KSR INSTITUTE FOR ENGINEERING AND TECHNOLOGY

KSRIET

THE DEPARTMENT MAGAZINE

DEPARTMENT OF MECHANICAL ENGINEERING

Mechzine

VOLUME 4 ISSUE 2

ACADEMIC YEAR 2017-2018

KSR INSTITUTE FOR ENGINEERING AND TECHNOLOGY

Vision

To become a globally recognized Institution in Engineering Education, Research and Entrepreneurship.

Mission

IM1	Accomplish quality education through improved teaching learning process
IM2	Enrich technical skills with state of the art laboratories and facilities
IM3	Enhance research and entrepreneurship activities to meet the industrial and societal needs

DEPARTMENT OF MECHANICAL ENGINEERING

Vision

To produce globally recognized Mechanical Engineers and Entrepreneurs to meet the industrial challenges with ethical values.

Mission

DM1	Impart quality education in Mechanical Engineering through enhanced teaching learning process.
DM2	Provide platform to apply and analyze the engineering concepts with state of the art laboratories.
DM3	Augment the technical knowledge among students and faculty members through research activities to meet industrial and societal needs.

Program Educational Objectives (PEOs)

PEOs	Keywords	Description
PEO1	**Core Competency**	Graduates will adopt technological changes in core and allied areas of Mechanical Engineering.
PEO2	**Professionalism**	Graduates will have leadership quality with soft skills to excel in their professional career.
PEO3	**Higher Studies and Entrepreneurship**	Graduates will evoke interest in higher education and develop entrepreneurial attitude for ever changing industrial and societal environment.

MECHZINE

A plastic-damage model for concrete under compression

R. Parthasarathy, II Year, Department of Mechanical Engineering, KSRIET

Coupled elastoplastic-damage models have been applied extensively for the description of the progressive failure of materials such as concrete, geomaterials, woods, steel and composites. These models have the capability of representing both the permanent inelastic deformations due to plastic component and the degradation of elastic moduli due to damage component. While the framework for plasticity is well established with the additive decomposition of the strain tensor into elastic and plastic parts, flow rule and Kuhn–Tucker conditions, approach to damage has been rather diverse. One of the main distinctions between the alternative formulations is the way the strain tensor is decomposed. An initial attempt for merging elastoplastic and damage constitutive models can be found in Lemaitre where the total strain was partitioned as the elastic and plastic strains, while the effect of damage on the elasticity modulus was considered based on energy dissipation and thermodynamic principles. Simo and Ju employed the effective stress and effective strain concepts for the damage component and developed strain and stress based formulations and algorithms for the coupled elastoplastic-damage constitutive modelling. They also applied their theories for the simulation of the concrete material behaviour. Later, Ju developed an energy-based coupled elastoplastic-damage modelling approach. Constitutive models that are capable of coupling elastoplasticity and damage were also used for plain concrete by Meschke et al. , in which the inelastic strains were decomposed into plastic and damage components and their share was determined based on a scalar parameter which was calibrated based on experimental results. Algorithmic issues in their analysis have also been discussed in Meschke et al. [. Lee and Fenves successfully coupled plastic and damage models to simulate the cyclic behaviour of concrete in both tension and compression. Vaz and Owen developed an algorithm for failure predictions of multi-fracturing materials based on the

elastoplastic-damage modelling approach. Al-Rub and Kim [used a coupled plasticity-damage model for the simulation of the fracture process of plain concrete. Brunig developed an elastoplastic-damage model to capture the phenomenological behaviour of metals considering finite strains and anisotropic
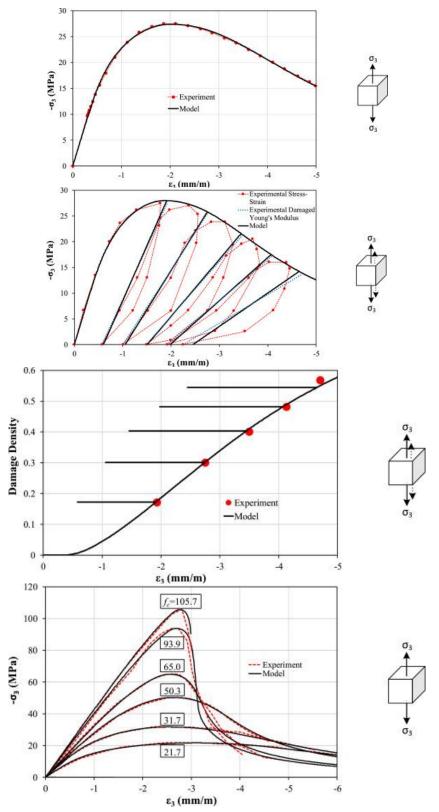
damage development. Later, Brunig and Michalski used the model to capture the behaviour of concrete in both tension and compression. Other coupled plasticity and damage models include the works of Benallal et al Lubliner et al. Hansen and Schreyer , Doghri Luccioni et alJason et al. , Grassl and Jirasek , Wu et al. , Einav et al and Voyiadjis et al. .

