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A VIRTUAL INSTRUMENTATION BASED SCHEME FOR AUTOMATIC GAS BURNER DRILLING MECHANISM USING LABVIEW

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Abstract- Gas burners are very important component of domestic and industrial applications. They are mainly used in gaseous fuel based cooking and heating appliances such as (liquefied petroleum gas) LPG stoves. So, being the product used on mass scale in almost every household, hotels / restaurants and many industrial manufacturing units, its fabrication requires state-of-the-art automatic drilling mechanism, so that burners can be produced efficiently in large volumes at effective costs.

These burners have different sizes and shapes. The patterns of holes drilled on them are also different for various categories of burners. These holes need to be drilled precisely at certain angles and their number also varies with the inter hole spacing between two adjacent holes for different type, shape and size of burners. Thus the number and patterns of the holes is the critical part of the gas stove and burner fabrication process as it defines the fuel efficiency.

A survey of the manufacturing units in and around Delhi/NCR region has revealed that manual electro-mechanical drilling tools or semi-automatic systems are employed for drilling holes on to burners. Most of these are small/micro scale industries and thus have limited financial and capital resources. It is found that at times the number of holes drilled onto the burner using such drilling tools is different than the actual number of holes that were originally planned to be drilled for a specific type of burner on account of the gears play and irregular push of plunger systems that are used in these manual drilling systems. These manufacturing units do manual inspection of the quality of finished burners.

Manual inspection of burners takes a lot of time and also the precision errors are bound to occur. Moreover, the prime objective of the drilling process also requires that the holes must be drilled at precise angles which are not so accurately met with the manual drilling operation.

In this paper, we propose a computer based cost effective and reliable solution for automatic burner drilling and inspection mechanism.

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Introduction

Scientists and engineers have carried out various experiments about optimizing the quantity of fuel (typically LPG Gas) consumed and the heating effect produced. Certain experimental conclusions are in place about the optimum sizes and number of holes to be drilled for particular shapes and capacity of the burners. These results are followed throughout the industry for the pattern design and drilling of holes onto gas burners, which shall optimize the quantity of fuel consumed and the heating effect produced.

According to Indian Standards Institution, the optimum gas-air mixture ratio for LPG is 1:31, which gives the best thermal efficiency. The Indian Standards document numbered IS4246 has various design specifications and recommendations for LPG based domestic gas stoves. A minimum of 64% thermal efficiency level is required, so that any LPG based gas stove can be given the certificate of passing the ISI Standard.

There is a standard formula for calculating the orifice jet sizes for the burners and for particular pressures to be kept across the burners for achieving the best thermal efficiency. In addition to this, a number of other factors are taken into consideration before defining the hole-size, pattern and angle at which the holes are drilled onto a specific type of burner. For calculating orifice size at any pressure and any flow rate, the formula used is given below as in (1)

$$Q=1658.5AC\sqrt{\frac{h}{d}} \quad (1)$$

Q = Orifice capacity in cubic feet per hour at STP (150 C, 760 mm Hg)
A = Orifice area in square inch
C = Discharge co-efficient orifice which varies with angles of approach of the orifice
h = Gas pressure in Water Column
d = Specific gravity of gas (Air = 1)
1 Psi = 27.6 inch water column

Fig. 1 and Fig. 2 below show a typical burner before and after the holes have been drilled.

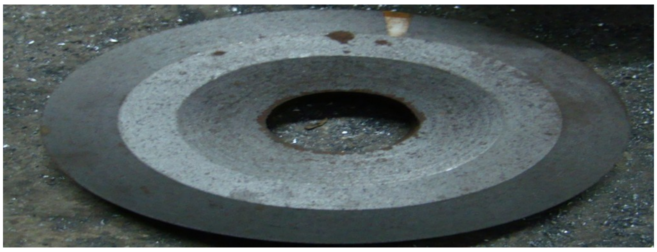

Fig. 1- An Undrilled Burner

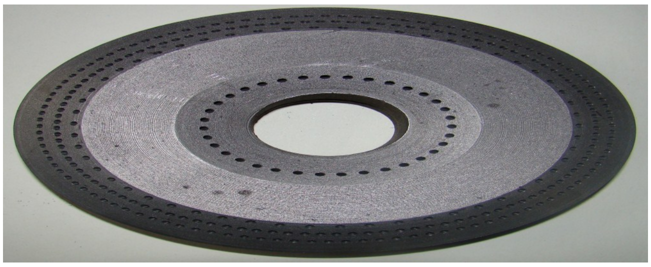

Fig. 2- A Drilled Burner

Fig. 3- A typical manually operated drilling machine which is being made automatic using virtual instrumentation system

