DEVELOPMENT OF ENHANCED PIEZOELECTRICITY

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***ABSTRACT*: *With the lessening in vitality utilization of compact electronic devices, the idea of reaping renewable energy sources in human encompassing excites a restored intrigue. In this specific circumstance, produce piezoelectric material that collects mechanical vibrations vitality utilizing a strategy known as the Solid State Technique. Furthermore, they designed and fabricated a reactor. The embarked piezoelectric transducer, which is an electromechanical converter, experiences mechanical vibrations in this way, produces power. A static converter changes the electrical vitality in an appropriate structure to the focused on versatile application. Estimates produce electrical power are stated and remarked. Lead Zirconate Titanate (PZT) nanoparticles hold a much promising future and current applications. One standard strategy is the Solid State method, wherein length time, temperature or mineralizer focuses are upgraded to deliver PZT nanoparticles with wanted morphology, controlled measure, and size appropriation. An enhanced solid-state process is utilized to fabricate PZT nanoparticles. PZT nanoparticles with a size circulation extending from 200 nm to 800 nm will be gotten with high crystallinity and cubic morphology. At last, a cluster reactor is developed to generously decrease the manufacture time and kept up a similar high caliber as the nanoparticles arranged in a prior stage. In this group procedure, a furnace is kept up at the procedure temperature (800˚C), while PZT arrangement is set all through the furnace to control the cooling and ramp-up rates. This arrangement is a very time-taking step of chilling off the heater, hence sparing incredible measure of procedure time making the production of a huge quantity of PZT nanoparticles conceivable.*

Key Words: Energy; Electronic devices; Renewable energy; Piezoelectric; Lead Zirconate Titanate; Nanoparticles.

1. INTRODUCTION

The piezoelectric review of some recorded achievements, for example, the disclosure of the piezoelectric impact, the development of piezoelectric ceramic materials, and business use of innovation. In 1880 Pierre and Jacques Curie explained piezoelectricity. They were directing an assortment of experiments on a scope of precious stones at the time. In those examinations, they inventoried various precious stones, for example, quartz, tourmaline, topaz, pure sweetener and Rochelle salt that showed surface charges when were precisely focused. In established researchers of the time, this perception was deliberated as a critical revelation, and the expression "piezoelectricity" was begotten to express this impact. "Piezo" is a Greek word that signifies "to press". In this way, piezoelectricity implies power produced from pressure - an extremely consistent name. This wording recognized piezoelectricity from the other related wonders of enthusiasm at the time; in particular, contact power and pyroelectricity. The disclosure of the direct piezoelectric impact is, along these lines, credited to the Curie siblings. Lippmann in 1881, didn't be that as it may, find the opposite piezoelectric impact or maybe, it was scientifically anticipated from principal laws of thermodynamics. The revelation of piezoelectricity created huge enthusiasm inside the European academic network. In general, inside 30 years of its disclosure, and before World War I, the investigation of piezoelectricity was seen as a tenable logical movement [1, 2].

The main genuine application for piezoelectric materials is produced by Paul Langevin and his collaborators in France, who manufactured an ultrasonic submarine detector. The transducer constructed was made of a mosaic of tiny quartz crystals that were stuck amid two steel plates in such a way that the composite framework had a reverberation frequency of 50 kHz. This device was utilized to transmit a high-recurrence tweet signal in the water and to gauge the profundity by timing the arrival echo. Piezoelectric crystals were utilized in numerous applications. A large number of the great piezoelectric applications, for example, amplifiers, accelerometers, ultrasonic transducers, and so forth., were created and popularized in this period. Advancement of piezoceramic materials during and later World War II altered this field. During World War II, huge research was made in the different countries, was gone for the improvement of materials with extremely high dielectric constants for the manufacturing of capacitors. The capacity to assemble new piezoelectric devices by fitting a material to a specific application carried various improvements, and creations [3, 4].

These days, a large portion of the examination in the vitality field is to create wellsprings of vitality for the future. With oil assets being over tapped and in the long run, bound to end, the time has come to discover inexhaustible wellsprings of vitality for what's to come. Piezoelectric materials are as a rule increasingly more concentrated as they end up being very bizarre materials with quite certain and new properties. These materials can convert mechanical bearing like vibrations into electricity. Such devices are normally suggested to as vitality reapers and can be utilized in applications. While ongoing research has indicated that these materials are used as power generators but the measure of vitality delivered is still low, subsequently needs to optimize [5, 6].

Problem Statement

Vibration vitality is created from any perceivable activity and usually seen as the clamor. However, if the vitality were searched at the specific degree of reverberation frequency, it can deliver the power yield in which can be executed to any valuable application particularly in the mille watt control levels application all things considered in the MEMS innovation. A few ponders have been led by the researchers with respect to the vitality collecting framework by utilizing the electromagnetic and piezoelectric transduction. These look into utilizing these two innovations to build up the crossover reaping vitality frameworks to catch the encompassing ambient source of vitality from the vibration [7, 8].

