any cooking pot on the gas stove. Thus the misuse of domestic gas will be stopped.

Keywords: Gas stove, Microcontroller based embedded system, Ultrasonic sensor, Valve and key system, servo motor.

1. Introduction

Proper use of natural gas is really essential for future energy production, domestic use and other purposes in Bangladesh. Recent statistics shows that, the growth rate of gas consumption is 10% [4] and the R/P ratio of Bangladesh is 17.8 years. Thus the reserved of natural gas will ends after 17.8 years. As the rate of natural gas consumption is 1000mmcfd, the domestic demand is 120mmcfd. Total customer of petrobangla is only 2369371 up to December, 2012 [1]. It becomes difficult for the government of Bangladesh to ensure natural gas supply to the remaining citizens. Moreover a big amount of this supplied gas for domestic purposes is misused. But this wasted gas can be used for further domestic gas connections. This paper presents a microcontroller based embedded system, which will enable the government to stop the misuse of natural gas effectively. Through the saved natural gas more new connections can be made. Thus other citizens can be benefitted.

2. Background

In order to stop the misuse of natural gas through natural gas stove, some research papers were published. In "Microcontroller based natural gas oven" [3], Authors only suggested a method using solenoid gas valve. But no practical construction was done. Thus there is no feasibility of this project. In the evaluation of pilot project, natural gas pre-paid meter was introduced for domestic users. Here a new billing methodology is proposed but no method for saving natural use was mentioned. In this research paper a method with practical construction for saving gas is shown.

3. Construction of mechanical Structure

In this project, a mechanical structure is constructed. In the constructed structure, a servo motor is connected with gas gate valve to operate the mechanical parts to start and stop the gas flow. Welded bars are joined with the gate valve and the rotating shaft of servo motor. So rotation of the output shaft of the servo motor controls the rotation of the gate valve. After every 90 degree rotation the gate valve opens and closes its paths respectively. The structure is shown in Fig.1. In Fig.2, it is shown that the gas gate valve is attached with the gas stove. In this position, the proposed embedded system will be placed.

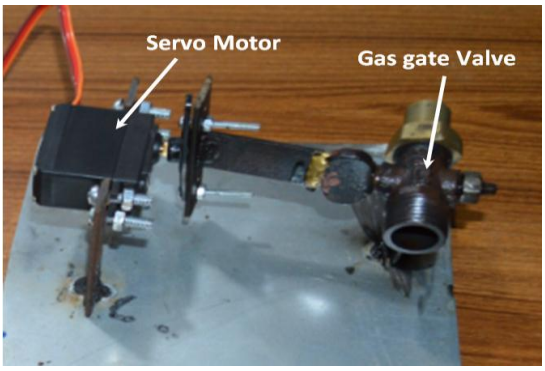

Fig.1 Constructed mechanical structure

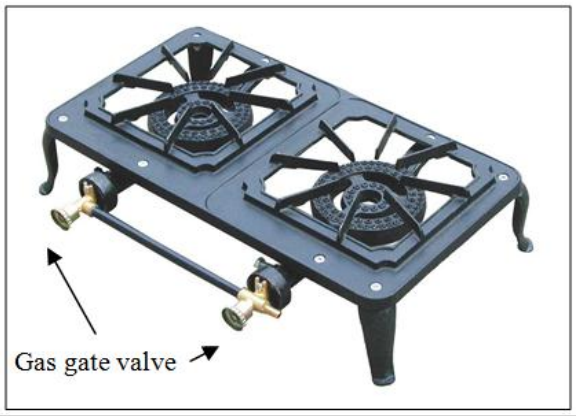

Fig.2 Natural Gas stove

4. Electrical components

In this research project, a microcontroller based embedded system is designed and interfaced with the mechanical structure. This embedded system consists of

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an arduino Mega 2560, ultrasonic sensor – HC-SR04 and a servo motor.

