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Development of Simple Low Pressure Suction Machine

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Abstract. Suction is widely used in the medical applications. The vacuum can be used for suction with high pressure which may result in damage to the human tissue. This study was aimed to develop a tool that can be used for low pressure suction without damage to the human tissue. This Low Pressure Suction machine has been developed by using a solid state relay and convection current concept to be more reliable in terms of software and hardware as well as to be more flexible to many applications in medicine.

Keywords: Low pressure, Suction, Biomedical, Suction machine

1. Introduction

The suction in the medical use is the process of taking out or draining out fluids from the body. The use of pressure suction has been published since 1933 [1]. The low pressure suction is important in medicine because it does not cause damage to the patient's soft tissue. Although the development of suction machine has seen a number of different machines over the years, there have been very few academic literatures regarding the concepts and the development of particular machines. The reason may be the fact that such development was done as a patent and was intended for commercial use [2]. In General, suction devices are available in three main types which are suction of the pipeline, mobile suction, and low suction. For the low suction, the major use is in gastrointestinal drainage such as bleeding in the stomach or intestines. Therefore, the low pressure suction machine must be able to drain the body fluid out in continuous manner without damaging the underlining soft tissues. Until there is an easy access to a simple low suction machine for the use in hospitals in rural areas, the development of such machine is very important and it will make the machine easily accessible and gain more widespread use.

2. Materials and Methods

2.1. Hardware Design

2.1.1. Solid State Relay Circuit (SSR)

Solid state relay which is an electronic switch was used to connect (Interface) between the control part and the power part where the two parts have a ground to separate the circuits and act as the short-circuit protection and prevent the interference with each other. Solid State Relay may be regarded as an invention designed to be used in place of the armature relay as it is more sensitive, smaller and more durable. The comparison of the two relays is in the following diagram.

For this low pressure suction machine, zero crossing type of AC switching circuit was used. Figure 2 shows the example of SSR with zero crossing type used in the circuit.

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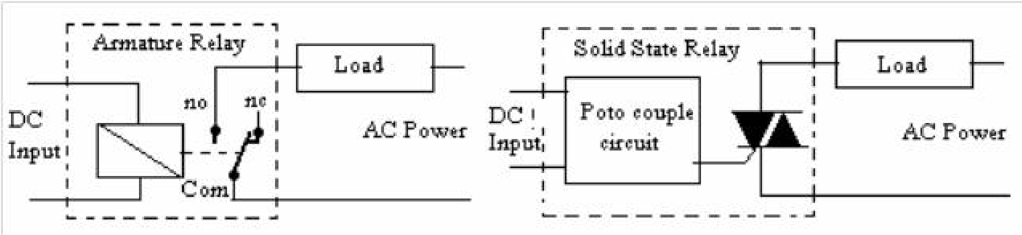

Fig. 1: A schematic diagram of the two relays.

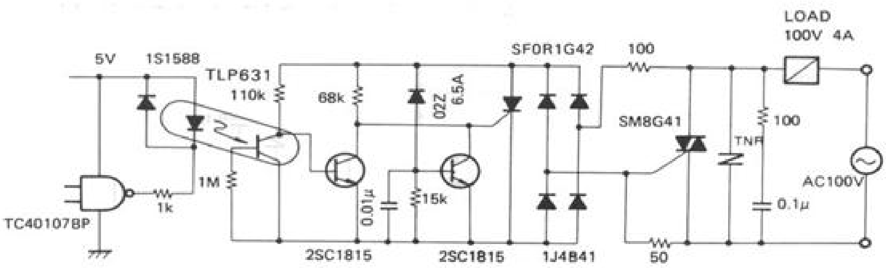

Fig. 2: A schematic diagram of zero crossing SSR.

2.1.2. Generating Heat in a Wire

Low pressure suction is generated by using the convection current concept that hot air rises and cool air sinks. Hot air is generated by passing electric current through the Nichrome wire which has a high resistance. The wire gets hot which is utilized in many applications such as electric stoves, irons and electric lamps. The movement of air cause the low pressure suction which can be controlled by the amount of time the wire is heated.

2.2. Software Design

A program was written to control the hardware in such a way that the two working modes can be selected as two different pressures; 90 mmHg and 120 mmHg. The pressures obtained were calculated from heating the cylinder for 2.5-3.5 seconds. The low pressure created in the cylinder gives 90 mmHg of low suction. On the other hand, heating the cylinder for 4.5-5.5 seconds gives 120 mmHg of pressure suction. A Flow chart in Figure 3 shows how the program works.

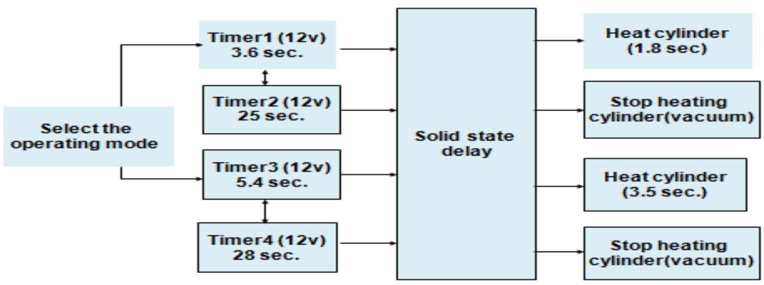

Fig. 3: A Flow chart of the program. Fig. 7: The results of suction of 1 litre of water

2.3. Assembling the Unit

Both hardware parts and software were fitted together as the low pressure suction machine was assembled into a portable unit connecting to a drainage glass container. Figure 4 shows the low pressure suction machine assembled.