Objectives and Scope of the Study

The goals of our combination are to give modest power. Change of lost vitality into helpful methods. To make our item financially savvy, ecofriendly and extremely high-recurrence reaction. Self-producing, so no requirement for outside source and easy to use as they have little measurements and extensive estimating range.

Energy harvesting takes an otherwise wasted energy source and converts it into electrical energy. The energy can then be deposited in capacitors or batteries and used to supply power. Ambient energy can be harnessed from the environment around us. Methods of energy harvesting include. Electromagnetic emissions energy is harvested from radio frequencies and signals such as Wi-Fi and Bluetooth. Kinetic energy is harvested by movement or friction. Devices will have the ability to be charged and powered just by user movement. Solar cell energy is collected from the sun. In the past, this form of energy harvesting has been used in watches as well as other small wearable devices. One of the main issues with this kind of energy harvesting is that the device must be constantly exposed to the light to continue charging. A solution to this is a fabric that has cells woven into it and is designed to harvest energy from both solar and indoor light. The thermoelectric type of energy harvesting converts heat into electric energy. Potential uses include cells that use human body heat to produce energy. One advantage of this type of energy harvesting is that it can be used at all times of the day. Piezoelectric kind of vitality collecting changes over mechanical vitality from vibrations or stuns into electrical vitality [9, 10].

When the vitality source is available, there are three different elements that must be available to finish a vitality reaping framework. A device that can change over a vitality source into electrical vitality. A module that can harvest, store and control that electrical energy. A wireless sensor network or another monitoring device. Piezo energy harvesting only creates small amounts of energy, but the ability to store it to eliminate the need for, or to prolong the life of, supplemental batteries is promising.

Raw materials and products

Piezoelectric material has been synthesized from two different methods. The raw material for lab basis synthesis is potassium bitartrate (Cream of Tartare) $KC_4H_5O_6$, sodium bicarbonate $NaHCO_3$, sodium carbonate Na_2CO_3, distilled water H_2O and ethanol C_2H_5OH. Raw materials of commercial basis synthesis are lead oxide PbO, zirconium dioxide ZrO_2 and titanium dioxide TiO_2. By testing successful three attempts in the lab to get the piezoelectric crystals as a finished product. In every attempt, compositions of reactants are changed, and efficiencies of crystals are measured. On the other hand, fabricated the reactor to make a finish product PZT from the solid-state reaction [8, 10].

Past, Present, and future of Raw Material and Product

Raw materials study is also important to get the desired product. Raw materials fundamental researches are present, and future availability must be ensured. All raw materials are processed; before the use of material, no further processing is needed and can be easily stored in normal atmospheric conditions. Handling of raw material should be appropriately done; materials are not harmful to the environment. Kindly read the general instruction of raw material before use and handling the material. The piezoelectric material is much underrated in the past because of less knowledge about the structure. By researches and experiments, materially improved consisting of high efficiency and high energy outputs. In modern days the piezoelectric material is becoming very important because of the massive use of the material in the industry and other sectors of the world and usage is getting higher and higher. The future of piezoelectric material is electricity generation from motion with nanoscale piezoelectric devices and walking illuminates your run on renewable energy. Israeli engineers aim to convert highways into renewable energy generators [11, 12].

Micro Electromechanical Systems (MEMS)

Over the recent decades, there has been a significant progression in the innovative work of potential ferroelectrics in light of the improvement of Micro Electromechanical Systems (MEMS), which are the core of cutting edge ultra-rapid execution devices. Although, the electromechanical business is confronting some principal difficulties to the progression of its advancements on account of the limitations of the center materials utilized. Applications over an incredible scope of user areas require future devices with altogether diminished size and power utilization, ultra-fast, and elevated levels of usefulness [13, 14].

Ferroelectricity was first discovered in Rochelle salt, a double tartrate of sodium and potassium crystallizing with four molecules of water. At present, above 38 structural families of ferroelectrics, the perovskite being one of the most technologically important families. Figure 1 portrays the structure of $BaTiO_3$ (barium titanate). The discovery of ferroelectricity in barium titanate in the early 1940s led to a burst of research and applications which is continuing to this day. The Ti^{4+} ion in $BaTiO_3$ is a little displayed from the center of the “cube” so that there is a separation amid the centers of the +ve and –ve charges in the unit cell, chief to an electric dipole instant. Ideally, all the unit cells in the ceramic should have the same direction of polarization to impart maximum overall polarization to the ceramic body [15, 16].

