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Design Centriguge by using Solar Cell

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Abstract:

A centrifugal system was designed that relies on 220 DC voltage generate by using the solar cell as a source of energy to operate it. The system consists of a centrifuge, from which the power card was removed and the solar cell was used with specifications (160 watts, 18.05V, 8.86A), battery (12V,60A), An electronic card that regulates the charging of the battery from the solar cell, invertor system which regulated to change 12V to 220V DC to turn on the centrifuge device with maximum speed around 6000 rpm.

Introduction

1.1. General Introduction:-

The chemical and biological laboratory involves mixing of reagents in different states. Filtration and sedimentation are the two most important principles used for separating different types of mixtures. Separating of butter from milk is one of the oldest methods of sedimentation which uses the rotatory motion called churning [1]. Scientific usage of centrifuge started with Benjamin Robins who came with the idea of whirling arm for calculating drag in fluids [2]. This later led to the development of butterfat extraction machine during the industrial revolution in 1864 by Antonin Prandtl and Alexander Prandtl [3]. As the technology progressed the mechanized rotation were replaced with motors. This led to the subsequent evolution of centrifuge as a common instrument in laboratories. This paper focuses on the multipurpose centrifuge used in chemical and biological laboratories.

1.2. Literature Survey:-

In this Literature Survey, an overview of important of laboratory centrifuge rotor design and other parameter selection is presented. It is mainly focused on studying the different parameters of laboratory centrifuge rotor to improve the strength of the rotor and safety of the product.

Paper-1: Xuan Hai-jun, Song Jian, "Failure analysis and optimization design of a centrifuge rotor", Science Direct, Engineering Failure Analysis Vol. 14 (2007) Pages: 101–109:-

In this Research Paper, Chemical analysis and microstructure observation were used for material inspection. It was identified that the material of the rotor was as per specified grade of high strength aluminum alloy and there was no material degradation. Therefore, mechanical stress analysis using finite element method was carried out for failure analysis after the metallurgical examination. It was found that the rupture was due to insufficient integrated strength of the rotor as maximum centrifugal stress exceeds the ultimate strength of the material. Further works were done for the structure optimization of the rotor standing centrifugal loading at 2 times the maximum operation speed. The rotor dimensions have been changed at two regions and the maximum centrifugal stress was reduced to a relative low level with an improved safety performance. The structure optimized centrifuge rotor was machined by the manufacturer and stood 2 times the maximum operation speed of 46,600 rpm with 5 min in the later over-speed spin testing. It can be concluded that 3-dimensions stress analysis and structure optimization based on finite element method are essential for the safety performance improvement of centrifuge rotors [4].

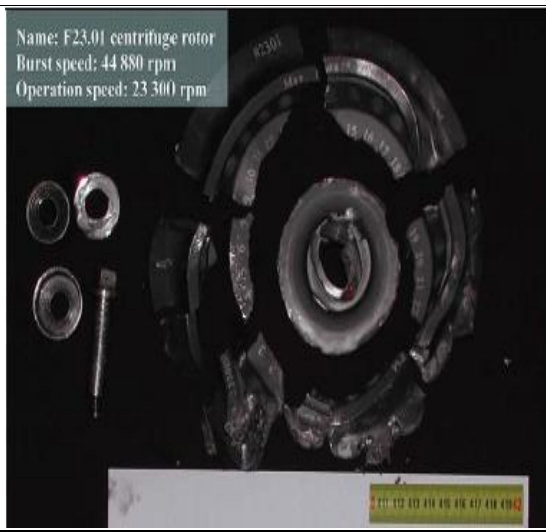

Fig. 1.1 Post-test reassembled rotor fragments.

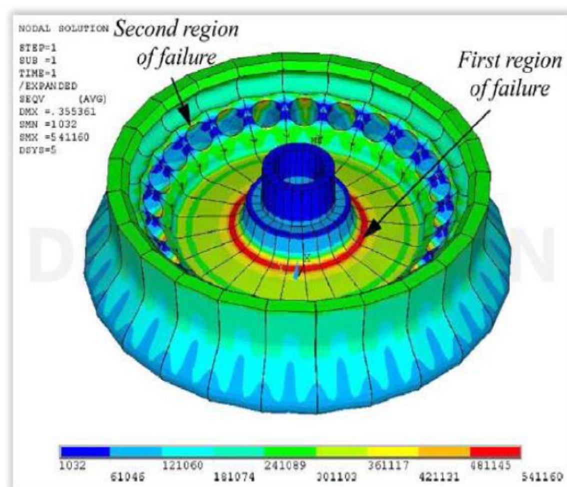

Fig. 1.2 Von Mises stress contour at speed 44,880 rpm (10-3 MPa).