In this work, we follow the idea which proposes the partitioning of the total strain into elastic, plastic and damage strain components. According to the authors' knowledge, the work of Klisinski and Mroz was the first in which the constitutive equationswere constructed by partitioning the total strain into the elastic, plastic and damage strain components. Yazdani and Schreyer , Armero and Oller , Al Rub and Voyiadjis , and Brunig also partitioned the total strain considering a damage strain component. Armero and Oller , however, introduced a novel framework in which the sharing of the total strain was determined based

on equilibrium conditionsbetween the updated stresses of the plastic and damage components of the model. In their framework the problem for damage is posed in a similar form to plasticity, in which given the damage strain, flow rule and Kuhn–Tucker conditions are applied to determine the damage evolution and stress update within the damage component. It is interesting to note that in Armero and Oller , damage strain component is reversible in parallel to the elastic strain, however, the damage evolution is irreversible which is represented by a separate damage variable. This definition of reversible damage strain differs from irreversible damage strain used in alternative studies e.g. Al Rub and Voyiadjis [23], and Brunig [8], which naturally leads to alternative expressions for constitutive equations. Ibrahimbegovic and his co-workers adopted the framework proposed by Armero and Oller [22] for the analysis of concrete in Ibrahimbegovic et al. [24], and mild steel in Ayhan et al. [25]. In this study, however, by defining an *a-priori* relationship between the total strain and the damage strain components based on the damage variable, we depart from Armero and Oller [22] in order to provide a simpler and more efficient computational

framework. We limit our approach to isotropic damage development.

The Best Engineering Stories of 2018

R. Manoj, II Year, Department of Mechanical Engineering, KSRIET

Socially and politically, 2018 was a year of volatility. Technologically, engineers and scientists kept a lower profile, while mothering a host of advancements across a number of disciplines, from biomedical to energy to robots. All were aided by the growing momentum in 3D printing and advanced manufacturing, tools that are seeping into almost every industry.

Technology is advancing at a rapid speed and engineers need to do the same to compete and advance. These changes require greater collaboration between engineering disciplines and non-engineering professionals. Soft skills are critical. Effective communication among team members and outside stakeholders is essential. But training is needed even more to master technology and ensure business success, for both newly hired engineers and those with experience.

These themes were explored throughout 2018 on ASME.org. Here are some of the articles that touched on those themes and were widely read by viewers.

At the core of the research, industrial and technological breakthroughs we wrote about are skills engineers need to practice and grow personally and in business. Today, those skills need to be nurtured and developed from the start of a career to the end. Engineers excel at solving problems, but developing soft skills to enhance their careers isn't always a top priority, as discussed in 12 Skills You Need to Advance an Engineering Career. Scoring an interview means you have the technical chops. After that, it's all about marketing yourself, asking the right questions,

making good connections, and choosing the paths that lead toward career goals. Without those, you're just another number in a large crowd of engineers.

Engineers familiar with multiple disciplines will be better prepared to work with today's product development teams, according to a survey by research firm Tech Clarity. But nearly 40 percent of manufacturers polled said the evolving and changing engineering skillsets needed for systems-driven product development is one of the biggest workforce challenges. We covered many of those trends during 2018.

New Skills for the World of Engineering, for example, explored the challenges companies face while developing new

skills for engineers and engineers who may lack support in learning them. "Surveys and articles dot the Internet about the need for continued training, but examples of companies that put that into place are rare," the report stated. One industry executive posed the question: "What happens if I train my employees and then they leave because they get a better offer? I answer, 'What happens if you don't train them and they stay?"

Increasingly, training involves design and 3D printing. It captures most industries but is perhaps best manifested in How Industry 4.0 Impacts Engineering Design. Industry 4.0 is a combination of digital processes such as the Internet of Things, automation, robotics, and additive manufacturing and how they have a disruptive impact on mechanical engineering design. Not only do engineers need to redesign processes and operations to accommodate these new advances, Industry 4.0 impacts how they design products for increasingly smart manufacturing facilities.