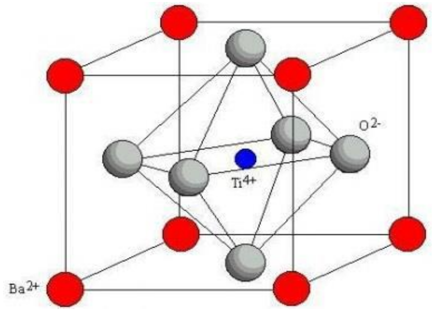


Figure 1: **Crystalline structure of the $BaTiO_3$ (barium titanate)**

However, to minimize the total energy, the direction of polarization is the same in an only a small region in a grain of the ceramic. These regions are called domains. The domains form spontaneously when the ceramic is cooled from its processing temperature below a characteristic temperature, called Curie temperature, Tc (~120 °C for $BaTiO_3$). The polarization direction in the various domains randomly oriented so that the net polarization in the as-prepared ceramic is nearly zero. The ceramic is subjected to an operation called poling in which the high electric field is applied to it. The polarization in the domains tends to orient in the direction of the external electric field. The favorably oriented domains grow. A high temperature, below Tc is used to facilitate this process [17, 18].

Piezoelectric materials is of two types natural or human-made. The widely recognized natural piezoelectric material is quartz, yet human-made piezoelectric materials are increasingly productive and for the most ceramics. Due to their composite crystalline structure, the way by which they can be made is very precise and needs to pursue definite steps. As clarified in Electroceramics: materials, applications, and properties, to set up a piezoelectric ceramic, “fine PZT powders” of the segment metal oxides are combined in specific amounts, at that point warmed to shape a uniform powder. The piezo powder is merged with an organic binder and is framed into structural components taking the ideal shape (circles, bars, plates). The components are terminated by temperature and a particular time, during which the piezo powder particles sinter and the material accomplishes a solid crystalline structure. The components are cooled, at that point formed or cut to details, and electrodes are put into the suitable surfaces. Although, piezoelectric material shows electric conduct and behaves like a dipole just under a specific temperature known as Curie temperature. The crystalline structure in the curie point will have a basic cubic balance so no dipole moment. As clarified before in this report, connecting dipoles structure locales called Weiss areas and showed a bigger dipole moment as each dipole in the space generally has a similar direction, consequently a net polarization. The alter of course of polarization among two neighboring domains is irregular, making the entire material neutral with no general polarization as appeared in Figure 2 [19, 20].

The most usually recognized piezoelectric material is quartz. Quartz (SiO_2) shows solid piezoelectricity because of its crystalline structure, implying that once the pressure is applied on a quartz gem, an electrical polarization can be seen laterally to the pressure direction. Gallium orthophosphate ($GaPO_4$) has nearly a similar structure as quartz and has similar qualities. Anyway, its piezoelectric impact is almost twice as significant as the one for the quartz, making it an important resource for mechanical application. Lead zirconate titanate (PZT) is viewed in today as the most efficient piezoelectric component. Consequently, it is utilized in a lot of uses.

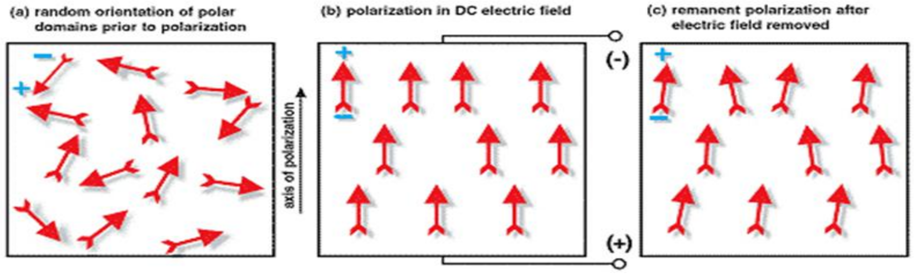


Figure 2: Method to pole a piezoelectric material

Lead Zirconate Titanate (PZT)

Piezoelectric materials with the perovskite structure have pulled in a lot of importance due to essential crystal structure encourages in considering the interchange between physical properties and structural changes. Furthermore, perovskite-based piezoelectric materials are ferroelectric, which guarantees proficient electromechanical change of vitality and sign with high piezoelectric impact. In particular, perovskites don't have a close-packed oxygen system, and this gives extraordinary adaptability to chemical substitution [21, 22].

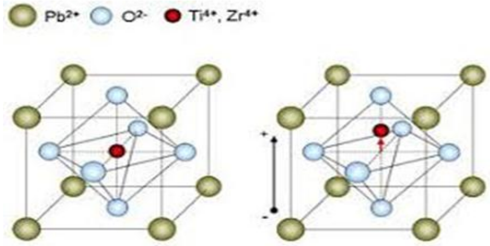


Figure 3: Crystal structure of the lead zirconate titanate (PZT) perovskite (ABO_3) structure

Figure 3 represents the crystalline structure of the lead zirconate titanate (PZT) perovskite (ABO_3). For previous years the solid solution $PbZrO_3$-$PbTiO_3$, usually recognized as Lead zirconate titanate (PZT), has conquered commercially due to its superior piezoelectric, dielectric properties and most widely used for electromechanical applications [22].

