Drones could be used to detect dangerous 'butterfly' landmines in post-conflict regions

Mr. Dnyanesh Bhagat (FE)

It is estimated that there are at least 100 million military munitions and explosives of concern devices in the world, of various size, shape and composition. Millions of these are surface plastic landmines with low-pressure triggers, such as the mass-produced Soviet PFM-1 "butterfly" landmine. Nicknamed for their small size and butterfly-like shape, these mines are extremely difficult to locate and clear due to their small size, low trigger mass and, most significantly, a design that mostly excluded metal components, making these devices virtually invisible to metal detectors. Critically, the design of the mine combined with a low triggering weight have earned it notoriety as "the toy mine," due to a high casualty rate among small children who find these devices while playing and who are the primary victims of the PFM-1 in post-conflict nations, like Afghanistan.

Researchers at Binghamton University have developed a method that allows highly accurate detection of "butterfly" landmines from low-cost commercial drones. Assistant Professor of Energy Geophysics Alex Nikulin and Director of the Geophysics and Remote Sensing Laboratory Timothy de Smet used mounted infrared cameras to remotely map the dynamic thermal conditions of the surface and recorded unique thermal signatures associated with the plastic casings of the mines. During an early-morning experiment, they found that the mines heated up at a much-greater rate than surrounding rocks, and they were able to identify the mines by their shape and apparent thermal signature. Results indicate that this methodology holds considerable potential to rapidly identify the presence of surface plastic MECs during

early-morning hours, when these devices become thermal anomalies relative to surrounding geology.

They believe their method holds great potential for eventual wide-spread use in post-conflict countries, as it increases detection accuracy and allows for rapid wide-area assessment without the need for an operator to come into contact, or even proximity of the minefield. Once further developed, this methodology can greatly reduce both costs and labor required for mine clearing operations across post-conflict regions.

The use of cost- and time-efficient remote sensing techniques to detect plastic MECs such as the butterfly mine from unmanned aerial vehicles has enormous potential that warrants further study, wrote the researchers. The team is actively pursuing this project further and are in the process of field testing and calibrating our methodology and hopes to develop a fully autonomous multi-drone system that would require minimum input from the operators.

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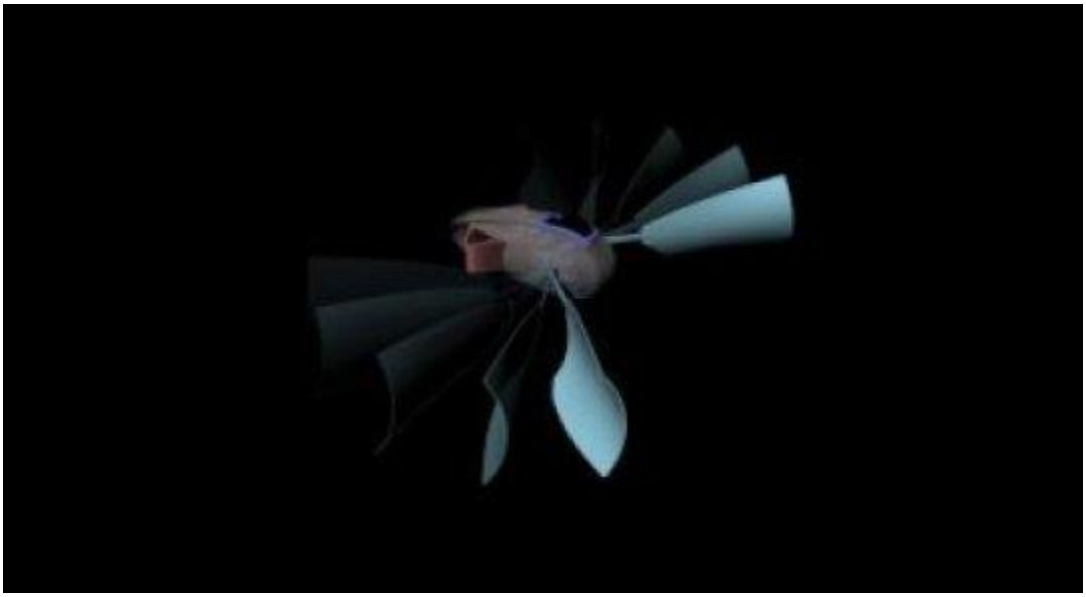
Swimming without an engine

Mr. Shubham Mane (TE)



The robot exploits temperature fluctuations in the water for propulsion without the need for an engine, propellant or power supply. As a proof-of-concept study, the researchers developed a 7.5-centimetre mini-submarine equipped with paddles, which they fabricated entirely using a multi-material 3D printer.

The paddles are actuated using a bistable propulsion element triggered by two shape memory polymer strips as previously developed by Shea and her doctoral student Tim Chen. Designed to expand in warm water, the polymer strips power the robot by acting like "muscles." If the water in which the mini-submarine floats is heated, the expansion of the "muscles" causes the bistable element to quickly snap, triggering a paddle stroke. The directional motion, force and timing of the paddle strokes are precisely defined by the robot's geometry and material.

Vessel with multiple propulsion elements

At present, each actuating element can execute a single paddle stroke and must then be reprogrammed manually. However, as the scientists point out, it is possible to fabricate complex swimming robots with multiple actuators. The scientists have already made a mini-submarine that can paddle forward with one stroke, release its "cargo" (a coin) and then navigate back to the

starting point with a second paddle stroke in the opposite direction, all by sensing changes in temperature of the water. Varying the geometry of the polymer muscles allowed the scientists to define the sequence at which the paddle stroke is triggered: thin polymer strips heat up faster in warm water and therefore respond faster than thicker ones.

A potential development would be using polymers that do not react to the water temperature, but to other environmental factors such as the acidity or salinity of the water.

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Aerial robot that can morph in flight

Mr. Muzaffar Patel (TE)

Birds and winged insects have the remarkable ability to maneuver quickly during flight to clear obstacles. Such extreme agility is necessary to navigate through cramped spaces and crowded environments, like forests. There are already miniature flying machines that can roll, pitch, or otherwise alter their flight attitude to pass through small apertures. But birds illustrate another strategy that is just as effective for flying through bottlenecks. They can quickly fold their wings during high-speed flight, reducing their imposing span, to easily negotiate the challenging paths before them.

Deployment of aerial robots in constricted and cluttered areas for search and rescue, exploratory, or mapping operations will become more and more commonplace. They will need to be able to circumnavigate many obstacles and travel through fairly tight passages to complete their missions. Accordingly, researchers from the Étienne Jules Marey Institute of Movement Sciences (CNRS / Aix-Marseille Université) have designed a flying robot that can reduce its wingspan in flight to move through a small opening, without intensive steering that would consume too much energy and require a robotic platform featuring a low-inertia (light and small robot).

Dubbed Quad-Morphing, the new robot has two rotating arms each equipped with two propellers for helicopter-like flight. A system of elastic and rigid wires allows the robot to change the orientation of its arms in flight so that they are either perpendicular or parallel to its central axis. It adopts the parallel position, halving its wingspan, to traverse a narrow stretch and then switches back to perpendicular position to stabilize its flight, all while flying at a speed of 9 km/h, which is pretty fast for an aerial robot.

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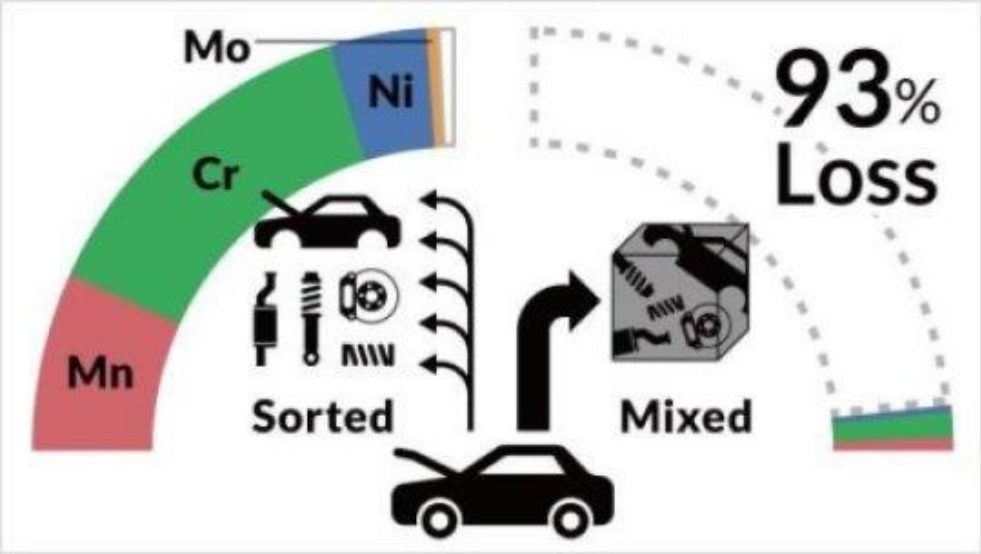
Optimizing recycling of scrap car parts yields big savings

Mr. Shubham Pati (SE)



While Japan mandates automobile recycling, scrap car parts are usually lumped together for iron, according to the study published in the journal *Environmental Science & Technology*. This means specific alloy elements present in the scrap, such as manganese, chromium, nickel, and molybdenum, are not optimally recycled.