4.1 Arduino Mega 2560

The operating voltage of arduino mega 2560 is 5V and the input recommended voltage is between 7V to 12V. It has 54 digital I/O pins among which 14 pins provide PWM output. It has 16 analog input pins. DC current per I/O pin is40 mA. Flash memory size is 256 KB of which 8 KB is used for boot loader. SRAM, EEPOROM and clock speed are 8 KB, 4 KB and 16 MHz respectively [7].

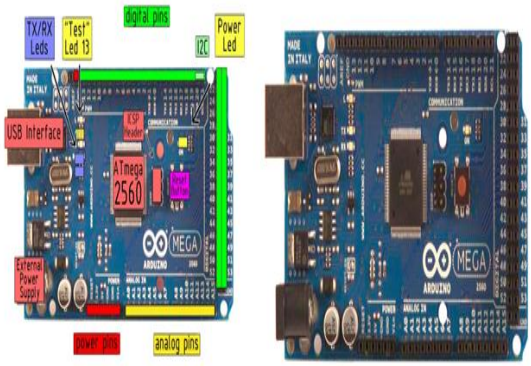

Fig.3 Arduino Mega 2560

4.2 Ultrasonic sensor – HC-SR04

It provides 2cm to 400cm non-contact measurement function. The ranging capacity can be extended to 3mm. It has ultrasonic transmitter, receiver and control circuit. Its working voltage, current, frequency and measuring angle are DC 5V, 15mA, 40Hz and 15 degree respectively. Trigger input signal is 10uS TTL signal and the echo output signal ranges in proportion.

Fig.4 Ultrasonic sensor – HC-SR04

4.3 Servo motor

The model of servo motor is Tower Pro MG 995. It is a metal geared motor. Its operating voltage lies between 4.8V to 7.2V and temperature range is 0 ^{o}C to 55 ^{o}C. The stall torque of this motor is 8.5Kg/cm at 4.8V and 10Kg/cm at 6V. Operating speed is 0.20 sec/60 degree at 0.16 sec/60 degree. It weighs 55g.

Fig.5 Tower Pro MG 995

5. Circuit arrangement

In the circuit arrangement, Echo pin is attached to arduino pin 7 and the Trig pin is attached to arduino pin 8. Onboard led is attached to led pin 13. VCC supply is 5V to the arduino. Maximum range of ultrasonic sensor is 25cm and the minimum range is 10 cm. Ultrasonic signal is sent after every 50ms duty cycle. The full circuit diagram is shown in Fig. 6

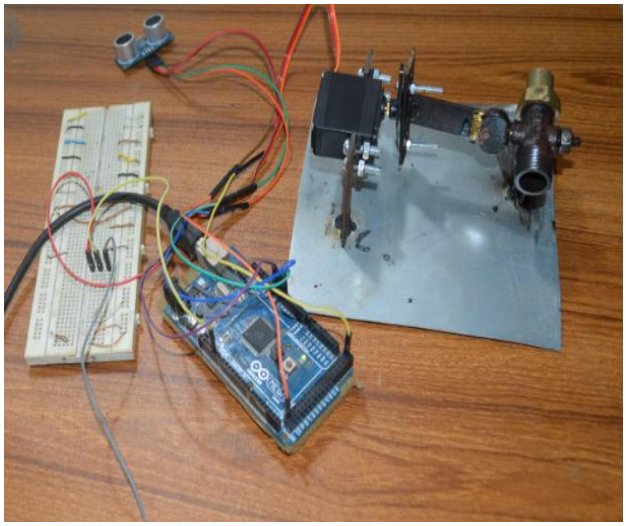

Fig.6 Interface of constructed mechanical structure and circuit arrangement

6. Control Mechanism

The embedded system enables the gas flow through gate valve whether there is any obstacle between the defined working ranges (10cm-25cm) of ultrasonic sensor. The range can be changed through arduino program according to the stove model. In this stage, the motor gives anti-clockwise rotation at 90 degree angle. This is shown in Fig.7 by using hand as an obstacle. Thus the gas flow was enabled through gate valve.