PZT Material Properties

Around 1952 researchers at the Tokyo Institute of Technology PZT created metallic oxide based piezoelectric material. Consequently, with the recently found metallic oxide based piezoelectric material Barium Titanate ($BaTiO_3$), PZT materials show the more prominent influence and have a higher working temperature. PZT, lead zirconate titanate, is the most regularly utilized piezo ceramic today. Generally, piezoceramics are the favoured decision as they are physically solid, chemically inert and generally cheap to fabricate. Furthermore, they can be effectively customized to meet the basics of a precise reason [21, 22].

2. METHODOLOGY

2.1 Production Description

Lately, the preparation of nanocrystalline lead zirconate titanate (PZT) powders has pulled in a lot of consideration because of their exclusive physical properties. The PZT based piezoelectric materials display exceptional electromechanical properties and generally utilized as ceramic filters, actuators, high power transducers, ultrasonic resonators. These techniques have gotten accessible for both research facilities and industrial production. The majority of techniques are utilized to make PZT powders. Table 1 shows the common correlation of the union courses for oxide ceramic powders [9, 20].

There are three ordinarily utilized procedures for the manufacture of PZT particles solid-state reaction, co-precipitation, and sol-gel systems. In the solid-state procedure, an appropriate molar proportion of oxides is blended and afterward experiences solid-state reaction by a calculation procedure, which is a top-down strategy presented toward the start of the part. The calculations procedure the oxides under 650˚C for two to three hours and afterward is held around 850˚C to permit re-crystallization. The last item is processed down to wanted molecule size.

The subsequent strategy is Co-precipitation from the arrangement, which is the technique utilized all through this examination. Encourages that are formed by blending an aqueous solution of oxides in with legitimate molar proportion with a precipitating agent. At that point, the precipitates are separated and go through a thermal procedure to shape the ideal product PZT for this situation. The aqueous strategy is one of the runs of the mill co-precipitation methods. The significant parameters incorporate Ph of the arrangement, blending rate, the proportion of the oxides, and temperature. With the legitimate modification of the parameters, the subsequent PZT can accomplish high clarity and fine particles. The third normal strategy Sol-gel process utilizes polymerization response of soluble precursor compounds to make three-dimensional structures and structure a gel. This gel is grounded and dried. It makes PZT with high density and high immaculateness.

Table 1: Synthesis methods

Property	Solid-State Reaction	Co-precipitation	Sol-Gel	Freeze Drying	Emulsion Synthesis	Hydrothermal Synthesis
State of development	Commercial	Commercial	R & D	Demonstration	Demonstration	Demonstration
Compositional control	Excellent	Good	Good	Excellent	Excellent	Moderate
Morphology control	Excellent	Moderate	Good	Moderate	Moderate	Excellent
Powder reactivity	Good	Good	Good	Good	Good	Good
Purity (%)	<99.9	>99.5	<99.9	<99.9	<99.9	<99.5
Particle size (nm)	>10	>10	>10	>10	>10	>10
Calcinations step	Yes	Yes	Yes	Yes	Yes	No
Agglomeration	Moderate	High	-	-	-	-
Costs	Low moderate	Moderate	High	Moderate high	Moderate high	Moderate high
Milling step	Yes	Yes	Yes	Yes	Yes	No

The second and third strategies are base up techniques and can deliver high immaculateness PZT. The study focuses on the second procedure—coprecipitation instead of the sol-gel strategy because of the accompanying two reasons. One is cost-viability, and the other is that sol-gel procedure still includes establishing as the gel was legitimately terminated and shaped polycrystals and this may prompt similar issues—pollution and non-uniform morphology [7, 17].

2.2 Process Selection

The solid-state procedure is chosen. It is the most immediate technique for making mixed oxides to respond to a blend of metal oxides, hydroxides or salts in the solid-state. Conventional processing to get ready multi-segment blended oxide ceramic powders includes three back to back strides of blending, solid-state response and processing. Particles can be formed either in an organized manner or haphazardly. At that point, the multi-segment stages are formed by means of solid-state reactions.

Subsequently, these solid-state responses regularly bring about the emergence of aggregates that need a comminution procedure to lessen the molecule size to the micrometer level. Then, processing to molecule size beneath 1 mm is trying for some hard materials, taints the product and is energy-intensive. The purity and homogeneity of the powder subsequently are deprived while the molecule size appropriation is wide. At a high temperature, the prerequisite to sinter the beginning blend rises the expenses and agglomeration, and sometimes, for example during PZT combination, it brings about loss of unpredictable oxides, for example, lead oxide. In spite of the disservices referenced over, this customary procedure has still been generally utilized in industry for delivering PZT powders because of its effortlessness and ease. Moreover, as PZT is a moderately delicate material, processing with one of its part zirconia media won't cause a critical issue of pollution. It is one of the methods that are

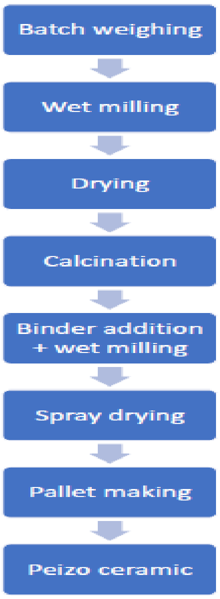


Figure 4: Block flow diagram for solid-state technique

feasible for working the block flow diagram of this research is shown in Figure 4. Batch weighing are lead oxide (PbO) is 223.20gm, zirconium dioxide (ZrO_2) is (123.22/2) gm and titanium dioxide (TiO_2) = (79.88/2) gm. These quantities must be added to make one mole of lead zirconate titanate (PZT).

