Paper ID: RT-101

Design and Construction of a DC Motor Driven Agitator for Lab-scale Work Agitation Purposes

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Abstract

Many times, it is required to use an agitator in various chemical or biochemical reactions, where effect of agitation is a vital criterion. For such cases, a dc motor powered agitator has been developed, which is easy to use and can be used at high speed requirements up to 600-700 rpm depending on the load and controlling the current supplied. A full scale agitator will be developed that will take power from its manually designed adapter. The power output from the adapter can also be modified according to requirement. The agitator is used in this research work, where it is used to disturb a feed material mixture for producing Biogas. This design and its modified version according to requirement maybe used in such works where this kind of agitation is required. The design, construction, use of the model, performances and scope of modification of the agitator are presented in this paper.

Keywords: *Lab-scale Agitator, Manually designed adapter, Biogas plant*.

1. Introduction

Mechanical agitation may be a process of mixing or stirring elements by means of rotary motion of a shaft or agitator. A full scale agitator was developed in India for a slightly different purpose, which was studying the performance of it [1]. The lab-scale agitator in this experiment was however constructed from the need to agitate the feedstock material of a biogas reactor. The agitation of feed material in biogas plants provides better production capacity of the gas [2]. Various other research works require agitation of proper magnitude and nature. Oxygen production from electrolysis can be greatly benefited by proper agitation [3]. The reaction speed in various chemical reactions is sometimes affected by the method and magnitude of agitation [4]. Soil chemical processes can also be benefited by using agitation in a proper manner [5]. Reaction between solid-liquid systems is also greatly affected by the presence of agitation [6]. Effect of paper waste on biogas production was being studied , where manual agitation was provided, by means of stirring the lab scale reactor by hand [7]. In larger biogas plants, larger agitators can be used which serve as the automatic or manually controlled stirrer of the plant [8]. In some lab-scale plants smaller dimension agitators have been developed, but due to the cost of those, the use sometimes does not seem sophisticated [9]. There are various problems concerned with designing agitators [10]. All the crises about designing and fabricating an agitator were considered.
The objective was to fabricate a lab-scale agitator, which is capable of providing sufficient torque, for the intended purpose of stirring the feed composition of the biogas plant. Another objective was to keep the construction and controlling simple. The cost was also kept low in order to justify the construction of the device economically.

2. Construction Method

The design of the device can be divided into two parts: 1. The agitator shaft with impeller and 2. The ac to dc converter. The converter circuit was needed to provide the continuous supply of power from ac current sources. A battery can also be an alternative solution of power, to run the motor in absence of electricity. However, use of battery comes with the problem of charging and was avoided therefore. The material used for the shaft and the impeller was Stainless Steel (SAE-301). The shaft and impeller were

weld using electrical arc welding. The shape of the impeller was given with pliers by hand. The motor was joined to the shaft on the other end by means of gas welding. The other method of connecting the motor with the shaft could be using bushings and nut-bolt, but was avoided as the diameter of the shaft used is very small in this set-up. The stainless steel material was selected because its properties like good weldability, anti corrosive nature and light weight were required. The shaft and impeller had to be anti-corrosive because the desired purpose of use of the agitator includes submerging it in liquid solution of feed materials.

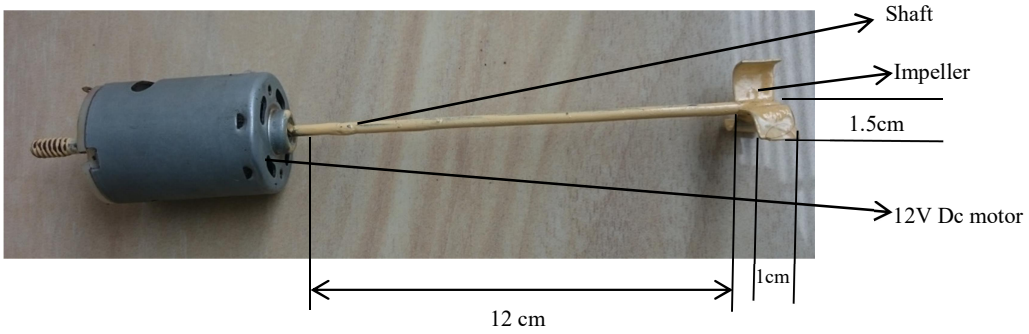


Fig.1. The dc motor driven agitator shaft

All the dimensions of the components were maintained as shown in **Fig.1**. The dimensions were chosen based on the requirements of the biogas reactor [11]. The cost of the materials used of Stainless Steel is roughly 20 Tk per agitator and the price of a 12v dc motor is 70 Tk in the local market. So, the materials for a single piece of agitator cost 90 Tk in total. The welding was done in lab, so there is no additional cost of that. Also the welding processes are very simple as no complex surfaces are involved. A converter providing dc current output and taking ac current supply as input was constructed to power the dc motors. The ac to dc converter was made according to the following circuit. The following electronics were used to build the converter circuit:

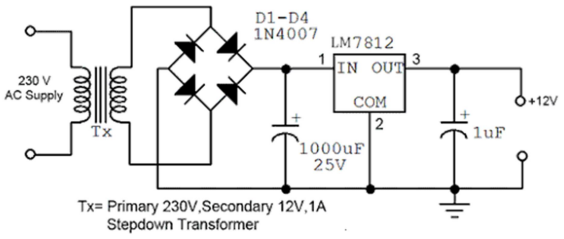


Fig. 2.Circuit diagram of the ac to dc converter

1.230/12v transformer of 1A (center tapped)
2.Voltage regulator (LM 7812)
3.4 piece diodes (1N 4007)
4.Capacitor 1000μF
5.Capacitor 1μF
6.Connecting wires(Jumper wires)
7.Bread board.