The researchers analyzed the composition of scrap car parts and what they could be reused for, and found they are best suited for nine steel alloys. The analysis found that between 94 and 99 percent of the alloy elements could be recycled from the scrap car parts. The scrap metal would be melted down in electric arc furnaces and remade into steel products, such as coils, plates and bars. The recycled alloy elements could replace about 10 percent of the new material used by electric arc furnace (EAF) steelmakers.

While it sounds like a small portion of the raw material that translates to huge savings -- steelmakers would save up to 15.2 percent spent on alloys. It would also reduce greenhouse gas emissions associated with the new material by 28.3 percent.

As part of their analysis, the researchers compared the tradeoffs between reducing costs versus emissions. They found that a small compromise on price could yield almost the greatest

emission reduction. They were even able to identify which recycled alloy elements contributed the most to this equation, for the maximum benefit.

The authors note that their methodology can be applied globally and to other industries, helping find the optimal balance between costs and emissions to make the most of recycling efforts. This methodology will also help advance efforts to establish a circular economy, one that addresses products from cradle to grave and minimizes harmful environmental impacts.

Despite the potential savings, the authors anticipate that improving car scrap recycling systems will likely require policymakers to support development of new automatic sorting technologies for recyclers, as well as incentivize steelmakers to purchase sorted scrap at fair prices.

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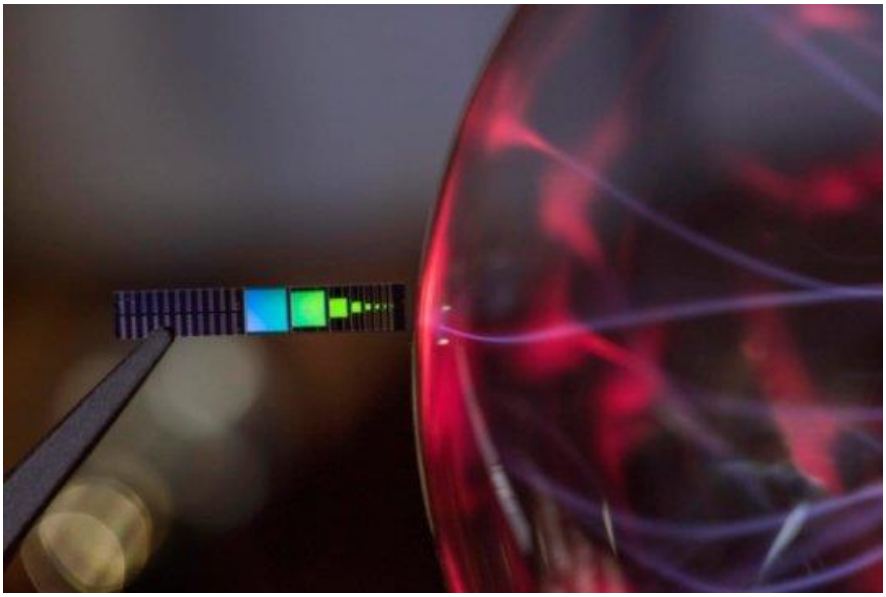
Generating electrical power from waste heat

Mr. Aditya Dhavale (TE)



Silicon device catches, channels and converts heat into power

Smaller than a pinkie nail, the device is about 1/8 inch by 1/8 inch, half as thick as a dime and metallically shiny. The top is aluminum that is etched with stripes roughly 20 times smaller than the width of a human hair. This pattern, though far too small to be seen by eye, serves as an antenna to catch the infrared radiation.

Between the aluminum top and the silicon bottom is a very thin layer of silicon dioxide. This layer is about 20 silicon atoms thick, or 16,000 times thinner than a human hair. The patterned and etched aluminum antenna channels the infrared radiation into this thin layer.

The infrared radiation trapped in the silicon dioxide creates very fast electrical oscillations, about 50 trillion times a second. This pushes electrons back and forth between the aluminum and the silicon in an asymmetric manner. This process, called rectification, generates net DC electrical current.

The team calls its device an infrared rectenna, a portmanteau of rectifying antenna. It is a solid-state device with no moving parts to jam, bend or break, and doesn't have to directly touch the heat source, which can cause thermal stress.

Infrared rectenna production uses common, scalable processes

Because the team makes the infrared rectenna with the same processes used by the integrated circuit industry, it's readily scalable, said Joshua Shank, electrical engineer and the paper's first author, who tested the devices and modeled the underlying physics while he was a Sandia postdoctoral fellow.

He added, "We've deliberately focused on common materials and processes that are scalable. In theory, any commercial integrated circuit fabrication facility could make these rectennas."

That isn't to say creating the current device was easy. Rob Jarecki, the fabrication engineer who led process development, said, "There's immense complexity under the hood and the devices require all kinds of processing tricks to build them."

One of the biggest fabrication challenges was inserting small amounts of other elements into the silicon, or doping it, so that it would reflect infrared light like a metal, said Jarecki. "Typically you don't dope silicon to death, you don't try to turn it into a metal, because you have metals for that. In this case we needed it doped as much as possible without wrecking the material."

The devices were made at Sandia's Microsystems Engineering, Science and Applications Complex. The team has been issued a patent for the infrared rectenna and have filed several additional patents.

The version of the infrared rectenna the team reported in *Physical Review Applied* produces 8 nanowatts of power per square centimeter from a specialized heat lamp at 840 degrees. For context, a typical solar-powered calculator uses about 5 microwatts, so they would need a sheet of infrared rectennas slightly larger than a standard piece of paper to power a calculator. So, the team has many ideas for future improvements to make the infrared rectenna more efficient.

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3-D printing of weapons threatens security on global, national and personal level Aerial robot that can morph in flight

Mr. Abhinandan Patil (TE)

While advances in additive manufacturing offer potential breakthroughs in prosthetic arms or jet engine parts, 3D printing, as it is known, may also accelerate weapons proliferation.

A new RAND Corporation paper suggests additive manufacturing could benefit military adversaries, violent extremists and even street criminals, who could produce their own weapons for use and sale.

3D printing technology is also susceptible to hacking, which could allow sabotage by hackers who maliciously instruct 3D printers to introduce flawed instructions or algorithms into mission-critical parts of airplanes, according to the paper.

"Lone-wolf attacks may become more lethal when individuals have ready access to 3D printers," said Trevor Johnston, lead author and an associate political scientist at RAND, a nonpartisan research organization. "Even in countries like the United States, where gun control laws have done little to restrict access to semi-automatic weapons, additive manufacturing could increase the risk of violence and murder."

Additive manufacturing may also indirectly support the survival and rise of pariah states like North Korea, which could avoid the costs of withdrawing from the international community by producing complex items domestically, skirting international sanctions.

From an economic perspective, by decentralizing manufacturing individuals and firms may choose to produce locally rather than importing goods. 3D printing could therefore weaken international connections currently sustained by complex, multi-country supply chains, the authors conclude. That in turn may create upheaval in labor markets -- and subsequent social conflict.

The relative risk and cost of future threats will depend in part on the evolution and regulation of additive manufacturing hardware (printers), raw materials and software (intellectual property). Threat prevention will be more effective if focused on material controls.

By limiting supplies of rare or dangerous raw materials, regulators can at least ensure that some of the most destructive weapons (e.g., nuclear or dirty bombs) do not become readily accessible. By monitoring online communities, law enforcement may be able to curtail digital exchanges of lethal creations. Unfortunately, the efforts of domestic law enforcement may be ineffectual on this front, the authors write. Alternatively, law enforcement may themselves hack additive manufacturing software to disrupt potential attacks or limit their destruction.

In all likelihood, these preventive measures will not stop the spread of new risks connected to 3D printing, according to the paper. There is little that regulation, export controls, treaties and law enforcement can do to fully prevent a motivated, well-financed, organized actor from eventually acquiring new technology. As such, policymakers should particularly focus on measures that mitigate the potential impact and cost of these future threats. While fraught with risks, policymakers should begin to address the hard security questions that additive manufacturing will bring.

Self-driving cars must reduce traffic fatalities by at least 75 percent to stay on the roads Aerial robot that can morph in flight

Ms. Priyanka Patil (SE)

The race is on for companies to present their driverless cars to the public, but recent collisions involving autonomous vehicles developed by Uber Technologies Inc. and Tesla Inc. have led consumers to questions whether these vehicles can alleviate traffic issues and increase safety.