Paper-2: Hak Gu Lee, Jisang Park, Ji Hoon Kim, "Design t heory and optimization method of a hybrid composite rotor for an ultracentrifuge", Science Direct, Mechanism and Machine Theory, Volume 59 (2013), Pages: 78 -95

In this study, the optimizat ion method of a hybrid composite disc that can be applied to the preliminary design of centrifuge rotors was developed based on the analytical solutions of a rotating orthotropic disc loaded by centrifugal body force under the plane stress condition. Since the results of the optimized disc give higher stress values than that of the 3-D rotor structure does, they can predict the performance of a designed hybrid composite rotor conservatively. If PEI, AS4/3501-6, and Kevlar/epoxy are used for the core, the composite outer layer, and the composite insert with the thickness of 2 mm, respectively, the optimized dimensions of a hybrid composite disc having 12 tube holes with the hole radius of 5 mm are the inner radius of 25.8 mm, the boundary radius of 43.0 mm, and the outer radius of 55.1 mm. The hybrid composite rotor having the above dimensions at its maximum radius can operate at 94 H.G. Lee et al. /Mechanism and Machine

Theory 59 (2013) 78–95 99,000 rpm with a safety factor higher than 1.50 and at 116,000 rpm with a safety factor higher than 1.09. From the results, it can be found that the ultimate condition of the designed hybrid composite rot or reaches an ultracentrifuge region (≥600,000×g) [5].

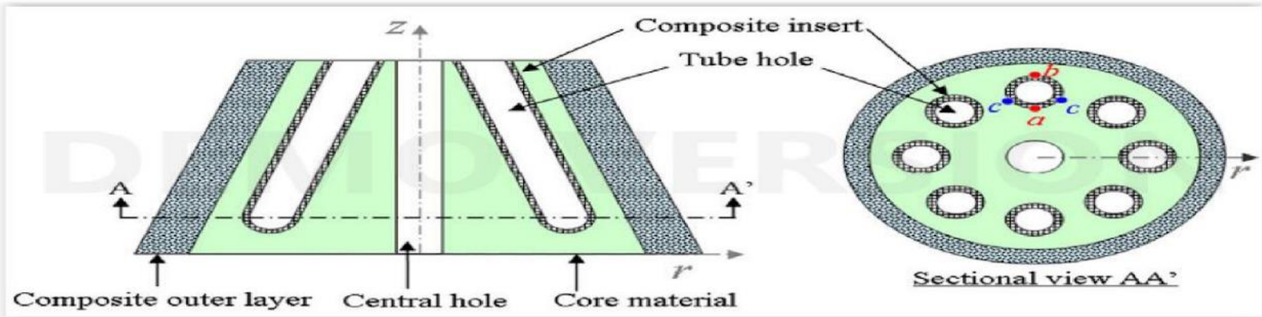

Fig. 1.3 Cross-section view of a hybrid composite rotor for an ultracentrifuge

Paper-3: M. Bayat , B.B. Sahari , M. Saleem, Aidy Ali, S.V. Wong, "Bending analysis of a functionally graded rotating disk based on the first order shear deformation theory", Science Direct, Applied Mathematical Modelling Vol. 33 (2009), Pages: 4215–4230

The theoretical formulation for bending analysis of functionally graded (FG) rotating disks based on first order shear deformation theory (FSDT) is presented. The material properties of the disk are assumed to be graded in the radial direction by a power law distribution of volume fractions of the constituents. New set of equilibrium equations with small deflections are developed. A semi-analytical solution for displacement field is given under three types of boundary conditions applied for solid and annular disks. Results are verified with known results reported in the literature. Also, mechanical responses are compared between homogeneous and FG disks. It is found that the stress couple resultants in a FG solid disk are less than the stress resultants in full-ceramic and full-metal disk. It is observed that the vertical displacements for FG mounted disk with free condition at the outer surface do not occur between the vertical displacements of the full-metal and full ceramic disk. More specifically, the vertical displacement in a FG mounted disk with free condition at the outer surface can even be greater than vertical displacement in a full-metal disk. It can be concluded from this work that the gradation of the constitutive components is a significant parameter that can influence the mechanical responses of FG disks [6].

Paper-4: Naik Shashank Giridhar, Sneh Hetawal, Baskar P.; "Finite Element Analysis of Universal Joint and Propeller Shaft Assembly", International Journal of Engineering Trends and Technology (IJETT) – Volume 5 Number 5 - Nov 2013, Pages: 226-229 :-

In this Paper, Analysis of the Yoke clearly shows that by a small modification in the existing design the strength of the part can be increased significantly. Also with the same changes they obtain a small amount of weight reduction in the design. The maximum stress values generated are significantly reduced and the stress is evenly distributed over the entire part. Propeller shaft can be made either from steel or from the aluminium. The stress generated are approximately the same but the deformation in aluminium shafts is higher than that of the steel shaft. FEA has been carried out with ANSYS Workbench Software.[7]

Paper-5: F. N. Werfel, U. Flogel-Delor, R Rothfeld, D. Wippich, T Ridel, "Centrifuge advances using HTS magnetic bearings" Physica C 354 (2001), Pages: 13-17.

A prototype centrifuge with a HTS double bearing design and an integrated 15W cryo-cooler was assembled in vertical geometry. Toward this application of SMB the rotor dynamics studied by stability measurements with and without unbalanced masses. In the resonance case extreme eccentricity values of up 2mm are safely passed due to the high damping efficiency of the SMB modules. The prototype could serve as the basis for a first advanced centrifuge type equipped with HTS bearings.