Requirement of skilled /trained workers for drilling operation is needed when drilling is done manually using the manual electro-mechanical drilling machine as shown above in Fig. 3. In such drilling operations, repeatability and precision is poor. There is a great scope for low cost automation of these type of gas burner drilling machines. The proposed scheme aims to evolve a systematic virtual instrumentation approach for burner drilling and inspection.

Schematic of the Proposed Automatic Gas Burner Driller

The schematic of the Proposed Automatic Gas burner Driller is shown below in Fig. 4 The Programming is done on the LabVIEW environment which is graphical in nature. The program code developed is popularly known as G-code or G-program. The project design consists of an electro-pneumatic drilling operation. The drill bit is operated using spindle and belt arrangement powered by an AC induction motor. The motor stays ON throughout the operation to make the drill rotate continuously. There is an Electro-pneumatic piston cylinder arrangement, which is attached to the whole mechanical drill assembly. This is to provide vertical motion to the complete mechanical drill assembly, which is continuously rotating as previously described. Using this piston cylinder arrangement which is actuated by a 5/2 electro-pneumatic valve, the whole mechanical assembly of drill is brought down on to the work piece, to drill the hole return back upwards to its original position. This vertical up and down motion is again controlled using the LabVIEW based G-program through the use of DAQ (Data Acquisition System) linked to computer, on which LabVIEW based virtual instrumentation suite is installed.

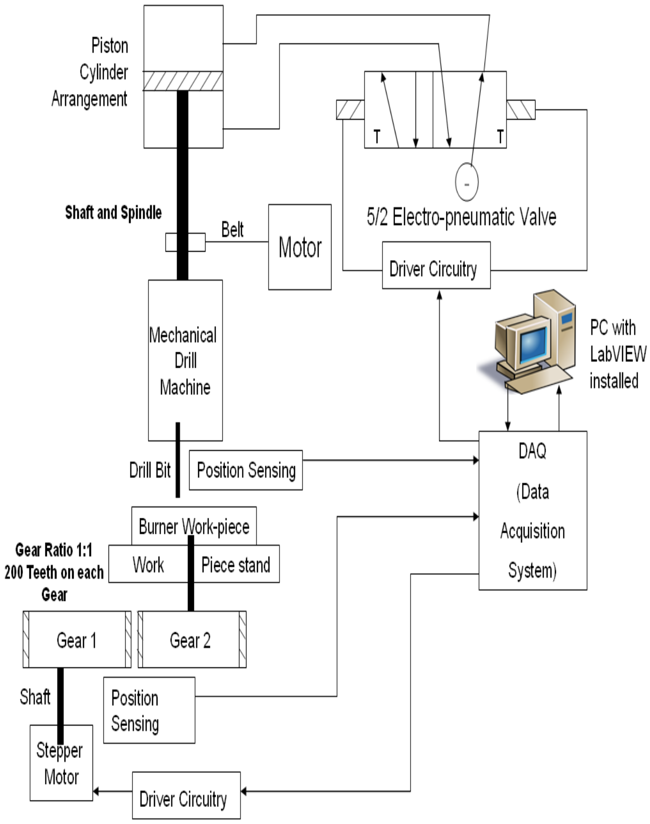

Fig. 4- Proposed Schematic of virtual instrumentation based automatic gas burner drilling mechanism