To answer this question, researchers employed an expressed-preference approach – a method that has not previously been employed in this setting – to determine the socially acceptable risk of SDVs. The results showed that the public will not accept this new technology unless it is shown to be safer, approximately four to five times as safe as human-driven vehicles (HDVs). Despite the conveniences SDVs would bring to individuals, such as the ability to watch a movie, read a book, sleep or surf the internet, the public will be much less likely to accept, or even tolerate, SDVs if they have the same risk level as human driving. As suggested by previous studies, an individual increases his or her demand for safety when that safety is entrusted to an external factor, such as an automated vehicle.

One of the major motivations behind the development of SDVs is to improve road safety. Human error is believed to cause 94 percent of all traffic crashes in the U.S., and 75 percent in the U.K. While SDVs have the potential to significantly reduce these types of crashes, they also introduce several new road risks, including accidents caused by cyber-attacks. Creating perfectly safe SDVs is both technologically and economically infeasible, but policies can require that the risk of having them on the road be as low as technically achievable.

The study was conducted by Peng Liu and Run Yang, Tianjin University, and Zhigang Xu, of Chang'an University. The survey was distributed to a convenience sample of residents in Tianjin, China. Of the 499 respondents, half were randomly assigned to complete a version of the survey for HDVs, while the other half completed an SDV version. Risk frequencies were expressed as one fatality per a certain number of vehicle-kilometers traveled and as one fatality per a certain number of population, respectively. Respondents were asked to accept or reject each

traffic risk scenario at one of four levels: never accept, hard to accept, easy to accept and fully accept.

The results show that the respondents believe that SDVs should be four to five times as safe as HDVs. Current global traffic fatal risk is estimated at 17.4 per 100,000, which is 350 times greater than the frequency accepted by 50 percent of the respondents for SDVs. This implies that respondents expect SDVs to improve safety by two orders of magnitude against the current traffic risk.

Based on the results, the researchers propose the following requirements for SDVs based on the tolerability of risk in industrial safety (a concept developed in the health and safety field) in which risks are distinguished by three criteria: unacceptable, tolerable and broadly acceptable. SDVs that are less safe than human drivers would be set as the unacceptable risk criterion. The tolerable risk is that SDVs be four to five times as safe, meaning they should be able to reduce 75-80 percent of current traffic fatalities. The broadly acceptable risk criterion for SDVs is set as two orders of magnitude lower than current global traffic risk, indicating a hundredfold improvement over current traffic risks, or the same order of magnitude experienced in public transportation modes, such as rail and commercial aviation.

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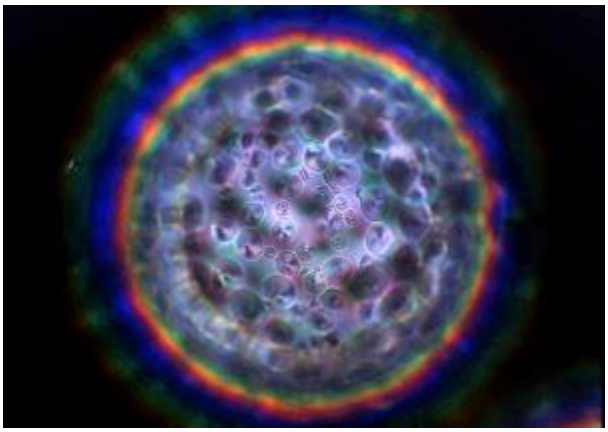
Liquid crystal shells: ‘Smart’ material enables novel applications in autonomous driving and robotics Aerial robot that can morph in flight

Mr. Akash Awati (BE)



Liquid Crystals, already widely used in flat-screen TVs, are materials that are in a state between solid and liquid. Prof Jan Lagerwall and his team at the Physics and Materials Science Research Unit (PHYMS) at the University of Luxembourg have been investigating the unique mechanical and optical properties of microscopic shells that are produced of liquid crystal for several years. Now, in a multidisciplinary collaboration with IT scientists Dr. Gabriele Lenzini and Prof Peter Ryan of the University's Interdisciplinary Center for Security and Trust (SnT) as well as Mathew Schwartz, Assistant Professor at the New Jersey Institute of Technology, they published a report in the scientific journal *Advanced Materials* describing potentially groundbreaking future applications for the material.

Liquid Crystal shells, only fractions of a millimeter in size so they can easily be applied to surfaces, have several unique properties that could be utilized in engineering: As they reflect light highly selectively, they can be arranged into patterns that are readable for machines, akin to a QR code, adding coded information to objects. "These patterns could be used to guide autonomous vehicles or to instruct robots when handling workpieces in a factory. This could become important especially in indoors applications where GPS devices don't work," Prof Lagerwall explains.

The shells can be manufactured to reflect only certain wavelengths of light, such as infrared, that would be invisible to the human eye. As the Liquid Crystal shells reflect light "omnidirectionally" meaning that beholders see the same pattern regardless of their position and viewing angle, the patterns can even be read by moving objects.

Additionally, the shells can be manufactured in a way that they change their structure when they are exposed to certain external impacts, such as pressure, heat or specific chemicals.

Together with computers to interpret these changes, the shells could be used as sensors, for example as pressure sensors in the fingertips of robots enabling tactile feeling which is currently hard to achieve in robotic engineering. Another application could be fire exit signage on walls inside buildings that only becomes visible when the temperature exceeds a certain threshold. The big advantage of these sensors is that they passively react to external impacts and don't need electricity and batteries.

Finally, liquid crystal shells could be used to prevent counterfeiting. The micropatterns that emerge when the shells are brought together are unique and impossible to copy. These unclonable patterns could be used to create uncopiable identifiers that can be attached to valuable objects, such as art works or expensive pharmaceuticals. In combination with cryptographic tools they could be used to create a system that ensures that a buyer or user has the original and not a counterfeited product.

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Safety of rear-facing car seats in rear impact car crashes

Ms. Priyanka Kale (BE)

Rear-facing car seats have been shown to significantly reduce infant and toddler fatalities and injuries in frontal and side-impact crashes, but they're rarely discussed in terms of rear-impact collisions. Because rear-impact crashes account for more than 25 percent of all accidents, researchers at The Ohio State University Wexner Medical Center conducted a new study to explore the effectiveness of rear-facing car seats in this scenario.

It's a question that asked a lot, concerning the safety of the child facing the impact of the crash. Mansfield and her team conducted crash tests with multiple rear-facing car seats, investigating the effects of various features like the carry handle position and anti-rebound bars. The study, which is published in SAE International, shows that when used correctly, all were effective because they absorbed crash forces while controlling the motion of the child, making rear-facing car seats a good choice in this scenario.

Mansfield says what they found aligns well with what is known from crash data in the real world, and it's important for parents to follow the recommended guidelines on the correct type of car seat for their child's height, weight and age. The rear-facing seat is able to support the child's head, neck and spine and keep those really vulnerable body regions well protected. These regions

are especially vulnerable in the newborns and younger children whose spine and vertebrae haven't fused and fully developed yet.

This research was funded by the Center for Child Injury Prevention Studies (CChIPS) at The Children's Hospital of Philadelphia.

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EVOLUTION OF BIO FOULING IN COOLING TOWER BY CHEMICAL TREATEMENT

Juned Pathan (TE), Abhihek Jagtap (SE)

INTRODUCTION

A Cooling tower is a heat rejection device which extracts waste heat to the atmosphere through the cooling of a water stream to a lower temperature. Cooling towers may either use the evaporation of water to remove process heat and cool the working fluid to near the wet-bulb air temperature.

In the thermal power plant condensing the steam from the turbine outlet is done by the condenser to condense this steam we supply to the condenser and this water is absorb the heat of steam and heated to high temperature. This water is then cooled in cooling tower. The heat transfer at the condenser is affected by number of factors out of that bio foiling is important issue because the water required the cooling tower is received from the river, sea, lake etc. and if contain some of microorganism, the temperature of cooling water cycle in the cooling tower is helpful to growth of the microorganism.

For study of this problem of bio fouling we were visited to cogeneration plant of Datta Sahakari Sakhar Karakhana Shilol. We are got permission to study this problem under guidance of Mr. Patil head of cogeneration plant. We design pilot plant to study bio fouling effect, and defining the strategies for the control the bio fouling.

In the power plant for controlling the bio fouling they have chemicals which are intermittently mixed with cooling tower water but they are selection of proportion of these chemicals on their past experience. It is necessary to check water quality intermittently and use correct proportion of chemicals. So the setup of pilot plant is very useful to study the bio- fouling characteristics for each sample of water. The chemical mixed water first tested in pilot plant and then used in actual cooling tower. It is helpful to reduce the bio fouling effect in actual thermal power plant. So it is important to have pilot plant for each power plant.

