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THE WONDERWORLD OF GRAMMAR THROUGH THE WONDERWORLD OF ENGINEERING

Рекомендовано Методичною радою УДМТУ як навчальний посібник

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Рекомендовано Методичною радою УДМТУ як навчальний посібник

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Посібник "The Wonderworld of Grammar through the Wonderworld of Engineering" призначений для студентів-філологів, яких навчають науково-технічному перекладу з англійської мови на українську і російську. Він розрахований на тих, хто вже має загальну підготовку з англійської мови, засвоїв курс нормативної практичної граматики англійської мови і повинен вдосконалити навички перекладу. Даний посібник – це можливість представити декілька елементів функціональної граматики: засоби вираження темпоральних і деяких модальних відношень. Метою стає навчити розуміти частину смислу вислову через розуміння граматичної форми дієслова і місце цієї граматичної форми у системі правил. Цей підхід не можна вважати самостійним при вивченні граматики, але він допомагає зрозуміти взаємодію когнітивного знання для виконання адекватного перекладу.

Посібник складається з двох частин, тезаурусу основних інженерних понять, англо-українсько-російського словника.

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THE WONDERWORLD OF GRAMMAR THROUGH THE WONDERWORLD OF ENGINEERING

Grammar *is the science which contains the knowledge of the structural rules (grammatical properties) about how words change their forms (structure) and combine with other words to make sentences.*

Engineering *is the science by which the knowledge of the properties of matter and the sources of power in nature are made useful to humans in structures, machines and products.*

Engineering

General design considerations

– **history of knowledge**
– organization (laws, principles, methods, techniques, models)
– matter (properties)
– space (relations)
– shape (form)
– time (change)
– constitution
– movement
– safety (environment)
– economy (cost)
– local culture
– measurement
– processes of fabrication
– power:
  *sources (solar, steam, electrical, nuclear, etc.)
  *generation
  *conservation
  *transmission
  *conversion
– f**uture advance in knowledge**

Part 1. TEMPORALITY

Time and/or Tense

Час чи час!?

Time present and time past
Are both perhaps present in time future
And time future contained in time past.
If all time is eternally present
All time is unredeemable.
What might have been is an abstraction
Remaining a perpetual possibility
Only in a world of speculation.
What might have been and what have been
Point to one end, which is always present.

Th.Eliot

Study the texts and:

– explain what situations the underlined verb-forms show;
– explain how they are expressed in Ukrainian and Russian;
– read the text and tell what it is about in Ukrainian. If you fail to do it, turn to the text again and again until you can do it properly;
– now start translating it.

PRESENT

Engineering Education: Age-old Qualities, New Directions

From a traditional perspective, the design and engineering profession is a result of continuing education, support, and design experience in addition to formal training.

Continuing Engineering Education: New Goals

Continuing engineering education consists of self-taught advanced principles and active participation in R&D. The support of capable and more experienced engineers is also important whether it is in education or industry. Relevant engineering experience involves experimentation and evaluation of materials and manufacturing processes. The future engineer understands that education is largely self-taught and is never-ending requirement.

Some goals are usually considered: materials technology, manufacturing familiarity, industry-oriented approach.

By materials technology, they mean course work that involves structure and properties of materials as well as materials manufacture and testing processes.

By manufacturing familiarity, they mean course work that comprises hands-on manufacturing practice, as well as production operations, and the effects of product failure on the design process whether it occurs from design material, work manship or overload.

Somebody states that it is art which is intuition-learned from practice.

And another important thing is environment-friendly design and production when an engineer considers the impact of engineering structures on the environment.

Best Product Realization Practices – Best Designs

The time is right for success in engineering design

It is also clear that product realization in a competitive manufacturing business involves more than technical engineering issues. Thus, it may well make sense to set new goals.

1. New and improved product and process ideas from customers and employees are obtained to facilitate a continuous influx of information about new methodologies, materials and technologies.
2. New ideas for preliminary study relating design, market potential, manufacturing, cost and company strategy are selected.
3. The design using cross-functional teams to accomplish integration of product function, manufacturing processes, marketing is applied throughout the product realization process.
4. Computational prototyping and simulation methods and technologies are used as much as possible.
5. The role of prototypes (their purpose, number, timing and technology) is paid attention to.
6. Replacement materials are constantly searched for.
7. Tight quality control is achieved.

8. Tolerances are paid special attention.

9. Mechanical, electrical, computer and optical technologies are integrated.

10. Activity – based costing concepts are used as much as possible.

Making Safety Part of the Process

Process safety is really a hot topic because there have been some dramatic, highly publicized accidents involving process facilities.

Inherent safety is built into a process from the beginning:

– reducing system operating temperatures and pressures;

– substituting less-hazardous raw materials for more-hazardous ones;

– designing in elements that allow the system to survive routine upsets without the need for direct operator intervention;

– providing for fail-safe positions for valves and controls, so they can survive a loss of power;

– using reliable equipment and components.

The main goal of process safety are:

– to protect people, property and the environment from some kind of destructive release of energy (heat, fire, electric current, high-pressure gases, highly reactive chemicals, nuclear radiation).

Sufficient barriers have to provided to protect against accidental or protect against accidental or unintended energy releases: structural (a wall, a door), equipment (pipe, automatic control system, valve), administrative (strict and precise procedures for operating equipment and controls).