4D printing is one of the next major technologies on the horizon. Georgia Tech researchers, showcased in the story 4D Printing Advances Additive Manufacturing, built a powerful 4D printer that quickly and efficiently creates self-assembling 4D structures. It combines four different printing technologies: aerosol, inkjet, direct ink write, and fused deposition modeling. It can also make products from a variety of materials, including hydrogels, conductive inks, elastomers, and shape memory polymers, which can be programmed to "remember" a shape and then transform into it when heated to a certain temperature.

Artificial intelligence is another combination of technologies quickly being integrated into a variety of systems, bringing the reality of radical change to many industries. As we reported in Artificial Intelligence Transforms Manufacturing, Stanford researcher Andrew Ng says AI will perform manufacturing, quality control, shorten design time, reduce materials waste, improve production reuse, and perform predictive maintenance. Going beyond that, the story describes a two-armed robot that can manufacture products without having to be programed.

Autonomous, Robotic Boat First to Sail Across the Atlantic

S. Gaby Sachin, III year, Department of Mechanical Engineering, KSRIET

No Atlantic crossing is easy, but the little Sailbuoy has to maneuver past oil platforms, navigate high-traffic areas, and withstand gale force winds without a human hand at the tiller. It took 80 days for Sailbuoy to travel from Newfoundland in Canada to Ireland, becoming the first self-maneuvering boat to complete a transatlantic journey.

The rough distance, as the crow flies, is about 2,000 miles, but the sail distance turned out to be about 3,169 miles. The boat experienced smooth sailing and faced no major challenges, said David Peddie, CEO of Offshore Sensing, the Norway-based company that made the boat.

"We were concerned about icebergs and being picked up by fishing boats, so we avoided ship traffic," Peddie said. "We had some strong currents pushing it backwards, but this only delayed the crossing."

The unpredictable nature of the ocean caused a previous attempt by Sailbuoy, and other groups, at a transatlantic journey to fail.

"Last year we only made it halfway. The reason for this was a screw that came loose and shorted an electrical connection disabling the autopilot," Peddie said. "We forgot to lock it securely.

"One doesn't know what one might hit, one can get tangled in nets or floating debris, get smashed by a whale, chewed on by a shark or maybe something else," Peddie added. "This is quite rare, but you never know."

The Sailbuoy is loaded with echo sounders and atmospheric and water quality sensors for industry and scientific uses. Image: Sailbuoy

The Sailbuoy used wind for propulsion and solar panels for power. Unlike autonomous cars, the boat didn't use cameras for obstacle detection or navigation. Instead, it used GPS and sensors to find its position, heading, and speed. The boat transmits data to and from shore in real time using the Iridium satellite system.

It is designed for a handful of applications, such as measuring ocean and atmospheric parameters, fishery management, aquaculture, tracking oil spills, and serving as a communication relay station for subsea instrumentation.

During its recent journey, the robotic boat received waypoints toward which it was to travel via the satellite network. The Sailbuoy navigated to each waypoint without human intervention. Sailbuoy sails

in much the same way as a traditional sailboat, tacking to make headway against the wind and to approach a particular waypoint.

With a length of 2 meters and an average speed of about 1.5 knots, Sailbuoy has an internal battery with a 400 Wh payload that could keep the boat operational for 6 months. The boat could survive waves as high as 8 meters. Much smaller than a conventional boat, it measures 2 meters, weighs 60 kilograms, and travels at an average speed of about 1.5 knots.

The Sailbuoy is loaded with echo sounders and atmospheric and water quality sensors. While at sea, it gathered measurements on wave height. Remote pilots control the boat through a website where they update waypoints, download data, and monitor Sailbuoy's progress.

Though the ultimate goal is to build a series of travelling ocean-going sensors to make environmental readings, the purpose of Sailbuoy's transatlantic crossing was simply to test its endurance.

The biggest challenge is yet to come. "A next hairy goal would be to circumnavigate the Antarctic," Peddie said.

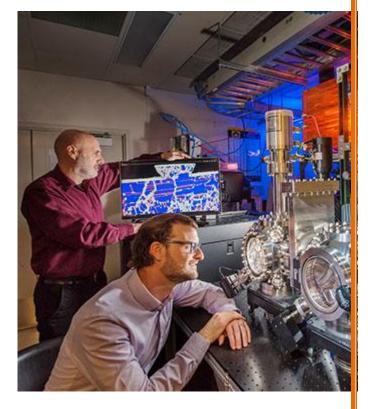# Is This the Most Wear-Resistant Material in the World?

C. Sunil Raj, III Year, Department of Mechanical Engineering, KSRIET

People love gold for many reasons. It's shiny, valuable, an excellent conductor, and doesn't corrode quickly. Gold is also extremely brittle. But when scientists at Sandia National Laboratories mixed platinum with a little gold, they ended up creating what some are calling the most wear-resistant alloy in the world.