Theory

2.1. Centrifugation and centrifuge definition:

Centrifugation is the technique of separating components where the centrifugal force/ acceleration causes the denser molecules to move towards the periphery while the less dense particles move to the center. The process of centrifugation relies on the perpendicular force created when a sample is rotated about a fixed point. The rate of centrifugation is dependent on the size and density of the particles present in the solution.

Centrifuge can refer to a machine that houses a rapidly rotating container to separate its contents by density or to the act of using the machine or A centrifuge is a piece of equipment that puts an object in rotation around a fixed axis (spins it in a circle), applying a potentially strong force perpendicular to the axis of spin (outward). The centrifuge works using the sedimentation principle, where the centripetal acceleration causes denser substances and particles to move outward in the radial direction. At the same time, objects that are less dense are displaced and move to the center. Hence, a centrifuge uses centrifugal force to separate two or more substances of different densities or masses from each other. [9]

Effective separation of mixtures is a common challenge experienced in many industrial processes. These mixtures could be two immiscible liquids or solid suspension in liquid. The oldest and easiest way of separating such mixture is by allowing it to settle into two distinct layers with the denser liquid/solid at the bottom while the lighter liquid stays on top (sedimentation) before decanting. Unfortunately, this sedimentation process for most mixtures is time consuming (consuming several hours and in some cases, may run into days) causing a consequent stagnation in production. To achieve continuous production for such systems and reduce overall production time,there is need for a faster means of separating such mixtures.

Centrifuges achieve separation by means of accelerated gravitational force achieved by a rapid rotation. [10]

This replaces the normal gravitational force required for settling. Hence, sedimentation can be achieved in less time by replacing the sedimentation tank/vessel with a centrifuge. Centrifuges are used in a variety of medical and industrial applications. [11]

Although different centrifuge designs and capacities are already in existence, most of these centrifuges are complex to operate and costly to maintain by small and medium scale producers, especially in developing countries. Hence, the need to develop a simple and cost effective centrifuge for small and medium scaled industries using locally sourced materials.

2.2. Theory of Centrifuge Operation :-

An example of a fixed angle centrifuge is the Neuation iFuge M12 device. This is illustrated in figure 2.1 which shows the device with the lid raised and twelve micro centrifuge tubes placed in the rotor.

The theory of centrifuge operation can be developed as follows. Let a centrifuge tube of length l_0 metres and cross sectional area A m^2 be filled to a height of l metres with fluid of density ρ_s. Let the fluid contains a suspension of spherical particles of radius r metres and density ρ_p kg/m^3. See figure 2.2.

The tube is inserted into the centrifuge and the device operated. In practice a centrifuge must always be loaded with an even number of tubes, diametrically opposed containing the same mass of liquid so that the rotor is balanced. Running a centrifuge with a single tube would certainly make the centrifuge vibrate and could quite easily break the device. However for the point of developing theory, only the forces acting on a single tube will be considered. As the rotor spins, an apparent centrifugal force acts on the sample of fluid and the particles inside it, pushing both radially outwards towards the side of the centrifuge tube.

Fig:2.1 High Speed Centrifuge with Fixed Angle (NTPL, Gandhinagar)

The magnitude of the centrifugal force, FC can be show to be [12] given by equation (1.1).

$FC = m\omega 2R$ (1.1)

where

FC :-Magnitude of the centrifugal force (units Newton)

ω:- Angular Velocity of the Centrifuge (units radian/second)

R:- Radius of the circular motion of the centrifuge (unit metre)

M :-Mass of the particle being spun.

This could be either the mass of the total solution, or the mass of a particle depending on the context of the discussion.

The linear velocity v of the tube as it moves in a circle is given by equation (2.2).

$\upsilon = \omega R$ (2.2)

The force FC acts on the particles in the fluid sample, pushing them towards the outside of the centrifuge tube and thence causing them to slide down the tube to form a pellet at the bottom. This force plays the same role as that played by gravity in the sedimentation. Again there is a force of Buoyancy FB played a role. However, in this case the buoyancy force acts in the opposite direction to the centrifugal force rather than towards the fluid surface. Also there is again a drag force FD, as the solution resists the flow of particles and again this acts to oppose the motion of the particles. Equating all forces, we find that when the suspended particles attain terminal velocity, they behave as predicted by equation (2.3).

$$\frac{4}{3}\pi r^3(\rho_p - \rho_s)\omega^2 R = 6\pi r \eta v_T \quad (2.3)$$

The time for all particles to collect into the pellet in the centrifuge tube.