COOLING TOWER PROBLEMS

By their very design, open re-circulating cooling systems are prime candidates for contamination problems. As the cooling water evaporates, contaminants are allowed to concentrate in the system. Contaminants enter the system either through the makeup water or from the air via the cooling tower. If left untreated, high concentrations of impurities in open re-circulating systems can lead to a number of serious problems, including:

Scaling

The most serious side effect of scale formation is reduced heat transfer efficiency.

Loss of heat transfer efficiency can cause reduced production or higher fuel cost. If heat transfer falls below the critical level, the entire system may need to be shut down and cleaned. Unscheduled downtime can obviously cost thousands of dollars in lost production and increased maintenance. Once scale becomes a serious threat to efficiency or continued operation, mechanical or chemical cleaning is necessary.

In most cases, mineral scale is a silent thief of plant profitability. Even minute amounts of scale can provide enough insulation to affect heat transfer and profitability severely.

Scale in cooling water systems is mainly composed of inorganic mineral compounds such as calcium carbonate (which is most common), magnesium silicate, calcium phosphate and iron oxide. These minerals are dissolved in the water, but if left to concentrate uncontrolled, they will precipitate. Scale occurs first in heat transfer areas but can form even on supply piping. Many factors affect the formation of scale, such as the mineral concentration in the cooling water, water temperature, pH, availability of nucleation sites (the point of initial crystal formation) and the time allowed for scale formation to begin after nucleation occurs. Dissolved mineral salts are inversely temperature soluble. The higher the temperature, lower their solubility. The most critical factors for scale formation are pH, scaling ion concentration and temperature. Consequently, most open recalculating systems operate in a saturated state, because the scaling ions are highly concentrated. Precipitation is prevented under these conditions by the addition of a scale inhibitor.

Fouling

Waterborne contaminants enter cooling systems from both external and internal sources. Though filtered and clarified, makeup water may still hold particles of silt, clay, sand and other substances. The cooling tower constantly scrubs dirt and dust

from the air, adding more contaminants to the cooling water. The solids agglomerate as they collide with each other in the water. As more and more solids adhere, the low water velocity, laminar flow, and rough metal surfaces within the heat exchangers allow the masses of solids to settle out, deposit onto the metal. and form deposits. These deposits reduce heat transfer efficiency, provide sites for under deposit corrosion, and threaten system reliability. Waterborne fouling can be controlled by a combination of mechanical and chemical programs

Microbiological growth

Cooling water systems are ideal spots for microscopic organisms to grow. "Bugs" thrive on water, energy and chemical nutrients that exist in various parts of most cooling water systems. Generally, a temperature range of 70-1 40º F (21-60 oC) and a pH range of 6-9 provide the perfect environment for microbial growth.

Bacteria, algae and fungi are the most common microbes that can cause serious damage to cooling water systems. Microbiological fouling can cause:

- Energy losses
- Reduced heat transfer efficiency
- Increased corrosion and pitting
- Loss of tower efficiency
- Wood decay and loss of structural integrity of the cooling tower

Corrosion

Corrosion is the breakdown of metal in the presence of water, air and other metals.

The process reflects the natural tendency of most manufactured process metals to recombine with oxygen and return to their natural (oxide) states. Corrosion is a particularly serious problem in industrial cooling water systems because it can reduce cooling efficiency, increase operating costs, destroy equipment and products and ultimately threaten plant shutdown.

Most cooling systems are very vulnerable to corrosion. They contain a wide variety of metals and circulate warm water at relatively high linear velocities. Both of these factors accelerate the corrosion process. Deposits in the system caused by silt, dirt, debris, scale and bacteria, along

with various gases, solids and other matter dissolved in the water all serve to compound the problem. Even a slight change in the cooling water pH level can cause a rapid increase in corrosion.

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Performance Improvement in Temperature Fluctuation On Domestic Refrigerator During Power Cut Off By Phase Change Material

Jagdish Choudhary (SE), Akash Bhandare (SE)

Thermal energy storage (TES) is a technology with a high potential for different thermal applications. It is well known that TES could be the most appropriate way and method to correct the gap between the demand and supply of energy and therefore it has become a very attractive technology. In this paper, a review of TES for cold storage applications using solid–liquid phase change materials has been carried out. The scope of the work was focused on different aspects: phase change materials (PCMs), encapsulation, heat transfer enhancement, and the effect of storage on food quality. Materials used by researchers as potential PCM at low temperatures (less than 20 degree C) are summarized and some of their thermo physical properties are reported. Over 88 materials that can be used as PCM and about 40 commercially available PCM have been listed. Problems in long term stability of the materials, such as corrosion, phase segregation, stability under extended cycling or sub cooling are discussed. Heat transfer is considered both from theoretical and experimental point of view and the different methods of PCM encapsulation are reviewed. Many applications of PCM at low temperature can be found,

such as, ice storage, conservation and transport of temperature sensitive materials and in air conditioning, cold stores, and refrigerated trucks.

Storage and transport of temperature sensitive products have become an important issue worldwide. The enhancement of thermal performance of cold application is under investigation and implementing thermal energy storage (TES) systems by using phase change materials (PCM) is one of the solutions to better storage. Hence, the selection of the suitable PCM for each specific application is an important matter. It is well known that PCM are one of the possible solutions to provide high energy density in TES systems. The addition of PCM in different cold storage systems and units have been investigated in order to enhance food quality and to reduce electricity consumption during storage and transportation as it has been shown before.

Nowadays, different types of chemicals such as inorganic salts, organic compounds as alkenes and water are used as low temperature PCM for cold storage. However, most aqueous salt solutions are corrosive to metals and hence a special care needs to be taken in the selection of PCM containers. Moreover, the selection of the suitable PCM for each specific application is an important matter. The development and improvement of PCM has been of great interest to many researchers over the years from the viewpoint of the application, even though it is hard to know which PCM is suitable for a specific or general application.

The issue of improving the cold chain applies to different applications such as low temperature storage (domestic or commercial freezers and refrigerators, low temperature warehouses) and food transportation (refrigerated truck or van). Refrigeration systems are used to remove heat gains and control the temperature of the units. Door openings by the users are another source of heat gain. Here, warm and moist air from the outside environment exchanges with the cool dry internal air when the doors of the cold storage space are opened. This raises the temperature inside the storage space, and also brings in moisture. Moreover, it could occur without previous notice an electrical power failure, and therefore having the refrigeration system not running. Also during defrosting, when the refrigeration system is stopped, a heater is used to melt the ice placed on the evaporator tubes and therefore direct heat gain to the store occurs.

It is well known that temperature fluctuations during the storage which are caused by the commented situations in commercial freezers could cause negative dramatic effects to the quality of the frozen food. Moreover, temperature drops during a partial thawing from an electrical

power failure is another important problem during both storage and transport of low sensitive temperature products, causing for example deterioration of the food products. All these situations could devaluate the quality of frozen food and therefore induce great economic losses to supermarkets and distributors. Furthermore, refrigerated transport is necessary for maintaining the quality and prolonging the shelf-life of fresh, frozen and perishable products during transportation and this sector is increasing constantly.

Classification & Application of PCM

Inorganic materials are further classified as compounds and eutectics. An eutectic material is a composition of two or more components, which melts and freezers congruently forming a mixture of the component crystals during crystallization. Eutectic mixtures nearly always melt and freeze without segregation, leaving little opportunity for the individual components to separate and melts almost at constant temperature. Main inorganic materials are salts, salt hydrates, aqueous solutions and water.

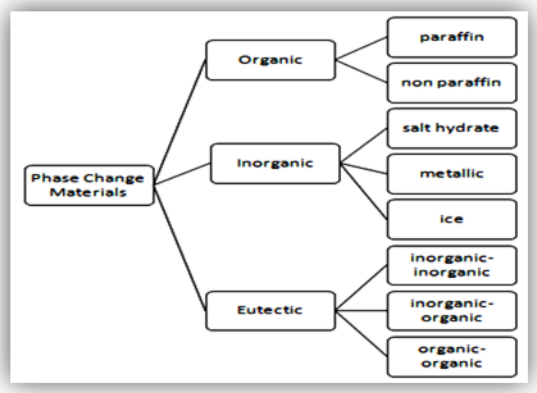

Fig. Classification of P.C.M.

Thermal Energy Storage using PCM for low temperature applications

Here the use of PCM in different applications is presented, differentiating those ones that are already in the market from those ones that have been studied by researchers.PCM offer the possibility of thermal protection due to its high thermal inertia. This protection could be used against heat and cold, during transport or storage. Protection of solid food, cooked food, beverages, pharmaceutical products, blood derivatives, electronic circuits and many other is possible. Some of the different applications for cold storage presented are the following ones:

- Cooling: use of off-peak rates and reduction of installed power, ice bank.
- Thermal protection of food: transport, hotel trades, ice-cream, etc.
- Medical applications: transport of blood, operating tables, cold therapies.
- Industrial cooling systems: re-gasification terminal.