Researchers at the U.S. national lab mixed 10 percent gold with 90 percent platinum and made an alloy that's up to 100 times more wear resistant than stainless steel, two to three times more than hard-gold metal alloys, and up to nine times more than gold. The new alloy could be used to make new power-generation systems, engines and other equipment that are long lasting and require low maintenance.

"There's nothing intrinsic about platinum or gold alone that drives you to select these like we did," said Nic Argibay, a materials scientist and researcher at Sandia. "In the right proportion, those two elements could be configured into a microstructure that has remarkable stability."

For You: Engineering Simulation Provides Real-World Design Benefits and Improvements

Researchers Michael Chandross (left) and Nic Argibay work on a computer simulation that predicts the wear resistance of their platinum-gold alloy. Image: Randy Montoya / Sandia National Laboratories

Past work on how metals wear and the use of alloys in electrical contacts motivated the scientists to look at the relationship between platinum and gold. Their understanding of how metals interact when sliding or rolling against each other led them to design new materials with superior performance. Inspired by research at MIT, which found that platinum-gold belonged to a class of nanocrystalline alloys with thermal and mechanical stability, Sandia

researchers began designing clever ways to increase the stability of particular alloys.

"We came to understand that the microstructure and its evolution -- the grain size and how stable the grain size is -- is fundamentally and primarily defining the frictional and wear properties of an alloy when it is rubbing against metal," Argibay said.

Platinum-gold will improve electrical contacts by reducing cost, increasing reliability, and achieving better performance in more aggressive environments, the researchers said. It could also be used as a coating to address tribological and structural issues in gears, engines, and other engineering products.

"One impact area we are excited about is next-generation wind turbines that may rely on noble-metal coatings like this to facilitate or obviate the removal of rare-earth metals," he said. "You may have a direct-drive wind turbine with electrically energized generators. Instead of having to put expensive, heavy and risky rare-earth metals in rotors, we can enable a different route to design next-generation large wind turbines that are equally reliable to what we use today, but much cheaper."

In the short-term, the alloy could be added to blade-pitch motors and communication slip rings used in wind turbines, which wouldn't need to be opened up and fixed repeatedly. Reduced maintenance costs, along with the longer life of parts, could offset the high cost of the metals.

"Even though it's an expensive platinum and gold alloy, that's a lot less costly now," Argibay said. "You might start considering using platinum and gold in cheaper commercial products if you need a tiny bit of it."

The researchers determined the ratio of platinum and gold that should give the alloy a grain size with better wear properties. The coatings – which were one to two micrometers in size, in line with standard gold coatings -- were synthesized through sputter. The coated steel was put through a friction and wear tester called a tribometer, and connected to a hard, smooth sapphire sphere. Samples were taken after progressively long periods of sliding or cycling wear and researchers determined the volume lost. A host of characterization techniques were also run to see what areas of the microstructure had worn. The researchers also ran molecular dynamics simulations.

The platinum-gold alloy is in the process of being patented. The research is being used as a springboard to find other wear-resistant alloys cheaper than platinum-gold. The researchers also want to test the effectiveness of platinum-gold coatings down to a few hundred nanometers.

Unique Gas Turbine Engine Powers Quieter, More Reliable Drones

S. Lavanya, IV Year, Department of Mechanical Engineering, KSRIET

The earliest drones David Ransom remembers were biplanes that ran on piston engines and took off from runways. Now battery-powered quadcopters take flight vertically with relative ease.

Inspired by those copters, Ransom, director of the machinery department at Southwest Research Institute, saw an opportunity to make a wider variety of unmanned aerial vehicles quieter, more reliable and able to fly longer than current engines allow.

As a result, the company built a small radial gas turbine that powers a small generator that provides thousands of hours of flight to drones. Current drone turbines typically wear out after a few hundred hours. SWRI's engine is also quieter and more durable than piston engines, and provides more flight time than battery-powered motors.

The fuel-to-electric system resulted from an IARPA-sponsored project to develop an architecture for a quiet unmanned aerial vehicle.

SwRI used a specialized 3D printer that can craft layered and highly detailed metal parts to build its radial gas turbine. Image: Southwest Research Institute

SWRI's turbine makes a very high-frequency noise that humans can't hear. It is designed for larger drones used for surveilling different types of equipment. Drones with SWRI's turbine would be carried around in a trailer and then ground-launched, Ransom said.

The turbine has an efficiency of 20 percent to 25 percent, which is not as good reciprocating engines, which can hit up to 50 percent. But the turbine's application calls for less noise, not more efficiency.