T is thus given by dividing l, the depth of fluid in the centrifuge tube by υT, the terminal velocity, and see equation (2.4).

$$T = \frac{9l\eta}{2r^2(\rho_p - \rho_s)\omega^2 R} \quad (2.4)$$

where

T :-Time taken to precipitate all suspended particles (unit seconds)

ω :-Angular velocity of the centrifuge (units radian/second)

r :-Radius of suspended particles (m)

η :-Viscosity of the solution (units Pa.s)

ρp :-Density of suspended particles (kg / m3)

ρs :-Density of solution (kg / m3)

R :-Radius of the circular motion of the centrifuge (unit metres).[13]

2.3. Types of Centrifuges:-

1. There are two fundamental types of rotors:

λ **Fixed Angle Rotor:**

These hold the tubes in the centrifuge at a fixed inclination (typically about 35 degrees) to the vertical. The most common devices hold eight tubes and they have the advantage of not having moving parts on the rotor. This arrangement means that the solute is forced against the side of the tube. This leads to a faster separation of the solute from fluid, but risks abrasion of the particles as they are forced down the wall of the centrifuge tube. Also the end result is a smear along the side of the tube rather than the precipitate forming a neat pellet.

Advantage:

Sedimenting particles have only short distance to travel before pelleting.

Shorter run time

This is the most widely used rotor type.

λ **Swinging Bucket Rotor:**

This form of rotor allows the centrifuge tubes to freely swing out towards the horizontal as the device operates. This gives the longest path of particle movement as the centrifugation proceeds and has the advantage that the solid forms in a clear pellet at the bottom of the centrifuge tube.

Advantage:

Longer distance of travel may allow better separation eg. Density gradient centrifugation.

Easier to withdraw supernatant without disturbing pellet.

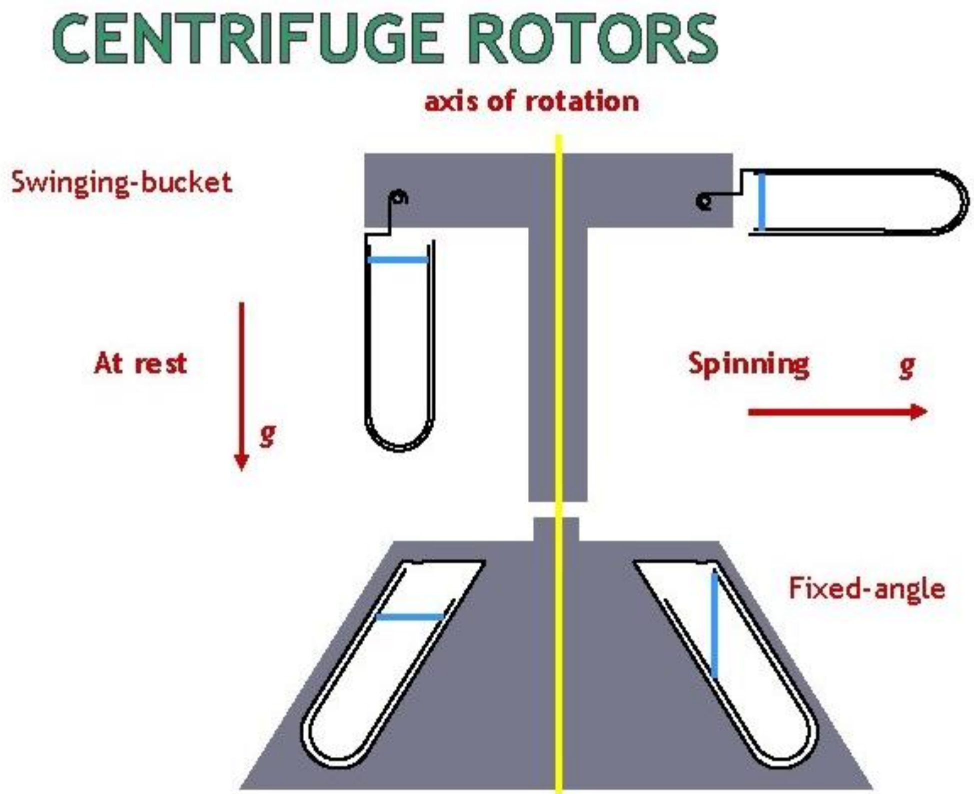

Fig:2.2 Types of Rotors

2. centrifuge operating speed classifications are:

* Low speed < 8000 rpm.

* Medium speed 8000 ~ 30000 rpm.

* High speed 30000 ~ 80000 rpm.

* Ultracentrifuge > 80000 rpm.

2.4. Application of Centrifuges:-

- Production of bulk drugs: In the bulk drug industry, whenever a crystalline material is to be separated from a suspension, e.g., aspirin is separated from its mother liquor by centrifugation.
- Production of biological products:

a. Separation of blood cells.

b. Purification of insulin by selectively precipitating other fraction of proteins.

c. Separation of most of the proteinaceous drugs and macromolecules.

- Biopharmaceutical analysis of drugs: Drugs present in the blood, tissue fluids and urine are normally present in the form of colloidal dispersion. Centrifugation is used for separating the drugs which is essential for the evaluation of pharmacokinetic parameters and bioequivalence studies.
- Evaluation of suspension and emulsion: Centrifugation method is used as a rapid empirical test parameter for the evaluation of suspension and emulsion.

e.g., A stable emulsion should not show any signs of separation even after centrifuging at 2000-3000 rpm at room temperature.

Ultracentrifugation are used for determination of molecular weight of serum albumin, insulin etc.