Commercial applications:

General containers for temperature sensitive food

One of the most known applications of PCM is that of transport of temperature sensitive food in containers. These containers must be kept in the refrigerator/freezer before use in order to solidify the PCM in it. An example of such a device is the container commercialized by SOFIGRAM with PCM melting points of 0 ºC, -15 ºC and -20 ºC. Some companies only commercialize PCM pads for use in any container, such as TCP

Fig.1.2. Gel packs of SOFIGRAM

Beverages

One application that has been commercialized is the so-called "isothermal water bottle", specially developed for cycling. It is a double wall bottle, with a PCM as active part. This concept could be used for many other products, such as isothermal maintenance of fresh drinks like wine, champagne, soft drink.

Catering products

In many catering applications, cooked meals or frozen products are produced in one point and have to be transported to another destination (Figure 4). PCM containers (Figure 5) could

also be used to avoid breaking the cold chain during transportation of precooked meals, smoked salmon, milk products, ice-creams and many others.

Different PCM containers

Containers to transport blood and organs ` containing PCM

Medical applications

In the medical sector, one of the main applications is the transport of blood and organs. Containers used for these purposes work similar to those explained before. Other medical applications can be hot or cold pads to treat local pain in the body.

Transport and storage of temperature sensitive materials

In the past decade the application of PCM in transport containers became one of the first fully commercial PCM applications. Therefore many researchers put effort in order to study the incorporation of PCM in different systems as follows:

- Transport of temperature sensitive materials
- Domestic refrigerators.
- Domestic freezers.
- Domestic refrigerator and freezer combination.
- Refrigerated trucks.
- Industrial refrigeration plants.
- Temperature sensitive products transportation and storage.

Domestic freezers

Many researchers have studied these problems and provided partial solutions by modifying the control of the compression cycle. The easiest control to implement in any refrigerator or

freezer system is the widely known on/off control via a thermostat, with a fixed compressor speed; however the most efficient control systems are those employing a variable speed compressor. Hence the temperature control of the freezer/ fridge cabinets plays an important role in the control system. However, temperature control is especially difficult if the low temperature cabinet is endowed with low-end sensing and actuating systems, which is typical for commercial and non-commercial applications. Therefore, other solutions to these problems are needed. One of the most critical point at the cold chain is the retail environment because many people are involved in the transport and storage of frozen food. Insulated containers equipped with phase change material (PCM) could enhance the quality of the transportation of sensitive temperature products, allowing flexibility to the cold chain management. PCMs are materials, which have high latent heat are capable of absorbing heat through melting at suitable temperature.

Some researchers have investigated the addition PCM in different cold storage systems in order to enhance food quality and reduce energy consumption. Storage and transport of sensitive temperature products at the final steps of the cold chain could be enhanced in order to improve the quality of food at this last stage in refrigerated and non-refrigerated systems. To the best of the review knowledge, there are no studies in the literature with regards to the effects of PCM systems on the behaviour of no refrigerated systems, such as ice cream trolleys or no refrigerated vans, which are not designed to extract heat from the load but to maintain the temperature of the frozen products using insulation. In previous work (Oro´ et al., 2012), it was improved the thermal performance of commercial freezers using PCM under door openings and electrical power failure; while here the main objective is to evaluate the thermal response of low temperature non-refrigerated chambers incorporating PCM having low freezing temperature.

Selection of Phase Change Material for Lower Temperature Application

It is well known that PCM are one of the possible solutions to provide high energy density in TES systems. The addition of PCM in different cold storage systems and units have been investigated in order to enhance food quality and to reduce electricity consumption during storage and transportation as it has been shown before. Nowadays, different types of chemicals such as inorganic salts, organic compounds as alkenes and water are used as low temperature PCM for cold storage. However, most aqueous salt solutions are corrosive to metals and hence a

special care needs to be taken in the selection of PCM containers. Moreover, the selection of the suitable PCM for each specific application is an important matter.

The development and improvement of PCM has been of great interest to many researchers over the years from the viewpoint of the application, even though it is hard to know which PCM is suitable for a specific or general application. PCM are encapsulated in containers in order to prevent leaking when liquid phase its present, hence the interest remains in designing a lightweight, high conductive, noncorrosive and low cost container. Moreover, the selection of the potential PCM regards as well in their melting range, latent heat, stability under cycling and cost for low temperature storage is needed.

Need of Phase Change Material

A PCM (phase change material) is a substance with high heat of fusion, melting and solidifying at a certain temperature, which is capable of storing and releasing large amount of heat energy. This heat energy is absorbed or released when the phase changing material changes its phase form solid to liquid or vice versa. By using phase change material we increase COP (coefficient of performance) of refrigeration and reduce temperature fluctuation, as well as reduce the compressor work. PCM stores 5 to 14 times more heat per unit volume than conventional storage materials such as water, rock etc. PCM may also be used in load shading applications to shift electricity usage to an optimum time.

PCM also can be used to provide thermal barriers for insulation, particularly useful for industrial sectors. As compared to the conventional vapour compression refrigeration cycle the COP of refrigerant increases 18 to 26% by using the phase change material. The performance of refrigerator is determined in terms of COP. It is ratio of refrigeration capacity to the electric power supply consumption by compressor. COP increases for higher evaporation temperature so COP increases as refrigerating effect increases. For this purpose of increment in COP, Phase Change Material is required.

The major loss related to compressor is due to migration of refrigerant. The efficiency losses due to refrigerant migration are noted from 5 to 30%, so using PCM this loss can be compensated. In off mode condition of compressor phase change material (PCM) gives refrigerating effect. This reduces the on/off time of compressor, which results in less temperature fluctuations. As compared to the conventional refrigeration system in a cabin for a specific time,

the average air temperature fluctuations are significantly reduced with the application of Phase Change Material. In refrigeration system lesser the friction losses, the higher the evaporation and lower the condensation temperature, as well as reduction of losses associated with a pressure equalization during off-working condition of the compressor can be achieved.

Global Scenario

Food transport and storage at low temperatures is a matter worldwide due to changes of the dietary habits and the increasing of the population. The issue of improving food storage applies at different applications such as domestic and commercial freezers or refrigerated trucks. The aim of this work is to improve the thermal performance of commercial freezers using phase change materials (PCMs) under door openings and electrical power failure. A commercial PCM was selected (Climsel-18) with a melting temperature of 18°C, which is contained in 10 mm thick stainless steel panels placed at different locations in the freezer. During 3 h of electrical power failure, the use of PCM maintained the freezer temperature 4 to 6°C lower and that of the frozen products remains at acceptable levels for much longer time. With frequent door openings the benefit of the PCM is evident when the temperature of the cabinet is near the melting temperature of the PCM.

In the refrigeration section, where the PCM can be successfully implanted are as follows:

i) Bulk Cold Stores: Environment controlled warehousing space intended for the bulk storage of perishable produce are known as bulk cold stores. It is designed for long duration storage of produce so as to build an inventory buffer which will serve to smoothen the episodic production by stabilizing & sustaining the supply lines. These are normally constructed in areas close to producing areas (farm-gate) to facilitate quick access to producers for a selective set of crops only. Generally used for storage of a single commodity, which is mostly operates on a seasonal basis e.g. stores for Potato, Chillies, and Apples etc.

ii) Multipurpose Cold Stores: Warehousing space with multiple temperature zones for functioning as a distribution hub. It is designed for short-term handling of products so as to serve as a distribution logistics platform for market ready packaged produce and ready to retail products. They are designed for storage of a variety of commodities which operate, round the year. The products stored in these types of cold stores are seasonal fruits, vegetables, dry fruits, spices, pulses, milk products etc.

iii) Small cold stores with pre-cooling facilities for fresh fruits and vegetables, mainly, for export oriented items like Grapes etc. The major concentration of these units is in Maharashtra but the trend is now picking up in other states like Karnataka, Andhra, and Gujarat etc.

iv) Frozen food stores with or without processing and freezing facility for fish, meat, poultry, dairy products and processed fruits and vegetables. These units have helped the promotion and the growth of frozen foods sector, both in the domestic and the export markets.

v) Controlled Atmosphere (CA) Stores: These are cold store fitted with technology that can alter the atmospheric gaseous contents, in addition to controlling the temperature. For certain fruits/ vegetables like apples, pears, cherries.

vi) Mini units / Walk-in cold stores located at hotels, restaurants, malls, supermarkets etc.