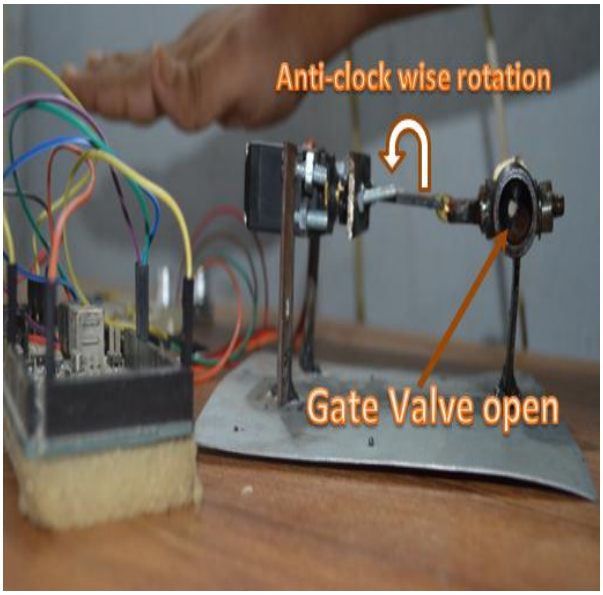

Fig.7 Gas flow enabled

If the obstacle is taken away from the working range, ultrasonic senor possess signal through microcontroller of arduino board. When this signal is forwarded to the servo motor, it gives clockwise rotation at 90 degree angle. Then the gas flow is disabled through gate valve. This phenomenon is shown in Fig.8.

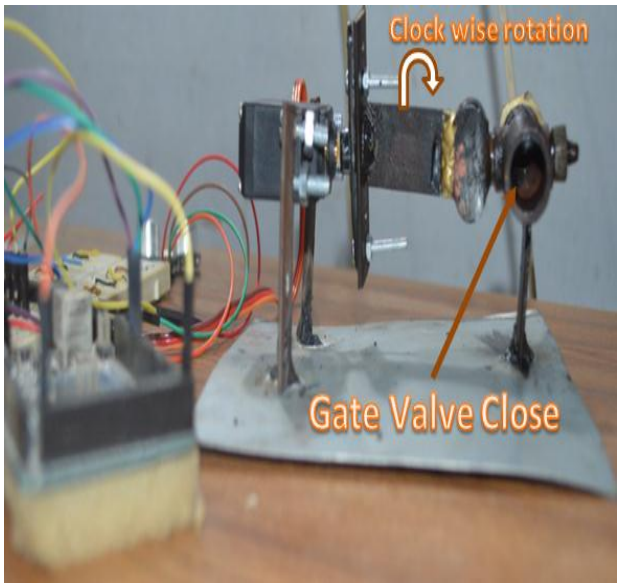

Fig.8 Gas flow disabled

When the gas flow is enabled, gas stove can be used for cooking purpose. Thus the embedded system make the gas stove to perform whether there is any cooking pot on it. In order to visualize the control mechanism, block diagram is shown in Fig.9. The flow chart is also given in Fig.10 which shows the whole working mechanism.