Isolation of bacterial cells, fungal and actinomycete mycelium and spores from liquid growth and fermentation media is facilitated by laboratory centrifuge.

Removal of finely suspended solid matter (clarification) from aqueous or oily materials can be carried out by centrifuging at high speeds without the necessity of a filter.

Ultracentrifuge can be used for separation of virus particles which has potential industrial applications.[13]

2.5. Solar cell:-

A solar cell (also known as a photovoltaic cell or PV cell) is defined as an electrical device that converts light energy into electrical energy through the photovoltaic effect. A solar cell is basically a p-n junction diode. Solar cells are a form of photoelectric cell, defined as a device whose electrical characteristics such as current, voltage, or resistance vary when exposed to light.

Individual solar cells can be combined to form modules commonly known as solar panels. The common single junction silicon solar cell can produce a maximum open-circuit voltage of approximately 0.5 to 0.6 volts. By itself this isn’t much but remember these solar cells are tiny. When combined into a large solar panel, considerable amounts of renewable energy can be generated.[13]

2.5.1. Construction of Solar Cell:-

A solar cell is basically a junction diode, although its construction it is little bit different from conventional p-n junction diodes. A very thin layer of p-type semiconductor is grown on a relatively thicker n-type semiconductor. We then apply a few finer electrodes on the top of the p-type semiconductor layer.

These electrodes do not obstruct light to reach the thin p-type layer. Just below the p-type layer there is a p-n junction. We also provide a current collecting electrode at the bottom of the n-type layer. We encapsulate the entire assembly by thin glass to protect the solar cell from any mechanical shock.[14]

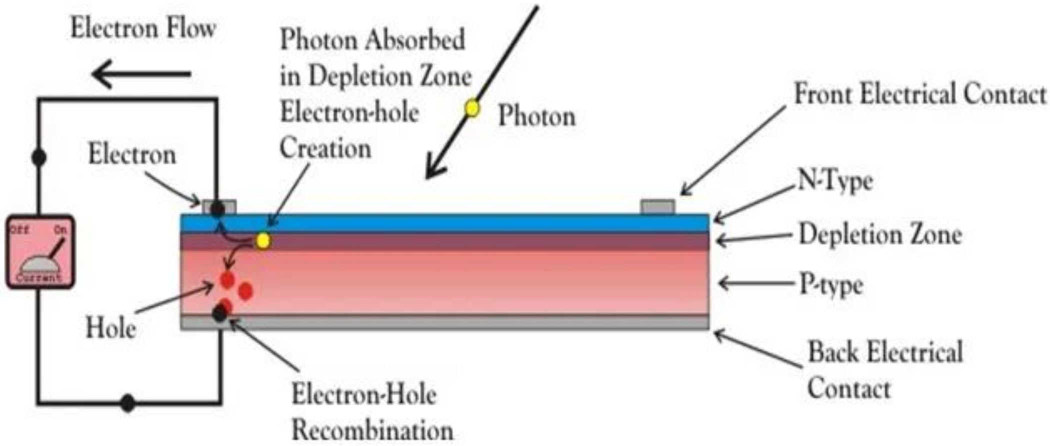

Fig:2.3 Construction of Solar Cell

2.5.2. Working Principle of Solar Cell:-

When light reaches the p-n junction, the light photons can easily enter in the junction, through very thin p-type layer. The light energy, in the form of photons, supplies sufficient energy to the junction to create a number of electron-hole pairs. The incident light breaks the thermal equilibrium condition of the junction. The free electrons in the depletion region can quickly come to the n-type side of the junction.

Similarly, the holes in the depletion can quickly come to the p-type side of the junction. Once, the newly created free electrons come to the n-type side, cannot further cross the junction because of barrier potential of the junction.[16]

Similarly, the newly created holes once come to the p-type side cannot further cross the junction became of same barrier potential of the junction. As the concentration of electrons becomes higher in one side, i.e. n-type side of the junction and concentration of holes becomes more in another side, i.e. the p-type side of the junction, the p-n junction will behave like a small battery cell. A voltage is set up which is known as photo voltage. If we connect a small load across the junction, there will be a tiny current flowing through it.[17]

2.5.3. V-I Characteristics of a Photovoltaic Cell:-

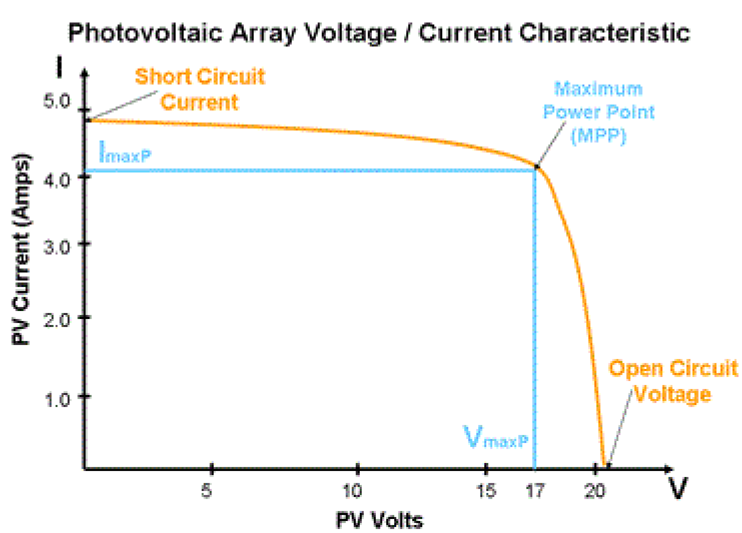

Fig:2.4 V-I Characteristics of Solar Cell[18]