2.4. Calibration and Tests

In order to use the developed low pressure suction machine in hospitals, calibration and other tests must be carried out to ensure that the low pressure suction machine has met the standards and the requirements of such a machine. The leakage current test was also carried out. Finally, the low pressure suction machine was tested with the real liquid to test the performance using 1 litre of water. Finally, a pig stomach was used for in-vitro testing of the real suction of liquid inside the stomach to see if the suction can be done without damaging the soft tissues.

Fig. 4: The low pressure suction machine and a pig's stomach used for in-vitro testing.

3. Results and Discussion

The calibration to verify that the low pressure suction machine allows two pressure selections of 90 mmHg and 120 mmHg was done by using the DPM2Plus Universal Pressure Meter, Fluke Biomedical, Cleveland, USA. The results for both pressure levels are satisfactory with the error of less than 2% (Figure 5).

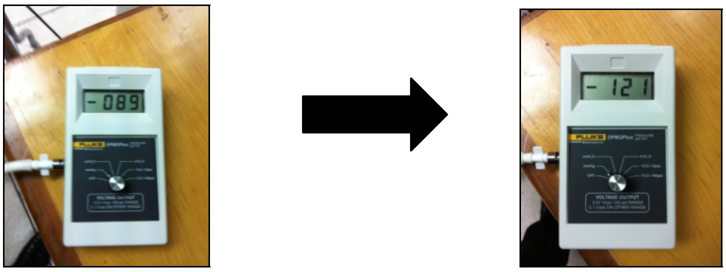

Fig. 5: A calibration test.

Electrical Safety Analyzer test was performed to check for any leakage current by using Fluke Esa620 Electrical Safety Analyzer (Fluke Biomedical, Cleveland, USA). The results are shown in Table 1.

The results from water suction (Table 2) and suction of liquid inside pig's stomach (Table 3) show that the low suction machine can function as they are supposed to do and the low suction did not cause any visible damage to the soft tissue of underlining pig's stomach after careful examination.

The results obtained from this study show that the low pressure suction machine developed meets the standards of ECRI which states that the leakage current must not exceed 300 µA. The low pressure suction machine developed gave the maximum leakage current of 22.9 µA.

In the past, commercial and business equipment are the reasons why the researches in medical devices are rather limited as the confidentiality and patents were submitted instead of publishing the developments in the academic journals. The development of low pressure suction machine is no exception as the patents were submitted since 1935 for the working principle of suction appliances [1]. However, the research and development have to cover all sorts of equipment in order to give easy access to all people when the equipment can be obtained at lower costs. The authors presented the methods used for achieving two levels of low suction pressures at 90 mmHg and 120 mmHg as they are the pressure levels used in medical applications. These pressure values do not cause any harm to soft tissues because they are similar to the values of the systolic and diastolic blood pressures generated naturally by the heart. The current research shows that the suction of liquid inside a pig's stomach did not show any damage to the underlining soft tissues of the pig's stomach. This confirms the authors' belief that the pressure values of 90 mmHg and 120 mmHg are safe for low pressure suction for the fluids in human body.

Table 1: Leakage current measured from a metal part in the low suction machine.

Test No.	**Max. leakage current allowed) µA)**	**Measured current) µA)**
1	300	22.9
2	300	21.3

Table 2: The time taken to drain 1 litre of water.

Test no.	Suction pressure 90 mmHg.		Suction pressure 120 mmHg.	
	Time to drain 1 litre of water (sec)	Rate (ml/min)	Time to drain 1 litre of water (sec)	Rate (ml/min)
1	197	304.5	200	300
2	202	297	201	298.5
3	201	298.5	202	297
4	202	297	202	297
5	204	294.1	202	297
Mean	201.2	298.2	201.4	297.9
S.D.	2.31	3.44	0.80	1.20

Table 3: The suction time of liquid inside a pig's stomach.

Test no.	**Time taken to drain (sec.)**
1	87
2	119
3	242
4	155
Mean	150.75
S.D.	57.91

The function of the low pressure suction machine was also studied by comparing the time needed to drain 1 litre of water. The findings for the time taken are consistent for both 90 mmHg and 120 mmHg with the mean values of 201.2 seconds (SD = 2.31 sec) and 201.4 seconds (SD = 0.80 sec), respectively. As expected, the time taken to drain 1 litre of water from the pig's stomach was varied and took longer than the water in a glass container ranging from 87 to 242 seconds with the mean of 150.75 seconds. The results may be explained by the fact that the mucus and fluids inside pig's stomach are viscous and inhomogeneous which can be difficult for the low pressure suction at times. This is understandable and can be found in real life when the low pressure suction is used to drain blood or fluids from the stomach or intestines.

The limitation of this study is that the authors have not performed the low pressure suction in human yet as it needs further tests to ensure that the machine complies with the standards required and the ethical approval for human subjects test is in place. However, the findings from this study give useful steps towards the development of simple low pressure suction machine to meet the required international standards. The machine can now be tested in the long term and applied to use in human subjects for the future research.

4. Acknowledgements

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5. References

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