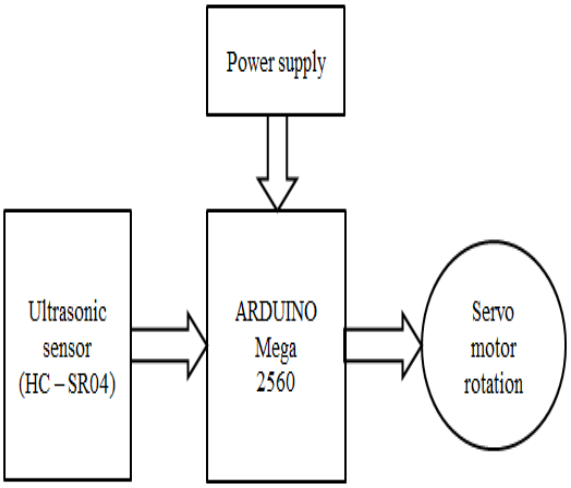

Fig.9 Block diagram of the flow system

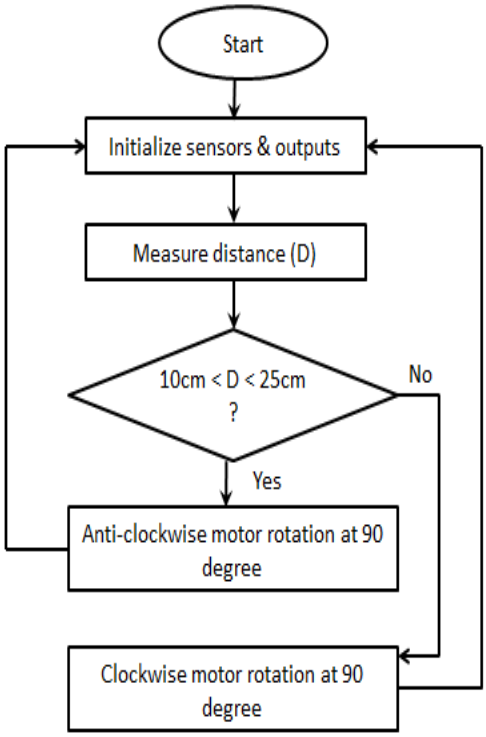

Fig.10 Flow chart of control mechanism

7. Cost analysis

It is shown in the annual report of Petrobangla [1] that the domestic consumption of natural gas from fiscal year 2011 to fiscal year 2012 was 89.29 BCF or 89290000000 CF. The number of domestic consumers of natural gas up to 2012 was 2369371 [1]. So consumption of one user is 37685.12 CF. Thus the daily consumption of one user is 103.25 CF. Past surveys showed that the individual consumer uses 8 hours a day to complete cooking purpose [5]. Though a big amount of natural gas is wasted for long time by most of the domestic users, it is assumed that 2 hours of the cooking

period is wasted by drying clothes, warming room for independent calculation. So the amount of wasted gas per day is 17.21 CF by an individual user. So the wasted amount of natural gas of one year by the total domestic user is 14883559 MMCF. According to the tariff structure of gas, the cost of bearing one household stove is BDT 146.25/MMCF. So the total cost of wasted gas is BDT 217.67 cores. For installation of the proposed system the government will need BDT 189.55 cores. Thus in first year of installation the profit of government will be BDT 28.12 cores. Moreover, this calculation shows that the yearly wastage of 6 users is 37689.9 CF which is more than the yearly consumption of one user. So using this embedded system, the government can connect natural gas to 394895 new consumers without new production. The amount saved gas by this embedded system will be 30, 612 MCF. The vast production cost of this embedded system with PCB system will be 189.55 cores BDT to connect this embedded system to the gas stove of 2369371 users. The profit of Government will be 213.24 cores BDT from 384895 new connections. So the profit will be 23.69 cores BDT. Thus 394895 new gas connections can be made which is 16.67% of existing connections.

8. Result and Discussion

This Microcontroller based embedded system can stop the misuse of Natural gas. The domestic users will be able to use the natural gas only for cooking purposes through this system. But there will be no further scope to use our natural gas for drying clothes or warming room. Thus more gas connections can be made by using the present production. Government could not provide new gas connections for several months due to gas crisis. But this embedded system will enable them to make new connections without new production. The independent calculation of this research work shows that 3, 94, 895 new connections can be made using the designed microcontroller based. So the implementation of this project is essential not only for the common people but also for the government. Thus the right of every citizen on natural gas will be fulfilled.

9. Conclusion

Proper use of natural gas is really essential for the welfare of common people. Thus the implementation of this research project will ensure the right of common people on natural gas of our country. In different research projects, many methods were shown for controlling the misuse of natural gas. But the proposed embedded system will efficiently stop the misuse with economic benefits. So the implementation of this project is really essential for our country.

Further work of this research project can be the development of power supply from rechargeable battery.

NOMENCLATURE

TCF : Trillion Cubic Feet
Mmcfd: Million Cubic Feet a day
MCF : Thousand Cubic Feet
Nm^3 : Standard Cubic Feet
R/P : Réserves-to-production ratio
BCF : Billion Cubic Feet
CF : Cubic Feet
PCB : Printed Circuit Board
MMCF: Million Cubic Feet

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