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Design and Development of VCR waste heat recovery unit for food Reheating/Drying

Amay Panade (SE), Kamil Mutwalli (SE)

The demand for increase in requirement of energy as both the population and economy is increased. The use of fossil fuels will further deteriorate the environment. Refrigeration and air conditioning is one of the growing industries in today's world. Due to the change in lifestyle and also essential for increasing shell life of fruits, vegetables & also to store certain medicines. For all this purpose, a huge amount of energy is consumed. To overcome this experiment is conducted with PV Array of 300 watt. To check the performance of refrigerator with load and no load condition to study the cooling effect of storage. Therefore we found that there is loss of heat through the refrigerator also, the heat losses around 44 watt at a time. Major benefit of this setup is its payback comes in just a year, in comparison to diesel generator 0.75 watt, which was generally preferred in rural or remote areas.

Industry uses a wide variety of waste heat recovery equipment offered by a number of suppliers in United States and from other countries. Much of this equipment is designed for specific crosscutting industrial applications. There is no standard method classifying this

equipment; in many cases the manufacturers offer application-specific designs. The commonly used systems listed in this table are available from several suppliers and are used on industrial waste heat sources. In most cases, the systems are proven; however, they are continuously being improved in one of the following areas to offer better performance: Design changes to offer higher thermal efficiency in smaller footprint or size. Cost reduction through use of better design and manufacturing techniques. Improved seals to reduce maintenance or extend the life of the seals. Use different materials to improve heat transfer performance or maintenance cost of the system. Design changes to meet customer demands for different or previously untested applications.

The annual energy consumption of window mounted room air conditioners has increased as those have become a reliable means for providing zoned space cooling of residential and commercial buildings. The new energy efficiency standard for window type air conditioners will take effect in future. Therefore, more energy efficient systems are required to be developed to meet this standard. In order to increase system energy efficiency, component performance is needed to be improved. The purpose of this experimental apparatus is to develop a multi utility air conditioning system to produce air conditioning effect (cooling of space) and generation of hot water (by using extracted heat from cooling space) simultaneously. They developed experimental set up which uses waste heat from a window type air conditioner to heat water for residential and commercial use. It is found that generally the coefficient of performance (C.O.P) of an air conditioner decreases about 2 to 4 % due to increase of each degree Celsius in condenser temperature. So C.O.P of air conditioner could drop down as much as 40% in hot weather condition. This large reduction of C.O.P means more power consumption for air conditioner in summer when the demand for electric power is high. This increase in power consumption of air conditioner creates more pressure on the power network which is not desirable.

Today's world is vigorously leading energy crises and increasing global warming. As we are familiar with the concept that in any system rather it may be mechanical or chemical or thermal heat is evolved differently from the source in the form of waste heat and usually dumped to the environment. Focusing on our topic refrigeration has become essential equipment rather than a luxurious item. According a study it is found that about 15% of world's electricity is being

utilized by refrigeration and air conditioners. Due to having a tremendous amount COP in vapour compression refrigeration it has found a large application in domestic and industrial area. The paper mainly concentrates on reusing the waste heat produced by the condenser and utilize the same for certain application like food drying or keeping the food warm and simultaneously increasing the C.O.P effectively. This method is technically feasible and economically viable. This is one of the most convenient saving energy and balancing the demand and supply of electricity without spending any additional energy.

It will not wrong to say that due to rapid growth of industrialisation led to a vast advancement in development of technology across the world. But it has also given birth to some new concerns which cannot be evaded in any terms. Those are global warming and ozone layer depletion. We can also say that these two are the two biggest side effects of advancement and development of the technology. Another issue is that of energy crises or power crises. This makes us to give much more attention in the field of power saving and its conservation. This paper mainly deals with the recovery of the heat from source which is otherwise termed as waste. As discussed above almost 15% of worlds electricity is used for the purpose of refrigeration and air conditioning. So if we start using efficiently by reusing the waste heat we might save huge amount of energy.

Most of the domestic refrigerators run on the V.C.R system. In which mainly the refrigerant used is Terafluoroethane [hf3 134-a].These have a wide quality of refrigeration effect and C.O.P but also evolve huge amount of waste heat. In a V.C.R system the refrigerant used does not leave the system but is circulated all over the system. This operates as a condensate and even evaporates alternatively. In refrigerator there are 4 main components first three are fixed inside the system namely evaporator, compressor and expansion valve. Unlike the first three the fourth one is situated outside the system named as condenser. It is considered as the main component of the refrigerator because capacity of cooling system depends upon the type of cooling medium available.

It works in the high pressure side of the refrigeration. Its main function is to cool and condense the highly super heated vapour from the condenser. The saturated vapour refrigerant gives out latent heat through tubes or coils which is usually dumped to the atmosphere. This latent heat evolved is nothing but waste heat which can be recovered and reused for various purposes like food drying and for keeping the food warm. We can obtain maximum temperature

range from 54℃ to 59℃. This temperature is sufficient enough for keeping the food warm or drying the food.

Experimentally when a cabin is installed over the head of the simple refrigerator, this cabin will be an arrangement of coils that will work as a heat exchanger. These coils are hot coils of condenser of the refrigerator that will be modified and will braze in the cabin. It can serve the purpose of keeping the food warm. Besides, the refrigerator may be used as conventional refrigerator by keeping the cabin door open in case of absence of heat sink. Further increase in C.O.P is possible. Heat rejection may occur directly to the air in the case of a conventional household refrigerator having air-cooled condenser or to water in the case of a water-cooled condenser. This system rejected less heat to the environment so it is safer in environmental aspects. Even this method is technically feasible and economically viable. Now the question arises about the Coefficient of Performance of the new set up which is seen to increase with almost 10%.

What is Waste heat recovery?

Waste heat recovery is the use of surplus heat that has been produced. Energy use efficiency is more than doubled where the waste heat is utilized through a process known as waste heat recovery. Waste heat recovery systems are available to improve the overall efficiency of energy use by recovering heat from combustion gases in a steam boiler. Waste heat recovery is the use of surplus heat that has been produced, for example from a gas turbine on an offshore platform.

The recovery and reuse of waste heat energy has the potential to significantly reduce data center operational costs. The main barrier to the implementation of waste heat recovery and reuse systems into operational data centers in that in contrast to many industrial waste heat recovery systems, the heat, although plentiful, is of low quality. The reuse of waste heat requires minimum supply temperatures that vary based on the application when directly using hot air for domestic heating. A waste heat recovery unit (WHRU) is an energy recovery heat exchanger that transfers heat from process outputs at high temperature to another part of the process for some purpose, usually increased efficiency. The WHRU is a tool involved in cogeneration. Waste heat may be extracted from sources such as hot flue gases from a diesel generator, steam from cooling towers, or even waste water from cooling processes such as in steel cooling.

Heat recovery units

Waste heat found in the exhaust gas of various processes or even from the exhaust stream of a conditioning unit can be used to preheat the incoming gas. This is one of the basic methods for recovery of waste heat. Many steel making plants use this process as an economic method to increase the production of the plant with lower fuel demand.
There are many different commercial recovery units for the transferring of energy from hot medium space to lower one:

1. Recuperators: This name is given to different types of heat exchanger that the exhaust gases are passed through, consisting of metal tubes that carry the inlet gas and thus preheating the gas before entering the process. The heat wheel is an example which operates on the same principle as a solar air conditioning unit.
2. Regenerators: This is an industrial unit that reuses the same stream after processing. In this type of heat recovery, the heat is regenerated and reused in the process.
3. Heat pipe exchanger: Heat pipes are one of the best thermal conductors. They have the ability to transfer heat hundred times more than copper. Heat pipes are mainly known in renewable energy technology as being used in evacuated tube collectors. The heat pipe is mainly used in space, process or air heating, in waste heat from a process is being transferred to the surrounding due to its transfer mechanism.
4. Thermal Wheel or rotary heat exchanger: consists of a circular honeycomb matrix of heat absorbing material, which is slowly rotated within the supply and exhaust air streams of an air handling system.
5. Economizer: In case of process boilers, waste heat in the exhaust gas is passed along a recuperator that carries the inlet fluid for the boiler and thus decreases thermal energy intake of the inlet fluid.
6. Heat pumps: Using an organic fluid that boils at a low temperature means that energy could be regenerated from waste fluids.
7. Run around coil: comprises two or more multi-row finned tube coils connected to each other by a pumped pipe work circuit.

OPPORTUNITIES IN REFRIGERATION

As the cost of fuels used for heating increases, the opportunities to economically recover heat from a refrigeration system grow. Domestic refrigerator consist of the condenser and evaporator which is extracted heat, these heat is waste there is no use of extracted heat. There are two types of condenser first one is water-cooled condenser and second is air cooled condenser. Heat extracted from water cooled condenser has been used for heating the water. And the heat from the air cooled condenser has been used for reheating and drying the food.