2.5.4. Advantages of Solar Cell:-

1. No pollution associated with it.
2. It must last for a long time.
3. No maintenance cost.[19]

2.5.5. Disadvantages of Solar Cell:-

1. It has high cost of installation.
2. It has low efficiency.
3. During cloudy day, the energy cannot be produced and also at night we will not get solar energy.[19]

2.5.6. Uses of Solar Generation Systems:-

1. It may be used to charge batteries.
2. Used in light meters.
3. It is used to power calculators and wrist watches.
4. It can be used in spacecraft to provide electrical energy.[19]

Experimental parts

3.1. Flc-04r Centrifuge: -

It is a Fixed Angle Rotor**,** With safety switch**,** Scope of supply includes the rotor, High speed for short centrifugation timers, Small footprint, Simple to operate, Step speed adjustment**,** Classical metal case, the maximum speed 8000rpm,Rotor ,capacity is 20ml*6,max RCF is 1790xg.

Fig:3-1 Flc-04r Centrifuge

3.2. Solar cell: -

Solar panels are devices that allow for the input of sunlight, and convert this sunlight into electricity. The shape of solar panels can vary in different rectangular and a combination of these rectangular shaped panels are installed and used to produce the electricity.

The specification of solar cell which used in this project:

Maximum power	160 watt
Voltage at Pmax	18.05 V
Open-circuit voltage	22.03V
Current at Pmax	8.86A
Short circuit current	9.48
Maximum system voltage	1000VDC
Operating temperature	-40 to +85 C
Weight	11KGS
Dimension	1480*680*40mm

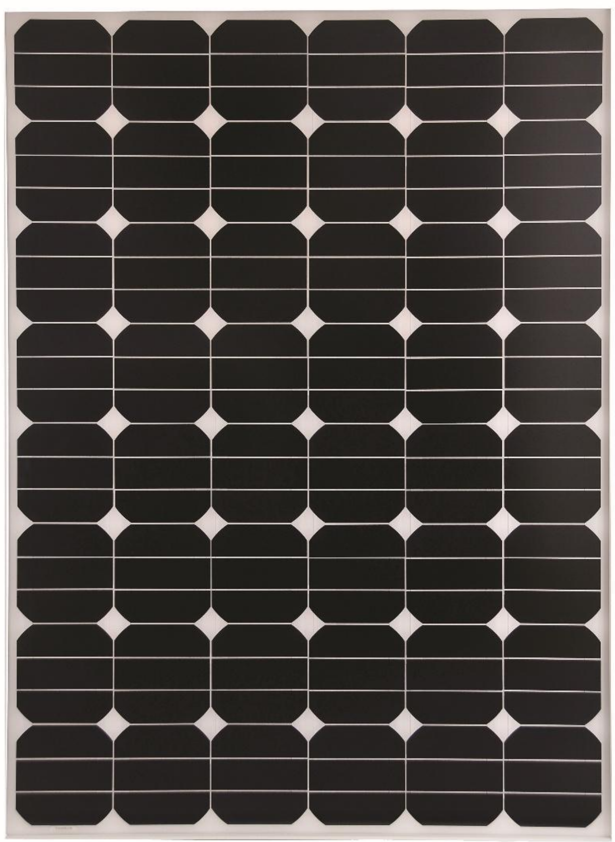

Fig:3-2 Solar cell 160W

3.3. Battery 12V :-

It is used to store electrical energy from the solar cell, the specification of it (12volt and 62 Ah).

Fig:3-3 Battery 12v

3.4. Charge controller circuit: -

In this project we need charging circuit to control with power of solar cell which must be stored in battery, to design this circuit we need some electronic components:

- Pic12F675
- Mosfet transistor TO-247AC or IRFP250
- Diode 1N4007
- Regulator 7805
- Resistors 3*10k,3.3(5watt),variable resistors 2*10k,100,2*2.2k
- LED
- Capacitor 100nF