Wet milling, likewise called wet media processing, is a procedure wherein particles are scattered in a fluid by shearing, by effect or squashing, or by wearing down. A factory is accused of media (little beads or spheres) and actuated by a fast instigator shaft to isolate the individual particles. At the point when the agitator rotates, it transmits kinetic energy to the media. At the point when the material is siphoned through the mill, this vitality follows up on the solids suspended in a fluid (slurry) to destroy them (shearing) or pulverize them, decreasing them in size. The particles are at the same time scattered in the fluid, which is then prepared to utilize or can be dried and isolated for use in different items.

Various materials are utilized for the grinding media. The beads or balls can be made of plastic, glass, ceramics production. Contingent upon the material that is being ground and what the end-use will be for the item, various media processing procedures can be utilized, including comminution (decrease to minute particles) and de-agglomeration (isolating particles that are grouped together). Elements that impact a definitive molecule size are the size of the granulating media, the time the material spends in the devastating chamber, the number of goes through the mill, and the speed of agitation. With the correct media processing hardware, makers can cost-viably make consistently fine particles with constrained or no contamination. Drying is a mass exchange process comprising of the removal of water or another solvent by dissipation from a solid, semi-solid or fluid. Calcination is the warming of solids to a high temperature to evacuate unpredictable substances, oxidizing a segment of the mass, or rendering them friable. Calcination, in this way, is some of the time, thought about a procedure of decontamination. The operating conditions are 850-900 degrees centigrade temperature and 4-6 hrs treating time required. The calcining rate must be slow in order to make a good pallet otherwise it will break.

A binder holds or attracts various materials together to form a consistent entire chemically, mechanically, by adhesion. In a progressively restricted sense, covers are fluid that solidifies by a compound or physical process and bind fibers, filler powder and other particles incorporated in it. To make a dense ceramic pellet PVA is added to the substance. The milling polycrystalline, calcinated powder is ball processed again to build its reactivity. Shower drying fluid nourishment is, for the most part, pre-focused by vanishing to economically lessen the water content. The concentrate is then presented as a fine shower or fog into a chamber with warmed air. As the little beads reach the warmed air, they streak off their moisture, become little particles, and drop to the tower base and are evacuated.

3. RESULT AND DISCUSSION

3.1 Equipment Design of Heating Specification

Batch reactor vessel warming by electric jacketed heater means initiation warming. The most developed exactness warming technique accessible to any liquid processing. Because of the warming framework being innately simple, the decision of warmth by induction ought to be viewed as the favored decision. Equipment for which induction heating is perfect fit autoclaves, cluster reactors, process vessels, heated vessels, and pressure vessels. Induction heating is a process utilized to bond, solidify or unstiffen metals or more conductive materials. The heating strategy is incited inside the part itself by flowing electrical flows. It depends on the novel qualities of radiofrequency. Since heat is moved to the product through electromagnetic waves, the part never comes into direct contact with any fire the inductor itself doesn't get hot, and there is no product sullying. At the point when accurately set up, the method turns out to be repeatable and manageable. Once a switching current is applied to the essential loop of a transformer, a rotating attractive field as given by faradays law. If the secondary coil of the transformer is located in the magnetic field an electric flow will be induced [8, 14].

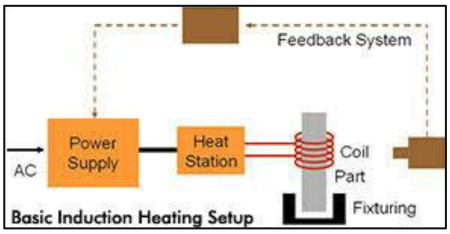


Figure 5: Basic induction heating setup

In a fundamental induction heating setup, as appeared in Figure 5 over, a strong RF control supply sends an AC over an inductor and the part to be warmed put inside the inductor. The inductor fills in as the transformer and the part that is heated can turn into a short circuit. While the metal part is fixed inside the inductor and enters the magnetic field, flowing current are actuated inside the area.