Application of the waste heat from the air cooled condenser

1. In hotel line where the food items are required to keep warm there these application can install.
2. In canteen and bakeries the cooling and heating are required, heating for food items like samosa, kachori etc. This application is more economical for food cooling and reheating by installing this arrangement over the head of refrigerater.
3. In the dairy line, for curd preparation it takes 6 to 7 hours but by this application curd has been prepared in only 3 to 4 hours. It is helps to increase the dairy production.

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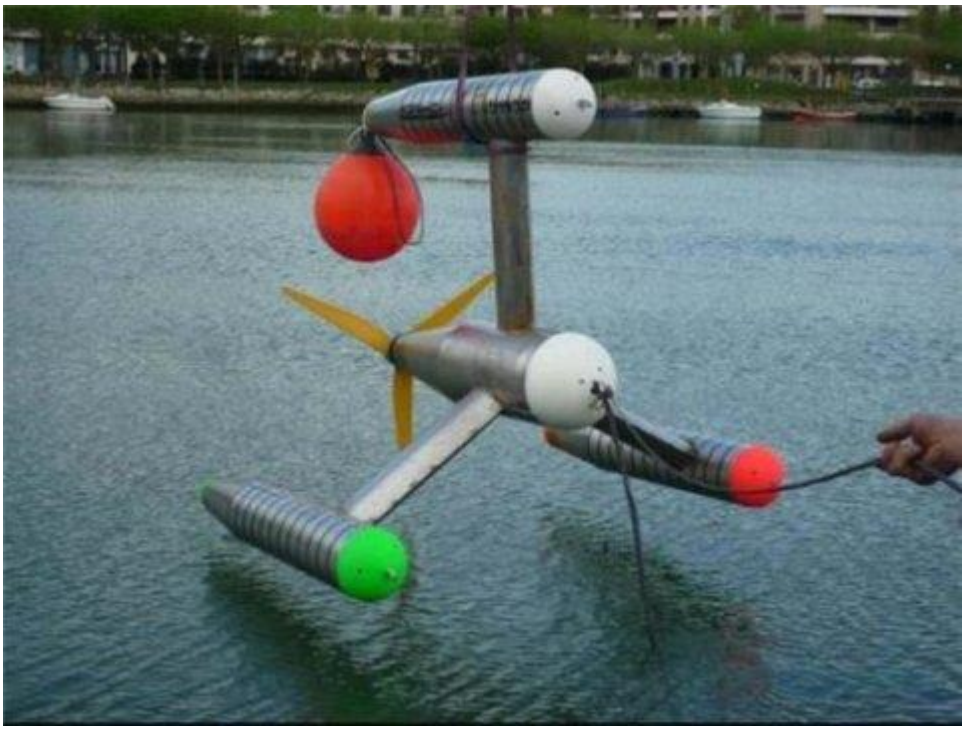
Obtaining energy from marine currents

Anuj Birnale (SE), Pratik Naikwade (FE)



The new devices using the energy from marine currents in great depths pose the problem of high cost of manufacturing, installation and maintenance. To tackle this issue, members of the Technological Research Group in Marine Renewable Energy (GITERM) at UPM have developed a method to assess the life-cycle cost of a power generation park based on these devices that can be used in the early design stages. The procedure has been recently published in the Renewable and Sustainable Energy Reviews. After a wide development of offshore wind power, experts agree that the next step is the use of the energy from marine currents, mainly produced by the tides. Today, Europe and Canada are starting to install the first experimental parks based on devices set on the seabed, called of the first generation. It is estimated that about 80% of the energy from tides are located in areas of over 40 meters of depth. Therefore it is necessary to use a new design device that can operate in areas where it is expensive to install first generation devices such as large structures held to the seabed. These systems of the second generation have anchors and a series of cables that hold the device to the seabed.

Amable López is a researcher from the GITERM group at the School of Naval Engineering at UPM and says, "Our GESMEY device, patented by the University, has been the first design worldwide tested in the sea and fit to operate fully submerged. Thanks to the cost analysis tool, we were able to assess diverse design alternatives with a final goal: to reduce as much as possible the production cost of the energy and to make this renewable source both financially and technically competitive, helping fight against climate change."

These economic analyses are added to the development of new anchoring systems that use simpler and more robust systems, such as the ones shown in the article published this year in the Revista Iberoamericana de Automática e Informática industrial. Powerful tools of simulation and control are used to develop these systems, which were also developed by the GITREM group.

The research group keeps working to achieve a future successful commercialization of tidal renewable energy devices since they have a great potential to generate power from the marine currents. José Andrés Somolinos, another researcher from GITERM says, "the energy from currents is a renewable source that has an additional value in a future energy market regarding other renewable energy sources due to its high predictability. Besides, tidal energy technologies are characterized by a CO_2-free energy that contributes to the economic growth and job creation in coastal and remote areas."

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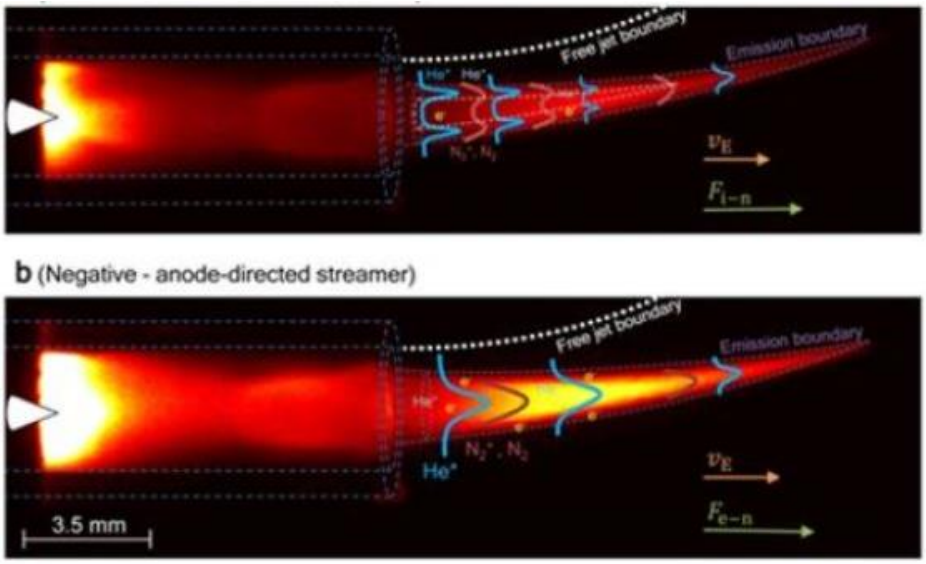
The principle of electric wind in plasma

Ankush Gurav (TE), Daphale Dipak (TE)



Professor Wonho Choe from the Department of Physics and his team identified the main principle of neutral gas flow in plasma, known as 'electric wind', in collaboration with Professor Se Youn Moon's team at Chonbuk National University.

Electric wind in plasma is a well-known consequence of interactions arising from collisions between charged particles (electrons or ions) and neutral particles. It refers to the flow of neutral gas that occurs when charged particles accelerate and collide with a neutral gas.

This is a way to create air movement without mechanical movement, such as fan wings, and it is gaining interest as a next-generation technology to replace existing fans. However, there was no experimental evidence of the cause.

To identify the cause, the team used atmospheric pressure plasma. As a result, the team succeeded in identifying streamer propagation and space charge drift from electrohydrodynamic (EHD) force in a qualitative manner.

According to the team, streamer propagation has very little effect on electric wind, but space charge drift that follows streamer propagation and collapse was the main cause of electric wind.

The team also identified that electrons, instead of negatively charged ions, were key components of electric wind generation in certain plasmas.

Furthermore, electric wind with the highest speed of 4 m/s was created in a helium jet plasma, which is one fourth the speed of a typhoon. These results indicate that the study could provide basic principles to effectively control the speed of electric wind.

Professor Choe said, "These findings set a significant foundation to understand the interactions between electrons or ions and neutral particles that occur in weakly ionized plasmas, such as atmospheric pressure plasmas. This can play an important role in expanding the field of fluid-control applications using plasmas which becomes economically and commercially interest."