We connected al electronic parts together show in Fig:3-3

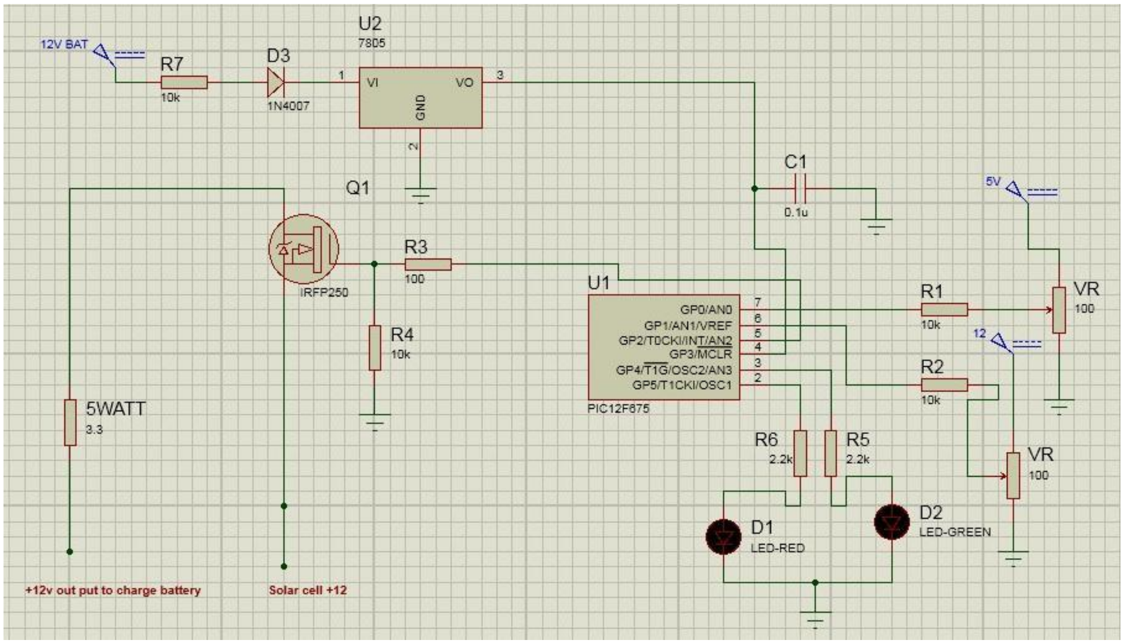

Fig:3-4 Charge controller circuit

In this circuit we note two variable resistors, the first which used to adjust the charging speed and the other working on cutting off the charge and recharging it.

3.5. DC to DC step up converter circuit:-

It used to convert dc 12 volt to 220 volt dc to turn on the Centrifuge depending on solar cell as the power supply instead of Ac electric supply.

The electronic components which need to build the circuit:

- Power supply 12v
- CD4047
- Resistors 2*100 Ohm(10watt),22k
- Capacitors 220 nF
- Mosfet transistors 2*IRFZ44
- Transformer
- Bridge diode

We connected al electronic parts together show in Fig:3-4

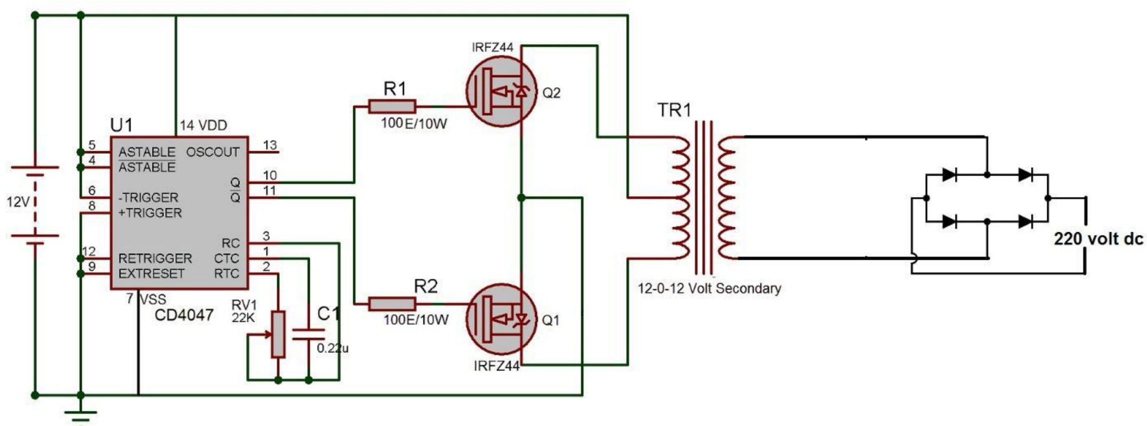

Fig:3-4 DC to DC step up circuit

Results and Future work

4.1. Results and Discussion: -

After we know each part of project in chapter three we collect all parts and connected together