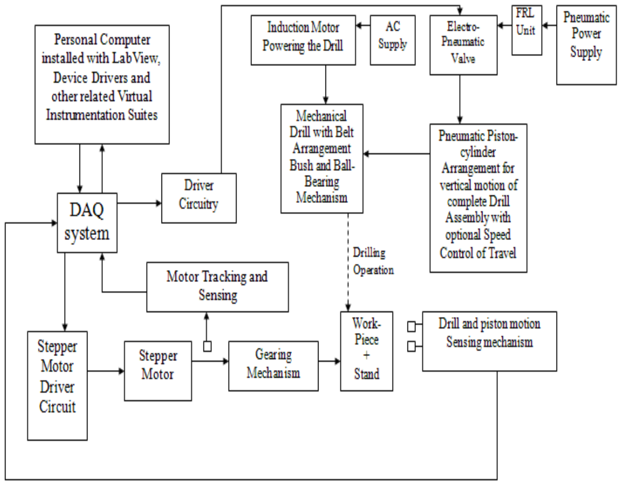

Fig. 5- Block Diagram for Virtual instrumentation based Automatic Gas Burner Driller

The Computer sends control signals coming from the LabVIEW G-program to the DAQ, which further sends the signals to the Driver circuit, which is used to run relays or solenoids of the Electro-pneumatic valves, which actuate the piston cylinder arrangement linked to the mechanical drill assembly. The burner work-piece, on which the holes are to be drilled, is installed on to the work piece stand, which is installed on the gearing arrangement. This coupled gearing arrangement is attached to the shaft of stepper motor with supporting mechanism. The motion (rotating angle and speed of rotation) of the Stepper motor is again controlled using the G-program through computer, DAQ Driver circuitry. Every time, the motor rotates by some pre-decided angle as controlled by the G-program, the gears and along with them the gas burner work piece rotates by the same angle. Thus, the rotating angle of the stepper motor as controlled by the G-program decides and controls the no. of holes drilled onto the burner work piece e.g. if 200 holes are to be drilled then the rotating angle will be 1.8 degree and the stepper motor starts stops 200 times the piston cylinder arrangement does the vertical motion of complete drilling assembly 200 times to complete the drilling of holes onto burner. There is motion tracking and sensing mechanism for the stepper motor with the help of which, the PC based virtual instrumentation system controls the rotating angle of the stepper motor and thus keeps tracks of the no. of holes actually drilled on to the burner. Thus, there is flexibility to decide the no. of holes to be drilled by the use of User Interface of the Lab VIEW G- program and there is no need for changing the mechanical gearing arrangement for changing the no. of holes to be drilled.

DAQ (Data Acquisition system)

DAQ (Data Acquisition system) acts as the interface between the PC and the electromechanical arrangements including the sensors. All the feedback signals by sensors about the positioning of burner work piece and no. of holes actually drilled, drill positioning etc are received by PC through the DAQ.

All control signals from PC are sent to the DAQ, which further sends it to the individual Electro- mechanical components through appropriate driver circuitry. The signals from sensors prove crucial in ensuring proper operation of the drill and stepper motor.

The timing for which the motor shall stop and start alternatively is decided by the computer depending on the sensor signals state. Similarly, the travel of the drill assembly and operation of Electro-pneumatic piston cylinder arrangement is dependent on the signal state of position sensors signals, which are installed near drill assembly. Vision mechanisms will be installed to monitor the quality of drilled holes, the angles at which the holes are drilled and the no. of holes actually drilled in addition to monitoring the spacing between the drilled holes.

Conclusion

Normally, small scale industries are into the fabrication of LPG Gas stoves. They use manual Electro-mechanical drilling tools or semi-automatic systems for drilling holes, where possibility of error is quite high in addition to lack of precision and speed operation. This strongly limits the production capacity of the plant. The proposed scheme aims to evolve a systematic computer based virtual instrumentation approach for automatic burner drilling and inspection. It is expected to introduce a new school of thought in burner holes drilling and fabrication technology for LPG gas based stoves and other industrial products. If drilling operation is made fully automatic using computer based virtual instrumentation, not only the production speed can be increased, but it results into cost-saving in terms of lesser requirement of labor, time saving, reduced errors and lesser wastage of the raw material. Precision and accuracy is increased plus the flexibility of drilling operation is seamless. Also, the automatic inspection system makes it sure that quality is maintained throughout.

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