"By and large, they're not the most efficient machines," Ransom said. "I wouldn't think of it as a replacement, but as a new enabling combination of technologies that allows you to do quiet flight operations."

Turbines are also more expensive than piston engines, but the simplicity of their moving parts means easier maintenance. The new turbines also run cooler than small turbines currently in use. Those turbines are also constantly exposed to high temperatures given off during the generator's combustion process. While turbines perform better as they get hotter, the extreme heat eventually damages them.

To solve the overheating problem, SWRI used a new selective laser melting machine (SLM) to build small, intricate airflow passages inside the turbine that cool it without affecting power. The design, Ransom said,

yielded a turbine that's both reliable and high-performing.

Turbines also have an advantage in remote monitoring applications, since gasoline and diesel could be easier to transport and find than a charging station. .

While other engineers are building even smaller micro gas turbine engines, Ransom doesn't think he could go any smaller with the SWRI turbine.

"What happens is you start to get dominated by the clearance effects between the compressor and turbine and the housing," he said. "So clearance starts to become quite large compared to the size of the air flow path. That's where you really start to lose efficiency. I think the designs that we're seeing right now in this class is about the smallest practical size for a gas turbine engine."

Low-cost, Low-maintenance Robot Hits Market at Right Time

M. Dinesh Kumar, IV year, Department of Mechanical Engineering, KSRIET

Automation continues to grow as companies look to increase productivity and cut costs. Economic reality is hastening that process output is increasing, competition is intensifying, and combining robots with technologies like IoT and AI has provided more efficient ways to produce and inspect products.

Igus has engineered its low-cost, low-maintenance Delta Robot specifically for assembly functions, pick-and-place tasks, and inspections. The robot is priced from $6,200 to $8,850, depending on the assembly and controller package. Similar robots typically start at about $20,000, according to some industry estimates.

The market, experts say, is ripe for lower-priced robots. Consulting and accounting firm PwC estimates that "robot density" is still growing worldwide, and acquisition prices are bound to come down. Robot and component makers are figuring out ways to reduce prices and maintenance costs of robots.

Listen to ASME TechCast: How Engineers Close Communication Gaps with Non-engineers

The new robotic solution is self-lubricating, maintenance-free, and lightweight. Image: Igus

The Delta Robot consists of maintenance-free components, including toothed belt drive lubrication-free linkage, encoders, stepper motors and optional drive controllers. The complete system -- made of aluminum and plastics -- can carry up to five kilograms at low speeds, with a maximum pick rate of 60 per minute. It is

also modular in design, giving it flexibility in assembly and maintenance. Speeds are limited to 60 picks-per-minute

The use of plastic bearings is one way to reduce costs associated with maintenance and downtime, said Matt Mowry, product manager at Igus.

Unlike traditional recirculating linear ball bearing systems, the Delta Robot utilizes low-cost injection molded plain bearings as well as extruded aluminum rails. Ball bearings require hardened precision steel shafts and rails and could be considerably more expensive. The robot also has the benefit of being self-lubricated and does not require oil or grease, which reduces downtime.

"The lubrication-free aspect makes them ideal for use in dirty, dusty environments since there is no oil to attract debris, which could contaminate and change the friction in ball bearing systems," Mowry said.

The lubrication-free aspect also means there is no oil to contaminate food or packaging, or lab and medical materials in sensitive environments, and the cost of

replacing a liner, compared to replacing a linear ball bearing and shaft is also less.

Key to robotics is simplicity and ease of use, and the unit takes up to 30 minutes to assemble on-site, though the goal is to ensure a customer takes no more than 15 to 17 minutes to put it together. Parallel kinematics help the robot move fast, which adds to the overall efficiency and output.

The robot requires an installation space of up to 420 millimeters in diameter. One challenge was to compact the robot within the space constraints, and fit as components as possible, said Fabian Koeching, an engineer at Igus.

The Galaxy of K.S.R. Educational Institutions

K.S.Rangasamy college of Technology
K.S.R. Institute of Dental Science and Research
K.S.R.College of Engineering
K.S.R.Institute For Engineering and Technology
K.S.Rangasamy College of Arts & Science
K.S.Rangasamy College of Arts & Science for Women
K.S.Rangasamy Institute of Technology
K.S.R. Polytechnic College

K.S.R. College of Education
K.S.R. Matriculation Higher Secondary School
K.S.R. Industrial Training School
K.S.R. Akhsara Academy
Rajammal Rangasamy I.T.I.
Rajammal Rangasamy Teacher Training Institute
Rajammal Rangasamy Higher Secondary School
Avvai K.S.R. Matriculation School

SINCE 1984

K.S.R Instutitue for Engineering and Technology