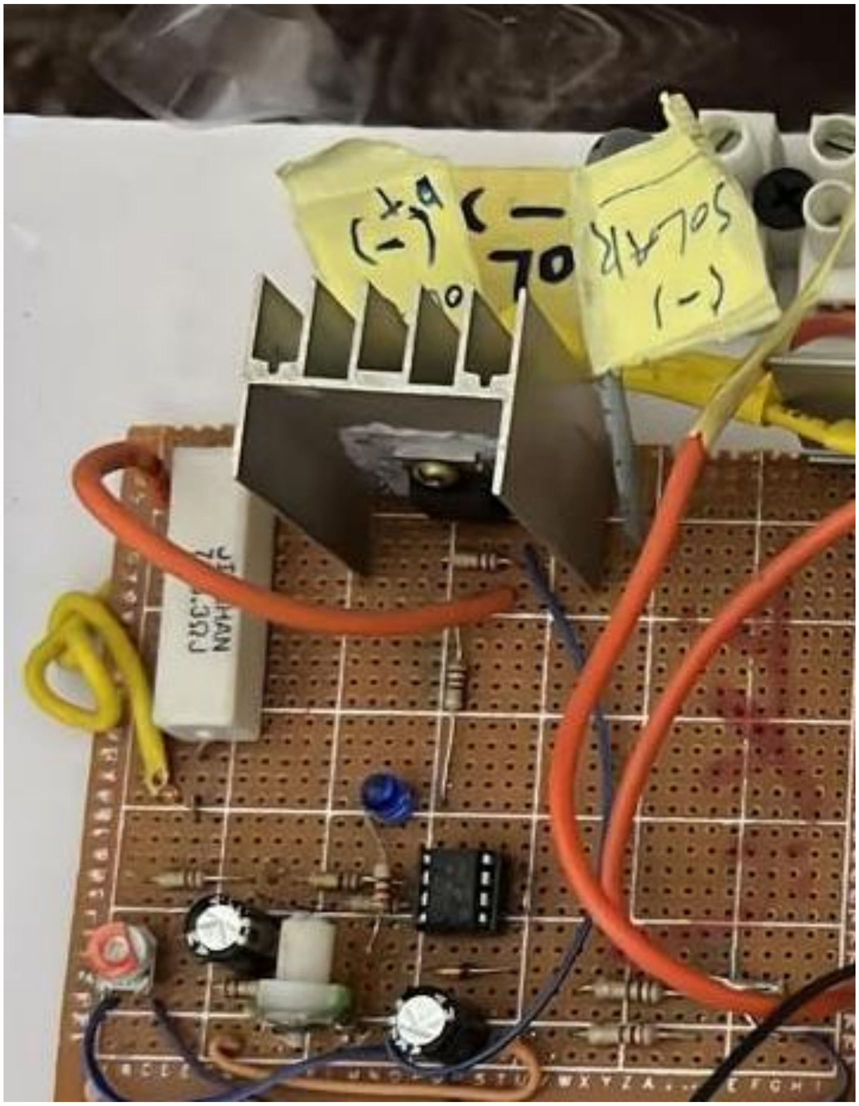

Fig:4-1 charging circuit

Fig:4-2 DC step up circuit

Fig:4-3 All parts of project

We remove the power supply card of centrifuge connected the control card of it with DC step up circuit and turn on show in Fig:4-4

Fig:4-4 centrifuge working at 220 dc voltage

We notice the maximum speed of centrifuge 6000 rpm show in Fig:4-5

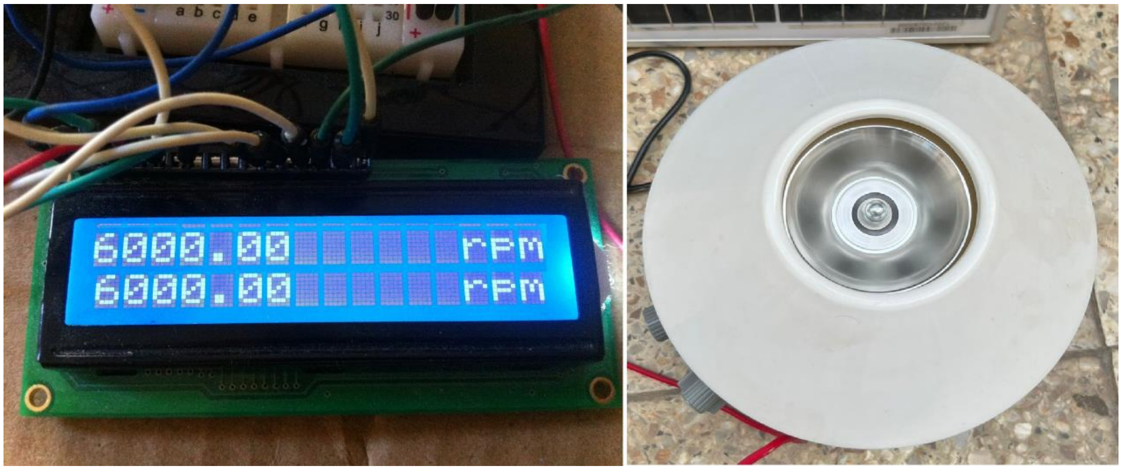

Fig:4-5 maximum speed of centrifuge

4.2. Future work:-

- Increase speed of centrifuge.
- Minimize the size of power supply card and putting internal of centrifuge device .
- We use solar cell system to turn on other medical devices.

Conclusion

In our conference, after reviewing all parts of the project in Chapter 3 and discussing the details of each part of our day, we were able to collect these efforts and activate them to achieve the desired goal. The way the charging process is integrated is also explained in Figure 4-1, which leads to a complete understanding of the registration process. The results extracted confirm the success of the design and implementation according to the specified goals, which closes the field intensively for joint research in this field. This research includes the scientific colors in the field of [medical devices], and we look forward to developing this idea to

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