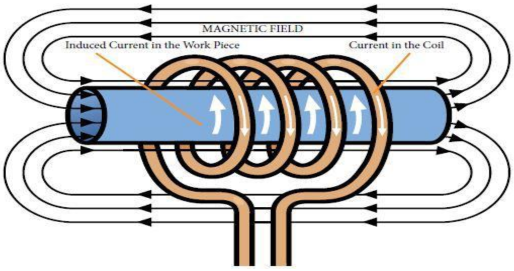


Figure 6: Eddy current flow against the electrical resistivity

As appeared in Figure 6, these swirl current streams along with the electrical resistivity of the metal, producing confined heat with no close contact between the inductor and the part. The heating occurs with mutually non-magnetic and magnetic parts and is commonly indicated as joule impact as given in joules first law—a logical equation stating the connection among heat delivered by an electrical flow go through a conductor. In addition, extra heat is delivered inside magnetic parts by hysteresis, inner contact that is made when magnetic parts go through the inductor. Magnetic materials normally offer electrical protection from the quickly changing magnetic fields inside the inductor. The opposition produces inside grinding which thus creates heat. The proficiency of the induction heating framework for a specific application depends on a few components are simply the qualities of the part, inductor structure, power supply limit and measure temperature requisite for the application [14].

Magnetic and non-magnetic is simpler to heat attractive materials. Furthermore the heat-persuaded by swirl current, attractive materials additionally produce heat through that is known as the hysteresis effect. This effect stops to occur at a temperature over the curie point-temperature as a result of which attractive material loses its magnetic properties. The general opposition of attractive materials is estimated on a porousness size of 100-500; magnetic materials can have permeability as high as 500 while non-magnetic has a permeability of 1.

Thin or thick with conductive materials, above 85% of the warming impact happens superficially or skin of the part; the heating power reduces as the distance from the surface rises. Thin parts normally heat more fast than huge thick parts, mostly if the bigger parts should be heated right through. Resistivity, in the event that you utilize a similar induction procedure to warm two same sizes of steel and copper, the outcome will be very unique. Why? Steel along with carbon, tungsten, tin has high electrical resistivity as these materials emphatically oppose the flow stream in the outcome heat-formed rapidly [6, 14, 19].

Heater calculation:

$D = 0.108$ m, $L = 0.216$ m, $V = 2\text{x}10\text{-}^{3}$ m^3, $R = 0.054*3.28 = 0.1771$ ft, $L = 0.216*3.28 = 0.7084$ ft,

$A = 2\pi rh+2\pi r^2$

$A = 2\pi\ (0.1771)(0.7084)+2\pi(0.1771)^2 = 0.985$ sq. ft

$Kw = A*1/R*\Delta T*SF/3412$

$\Delta T = 1472 - 32 = 1440\ ^{o}F$

SF = 1.2, R = 0.5 --- Un insulated

$Kw = (0.985*1/0.5*1440*1.2) / 3412 = 0.9977$ K watt

Reactor Sizing

Reactor sizing as shown in the Figure 7.

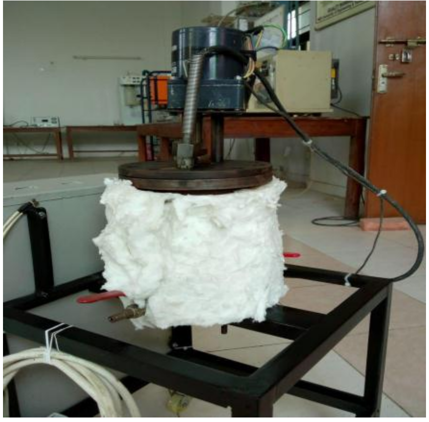


Figure 7: Reactor

The operating conditions are maximum reaction temperature = T = 800 ^{o}C, working pressure = 3.4 bar, design pressure = 1.5(3.4) = 5.1 bar, Volume of reactor = V =2 L.

Wall thickness and Diameter:

Wall thickness, $t = (p * r/ SE - 0.6P) + C$

Static pressure $Ps = \rho gh = 910*9.81*0216 = 1928$ Pa

Design Pressure in the reactor = 510 Kpa

Total pressure = static pressure + design pressure

Total pressure = 1.928+510 =5.11.928 Kpa

Now, Pmax = 1.1 (Pt) = 1.1*511.928=563.1208 Kpa

Form the ASME pressure vessel joints efficiencies for welded head E = 0.85

CODE – RT3 – Torispherical head

Corrosion allowance for lubricating oils = 0.3(multiply by factor 2) = 0.3*2 = 0.6mm = 0.00066m

TWCO – The World Corrosion Organization

S- for SA-516 grade 55 (carbon steel)

Division 2 (20^{o}C to 900^{o}C) = 18300/ Lower safety factor (2) psi = 9150 psi

S = 9150 psi * (1 bar/14.7 psi)* (1 *10^5 pascal / 1 bar) * (1 Kpa / 1000 Pa) = 622.45 Kpa