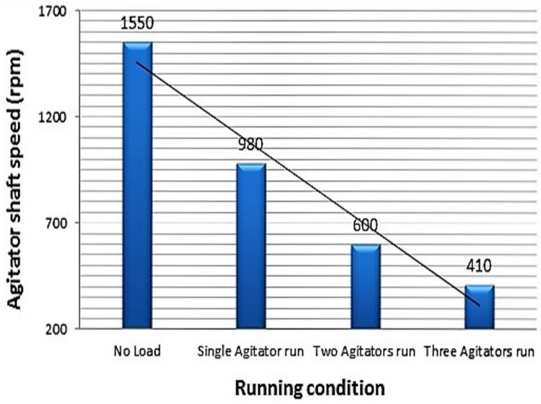
Fig. 3. The ac to dc converter

There was no additional cost of making this converter other than the purchasing costs of the mentioned electronics. In total it costed only 260 Tk in the local market of Rajshahi, Bangladesh to purchase all the equipments. There are also ready made adapters available in the local market, which could be used as alternative of the converter . The cost of the adapter is 500 tk , which is as much as twice of the cost of purchasing the components. Also for the experimental purpose , three agiator sets were required to run simultaneously. Using the converter

was a better solution for the purpose , as an adapter could power only one or two motors simultaneously. Also in comparison, the converter is more cost effective.

3.Performance characteristics & data

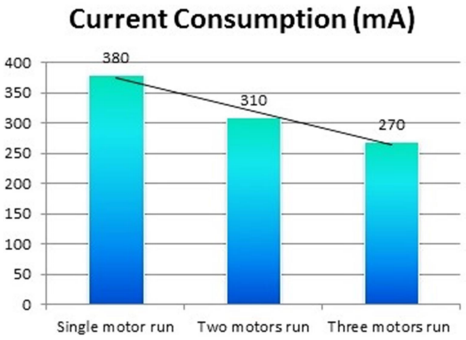
The performance of the agitator shafts were measured in various running conditions based on two parameters which are :1. The speed variation and 2. The current consumption .



Running Condition	Speed(rpm)
No load	1550
Single motor run	980
Two motors run	600
Tree motors run	410

Fig.4. Speed variation characteristics in various running conditions

The agitators had to run according to the biogas reactors' requirements. When more than one agitator had to run , they took power output from the converter circuit in parallel. **Fig. 4** Shows that, with increase in number of motros running simultaneously , the agitation speed decreases. This occurs as the output of the transformer used in the converter circuit is of 1A supply. This 1A current gets divided in parallel, decreasing the shaft rotation speed. A similar trend is observed with the current consumption of individual dc motors driving the agitators.



Running Condition	Average Electricity consumption (mA)
Single motor run	380
Two motors run	310
Tree motors run	270

Fig.5. Current consumption characteristics in various running conditions

The average current consumption of dc motors is seen to be decreasing with increase in the number of dc motors running simultaneously. The devices used to measure rotational speed of the shaft & the current consumption of the dc motors are:
1. Handskit DT-9205A multimeter (for measuring current consumption) and
2. Analogue tachometer available in the lab (for measuring rotational speed).

Fig.6. Handskit DT-9205A multimeter

Fig.7. Analogue tachometer available in the lab

4. Discussion and Recommendations

The construction of the agitators was in accordance to the requirements of a lab-scale biogas reactor [11]. The reactor required less amount of torque to stir the feed material and thus the load on the agitators was less. However, using the same method with some modifications, agitators of similar type but different dimensions and capacity can be constructed. The following recommendations can be useful:

1. If the rotational speed required is more than the speed shown in this set-up, simply a transformer of same voltage but higher current supply output could satisfy the requirements. For example: 230/12v 2A transformer could be used to replace the transformer.
2. For greater load on the agitator shaft, motors of higher voltage might be used. In that case only replacing the 12v dc motor with higher capacity motor would be required. 24v dc motor may serve the purpose. As the transformer used is center tapped, the same transformer can provide 24v supply.
3. The materials of the shaft and impeller can be changed according to requirements. Here SS material was used to prevent rust formation, as the shaft is required to rotate in water. If this is not required, cheaper materials like MS might be used to construct the agitator.

Fig.7. Set-up for which the agitators were constructed

5. Conclusion

The total cost of the three agitators constructed in the experiment was 530tk, which is quite cost effective. The agitators are constructed such a way that, there always is option for various modifications. Also, those could be used according to various requirements with ease. The same agitators could serve in various set-ups, where similar nature of agitation is required.

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