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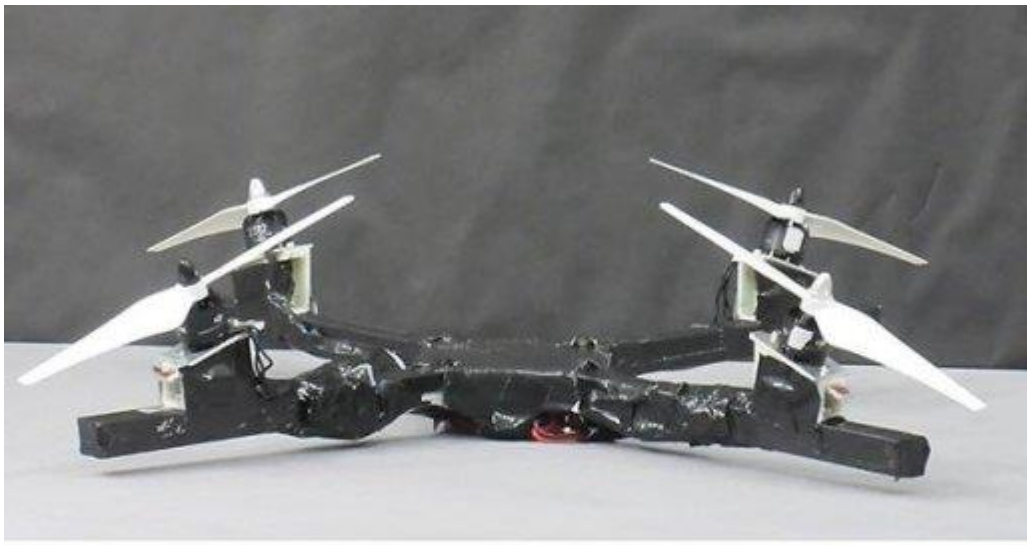
Improving drone performance in headwinds

Prathamesh Otari(SE), Pratik Jadhav (SE)



Multi-rotors have gotten much smaller since the turn of the century, and they have many uses, including for inspection, surveillance and transportation. A multi-rotor setup allows for both vertical takeoff and hover in calm conditions, but they are unstable in wind. Their rotors flap and the vehicle pitches upwards in a headwind. In this experiment, Hikaru Otsuka and colleagues set out to evaluate whether angling the rotor blades differently would improve control of quad-rotor vehicles in winds.

Pitching can occur because of three factors: the drag of the body, the asymmetry induced flow distribution on the rotor with the wind, and rotor thrust difference between the front and rear rotors. The team first estimated the effects of the wake of the front rotors on the rear, then isolated the rotors from the vehicle and measured the effect of different angles in a low-speed wind tunnel. They show that angling the rotors to the outer side by 75 degrees kept the airflow passing each rotor blade isolated, but increasing the angle to 90 or above meant the wake of the front rotors affected the rear.

Then they analyzed how this translated to a complete quad-rotor with all four rotors working together. In the wind tunnel, the team tested various angles of rotor attachment to the quadrotor and the effect on pitching moment generation. They measured the effects of outward and inward tilting of the rotor blades for five different angles. They found that rotor tilting by 20 to the outer side degrades the pitch of the vehicle by 26%.

The authors conclude that tilting of the rotors to the outer side reduces pitching moment of quad-rotor vehicles in winds. The work could have implications for both hobbyists and for professionals who want to use multi-rotor unmanned vehicles outdoor, as for inspections of wind turbines, disaster sites, or for safety of rescue activities.

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Crop-counting robot

Vishal Kagawade (SE), Uday Patil (SE)

"There's a real need to accelerate breeding to meet global food demand," said principal investigator Girish Chowdhary, an assistant professor of field robotics in the Department of Agricultural and Biological Engineering and the Coordinated Science Lab at Illinois. "In Africa, the population will more than double by 2050, but today the yields are only a quarter of their potential."

Crop breeders run massive experiments comparing thousands of different cultivars, or varieties, of crops over hundreds of acres and measure key traits, like plant emergence or height, by hand. The task is expensive, time-consuming, inaccurate, and ultimately inadequate -- a team can only manually measure a fraction of plants in a field.

"The lack of automation for measuring plant traits is a bottleneck to progress," said first author Erkan Kayacan, now a postdoctoral researcher at the Massachusetts Institute of Technology. "But it's hard to make robotic systems that can count plants autonomously: the fields are vast, the

data can be noisy (unlike benchmark datasets), and the robot has to stay within the tight rows in the challenging under-canopy environment."

Illinois' 13-inch wide, 24-pound TerraSentia robot is transportable, compact and autonomous. It captures each plant from top to bottom using a suite of sensors (cameras), algorithms, and deep learning. Using a transfer learning method, the researchers taught TerraSentia to count corn plants with just 300 images, as reported at this conference.

"One challenge is that plants aren't equally spaced, so just assuming that a single plant is in the camera frame is not good enough," said co-author ZhongZhong Zhang, a graduate student in the College of Agricultural Consumer and Environmental Science (ACES). "We developed a method that uses the camera motion to adjust to varying inter-plant spacing, which has led to a fairly robust system for counting plants in different fields, with different and varying spacing, and at different speeds."

This work was supported by the Advanced Research Project Agency-Energy (ARPA-E) as part of the TERRA-MEPP project at the Carl R. Woese Institute for Genomic Biology. The robot is now available through the start-up company, EarthSense, Inc. which is equipping the robot with advanced autonomy and plant analytics capabilities.

TERRA-MEPP is a research project that is developing a low-cost phenotyping robot to identify top-performing crops led by the University of Illinois in partnership with Cornell University and Signetron Inc. with support from the Advanced Research Projects Agency-Energy (ARPA-E).

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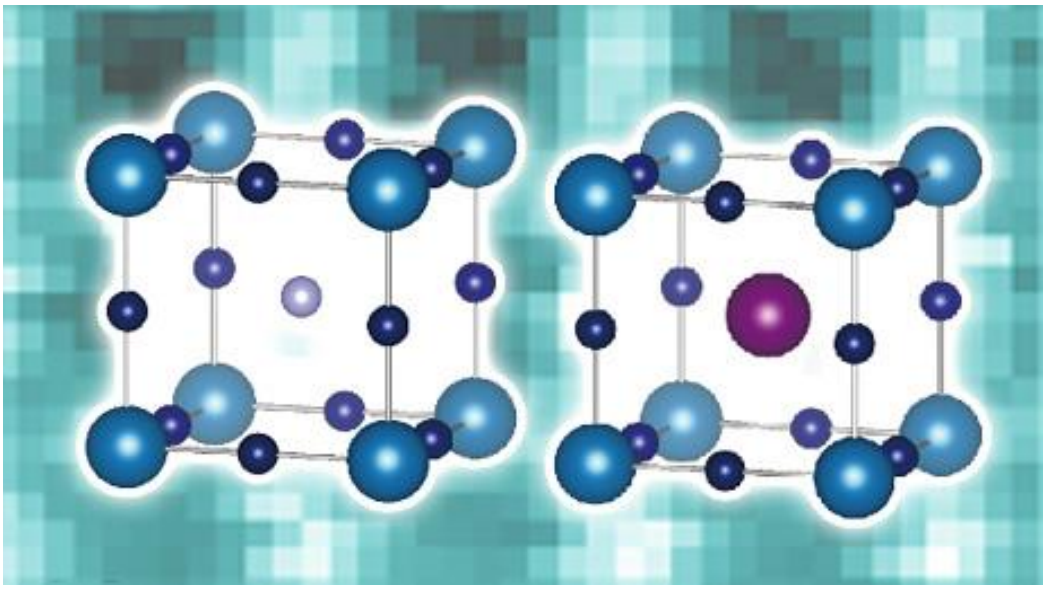
High performance nitride semiconductor for environmentally friendly photovoltaics

Yuvraj Kadage (SE), Pawar Amit (TE)



Thin film photovoltaics have equivalent efficiency and can cut the cost of materials compared to market-dominating silicon solar panels. Utilizing the photovoltaic effect, thin layers of specific p-type and n-type materials are sandwiched together to produce electricity from sunlight. The technology promises a brighter future for solar energy, allowing low-cost and scalable manufacturing routes compared to crystalline silicon technology, even though toxic and rare materials are used in commercialized thin film solar cells. A Tokyo Institute of Technology team has challenged to find a new candidate material for producing cleaner, cheaper thin film photovoltaics.

They have focused on a simple binary compound, copper nitride that is composed of environmentally friendly elements. However, growing a nitride crystal in a high quality form is challenging as history tells us to develop gallium nitride blue LEDs. Matsuzaki and his coworkers have overcome the difficulty by introducing a novel catalytic reaction route using ammonia and oxidant gas. This compound is an n-type conductor that has excess electrons. On the other hand, by inserting fluorine element in the open space of the crystal, they found this n-

type compound transformed into p-type as predicted by theoretical calculations and directly proven by atomically resolved microscopy.

All existing thin film photovoltaics require a p-type or n-type partner in their makeup of a sandwich structure, requiring huge efforts to find the best combination. P-type and n-type conduction in the same material developed by Matsuzaki and his coworkers are beneficial to design a highly efficient solar cell structure without such efforts. This material is non-toxic, abundant, and therefore potentially cheap -- ideal replacements for in use cadmium telluride and copper indium gallium diselenide thin film solar cells. With the development of these p-type and n-type semiconductors, in a scalable forming technique using simple safe and abundant elements, the positive qualities will further bring thin film technology into the light.

Journal Reference:

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