$t=(563.1208*0.054/(62244.9*85)-(0.6*563.1208))+0.6*10^{-3} = 1.12*10^{-3}$ m

Diameter, For semi batch reactor, height to diameter ratio is 2:1

$V = \pi/4\ D^2\ L = 2*10^2 = \pi\ D^2\ (2D)/4 = 0.108$ m

Therefore, L = H = 2D = 2*0.108 = 0.216 m

Outside diameter = Do = D1 + 2t = 0.108 + 2(1.2*10-3) = 0.1104 m

Reactor head:

Torispherical head is used for pressure less than 150 psi

Head thickness = 1.77(t), Head thickness = 2.124*102 m

Agitation design:

Impeller: (45’ tilted pitched blade turbine -4 blades), Impeller dia = D = D1/3 = 0.0108/3 = 0.036m

Impeller height above vessel floor = E = D1/3 = 0.0108/3 = 0.036m

Length of impeller blade = L = ¼(D1) = ¼(0.108) = 0.027m, Width of impeller blade = W= D1/5 = 0.108/5 = 0.0216m

Width of baffle = J = D1/10 = 0.108/10 = 0.0108m

For low degree agitation, the tip speed ranges from 10-20 ft/sec, Average tip speed = (10 + 20)/2 = 15ft/sec * (0.3040m/1 ft) = 5m/sec

Now, Tip speed = π dn, N = tip speed / πd = 5/ (0.108*3.14) = 14.74 RPM = 15 RPM

Modulus of electricity of carbon steel: E = 21.41 X 10^{-5} kg/cm^3

Heat transfer in reactor: Cooling jacket area available:

$A = (\pi dh) + (\Pi d^{2/4}) = (3.14*0.018*0.216) + (3.14*(0.108)^{2/4}) = 0.82\ m^2$

Power calculation of agitator: $P = Np*\rho*N^3*d^5$

Now, $Nre = ND^2\ \rho/\mho = (15*0.0362*910)/\ 3*10^{-3} = 5897 < 10{,}000$

And Np = 1.27

Therefore, Power = $1.27\text{x}910\text{x}15^5\ \text{x}0.036^5$ = 0.23 watt = $3.16\text{x}10^{-4}$ Hp

Table 2 specification sheet of reactor. Figure 8 shows the circuit outline of the control board. The principle circuit breaker panel is basically a major switch that securely disseminates the supply of power to your home. The electrical breaker box similarly houses other sub-switches that associate with explicit regions of your home. These small switches are called breakers, and their function is to guarantee electrical security. So as a mortgage holder, you would possibly need to get to the primary electrical switch board when the power trips or when performing fixes or substitutions. Relays are switches that open or close circuits electromechanically. It control an electrical circuit by opening and shutting contacts in other circuit. When it is utilized to switch a lot of electrical power, it is assigned by a contactor. Contactors regularly have various contacts, and those contacts are as a rule usually open, with the objective that power to the heap is closed off when the coil is de-stimulated. The sort K is the most well-known kind of thermocouple. It's modest, perfect and has a wide temperature extend. The K type is usually found in atomic applications in view of its relative radiation hardness. Greatest constant temperature is around 1,100 °C. Temperature controllers are broadly utilized in industrial control frameworks to alter or keep up wanted outputs of precise procedures inside an ideal range [10, 11].

The components that have worked for manufacture Rochelle salt crystals are 500gm of washing soda (sodium carbonate, Na_2CO_3), 200gm cream of tartar (potassium bitartrate, $KHC_4H_4O_6$) and 250 ml of distilled water. Afterward, turn the cream of tartar and washing soda into Rochelle salt (potassium sodium tartrate, $NaKC_4H_4O_6$). Wash the beaker stirrer spatula with distilled water first. At that point put all things considered 200 gm of cream of tartar into 250 ml of water.

Table 2: Design data of reactor

Parameter	Data	Parameter	Data
Volume	$2*10^{-3}$ m^3	Width of baffles	0.0108 m
Length	0.216 m	Impeller above bottom	0.036 m
Diameter	0.108 m	Length of temp sensor	6 inch
Number of baffles	4	Speed of impeller	18 RPM
Type of impeller	Pitched blade turbine	Diameter of shaft	5.4×10^{-3} m
Number of blades	4 (45' tilted)	Power requirements	3.16×10^{-3} Hp
Wall thickness	1.09×10^{-3} m	Jacket area	0.82 m^2
Head thickness	1.947×10^{-3} m	Length of blade	0.027 m
Impeller diameter	0.036 m	Width of blade	0.0216 m

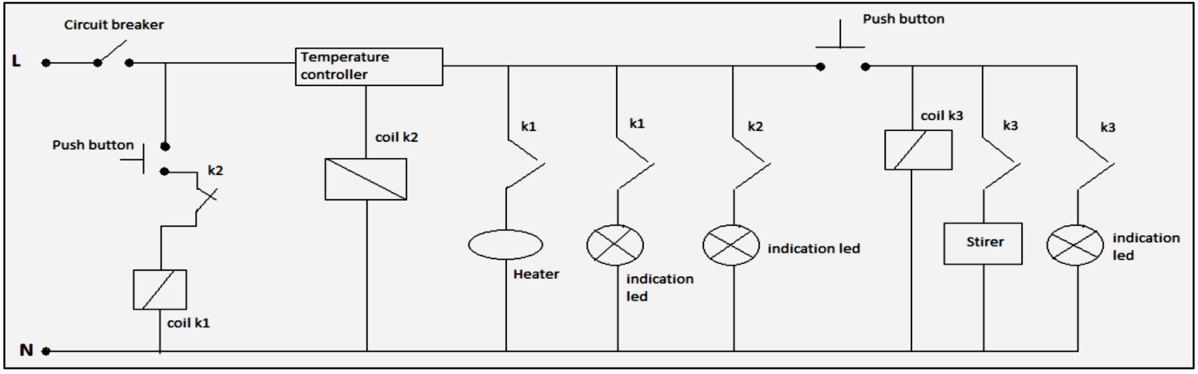
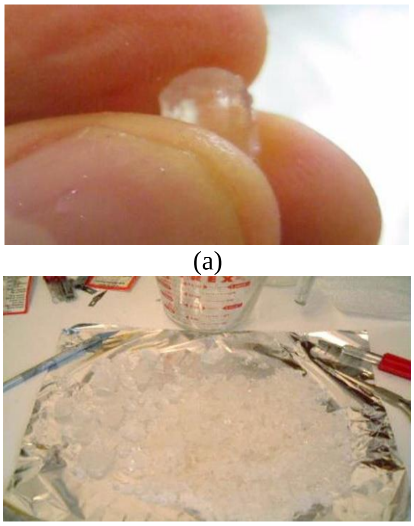


Figure 8: Circuit diagram of the control panel

Mix it well that the cream of tartar particles are suspended in the water, not settled in the base (stir well). Then set the water bath at 90-degree centigrade the put the Pyrex beaker having the solution (above prepared). Then add sodium carbonate gradually the solution bubbles up so use a beaker having a large capacity. Add sodium carbonate and then stir. Repeat the process until the solution becomes clear. Remove the beaker from the water bath. Then filter the solution using a coffee filter. It takes around 50 minutes to filter the whole solution. Then we put the solution in a cool place and leave it there for several days. Around 20 days the crystals are finally produced. Crystals are clear and in small size, as shown in Figure 9 (a and b) [5, 7].



(a)

(b)

Figure 9: (a) Clear transparent crystal (b) Small size crystals

The problems are the size of the crystal is small not up to the mark and fragile crystals. The troubleshooting is the size of the crystal, to increase size we do seeding. Use the small crystals to grow a large one. Place a small crystal in the solution so the generating crystals can stick to it make a big one. Fragility, to decrease it cover the beaker with some perforated material so that the dust can penetrate.

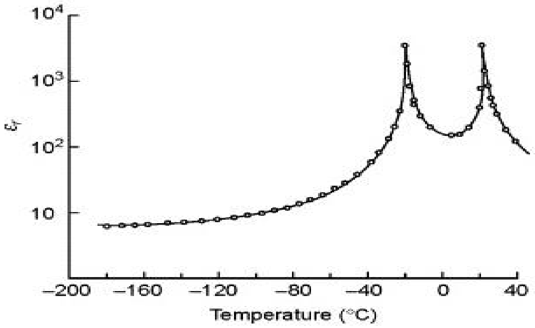


Figure 10: Graph of dielectric constant versus temperature

Rochelle salt is also known as Sodium potassium tartrate tetrahydrate, a solid crystalline structure having an enormous piezoelectric impact (electric charge induced on its surfaces by mechanical disfigurement because of pressure or twisting), making it helpful in vibration devices.

The crystal disintegrates at a low temperature of 55°C. In any case, the most attracting property of Rochelle salt comprises of two curie focuses, one upper curie temperature at +24°C, and the other lower curie temperature at −18°C. The nonpolar paraelectric stages for temperature greater than +24°C and temperature less than −18°C are orthorhombic. The polar ferroelectric stage, happening at the temperature go somewhere in the range of −18°C and +24°C, is monoclinic. The dielectric consistent, estimated along the *a*-axis with a small sign field of 1 kHz as a component of temperature, is appeared in Figure 10 [2, 4, 6, 7].

4. CONCLUSION

Piezoelectric energy receives a strategy that collects the mechanical energy from individuals' pressure on the piezoelectric board during the day to illuminate the road around night. This eco-accommodating energy is indicating another probability of powerful energy use. The piezoelectric gathering is the innovation that gathers mechanical energy utilizing a piezoelectric component. Electricity is produced through the quantum attributes the component has, and the energy originates from this electric field. Recent researches are being attempted to use energy more successfully, for example, harvesting innovation which transforms mechanical piezoelectric energy into electricity.

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