If engineers wish to have the trust of the public, they work to ensure that every plant is safer, cleaner, more reliable.

A Multimedia Tutor for Engineering Design

Choosing a bearing system, mounting a disk to a shaft and joining a cylinder

EDICS is the engineering design instructional computer system was set up at MIT to provide undergraduates with instruction, data and information on three fundamental areas of mechanical engineering design. Students work interactively with the system on their own time and in their own pace.

From high school on, students have been led to believe that a good back ground in the basic disciplines is all that is needed to be a well-prepared engineer. But a student is sure he has become aware of a wide range of technology and materials.

But there are many pedagogical problems and the situation has been dissatisfying to all because the experienced students are bored with long explanations and the inexperienced students are afraid to put their ideas down on paper because they donot know how to handle details.

While the authors believe that interactive video has advantages in introducing unfamiliar topics, they also expect that the use of EDICS leads to more knowledgeable study of texts.

Drafting Tools Move off the Drawing Board

As a substitute for the drafting table, the computer offers power and flexibility.

The computer married with a plotter or laser printer and CADD software comprises a system that can perform a complete range of drafting duties.

Precision drafting is a mater of measuring, calculating and drawing objects according to design specifications. Sections of CADD drawings – including lines and circles, groups of objects and drawing layers – are easily deleted or moved. A specified section of a drawing is made larger or smaller to fit better with the overall plan.

Laborious manual tracing is replaced by simple copy commands.

Computer – based systems are provided on screen grids. The x and y spacing care different increments and care set at angles to facilitate drawing isometric views.

Measurement in CADD environment is a function of the software. Exact lengths are entered by the user and reproduced by the system. If the drawing calls for curves, arcs, circles and ellipses, the draftsperson generally uses a French curve or compass to draw them. CADD systems offer many tools to calculate and draw curves and curved objects.

Indeed, the major advantage of CADD systems is derived from their powers of editing and revision. If the specifications of a design are changed or if a customer changes his or her mind while a draft is in progress, a CADD drawing does not have to be completely eliminated. A special bank of easily accessible drawings is applied to other projects.

Engineering Design: Age-old Ability to Design, New Possibilities

Some Steps to Smoother Product Design

The drive to push products out the door faster by shortening development cycles is approaching some climax.

Quality and time are two crucial problems. As new products incorporate a growing number of diverse technologies, engineers from a multitude of disciplines are working to unite their expertise.

Now we are observing a training film. The company is trying to get a new product to market quickly. Now they are selecting a strong project leader who is the most important element. Now a candidate is showing how he communicates with management, how open he is with the people on the team.

Now we see how the members of a cross-functional team are creating specifications for a new product. They have been here for two days, listed their ideas. They are writing the key issues on large sheets (storyboards) which are tacked up around the room. They are commenting and refining them.

Now we are witnessing the third stage. it is important to keep the project team lean talking to each other. it helps to have the team very close together physically. If the mechanical engineer and the electrical engineer are talking to each other about something and they reach an agreement, the software person, who is sitting there, says, "Hey, wait a minute! You can't do that!" If possible, team members should work within direct talking distance.

Now we see how they are building and testing models. The best way to do testing in an accelerated project schedule is to do lots of little tests, each building on its predecessor, rather than a colossal model that tests everything.

Now they are trying to understand how the product is viewed by prospective buyers and are determining the appropriate level of technology to put into a product (not to incorporate too much technology or invention into the product).

For an engineer, the hardest part of the development process often comes after the product has gone out the door. Although money is important, to many engineers financial rewards are not the prime motivator. The prime motivator is the satisfaction of doing a good technical job, finding the flawless product, or putting together some technical aspect that has never been put together before.

Concurrent Engineering: Better Designs

Concurrent engineering is the simultaneous design of a product and the process required to produce it.

It is important to remember that concurrent engineering is not a product – it's a process.

Today, design functions are moving down in manufacturing companies faster than ever: from conceptual design to design engineering, to manufacturing engineering, to suppliers and quality assurance.

The first step in implementing a concurrent engineering strategy is internal review. The companies are looking long and hard at what products they are producing and how those products are being designed for manufacturing. It can reveal astonishing information. For example, one company is evaluating how to cut time out of a one-year production cycle and is surprised to find, on closer inspection, that their actual production cycle is only three months long. The company is losing the other nine months in a labyrinth of getting approval.

Now many companies all over the world are demonstrating the global reach of a CIM system and, in this way, are supporting concurrent engineering. They are proving that concurrent engineering is paying off and their productivity is improving.

Technology to Fit Local Culture

Engineers from highly industrialized nations are taking their technology on the road to work with less-developed countries to design simple but effective machines that pump water, cook food and transport the disabled.

Engineers from highly industrialized nations are sharing their successes with less technologically advanced countries. Communities in Latin America and Africa are profiting from mechanical engineering solutions. However only persons with a thorough knowledge of the local economy and culture can determine whether a design is sustaining in that nation.

This includes knowing of a design is being constructed from materials and tools readily available, whether the design is fitting in with local customs and whether the cost is adequate.

During design and construction stages local governments, agencies, groups and communities are being partnered with.

Example 1. **Wheeled Mobility**

Traditional improved wheelchairs sell for $600 to $1200 for Nicaragua, and it is too expensive. Hotchkiss's wheelchair weighs less than 35 pounds because its design eliminates 26 welds and 82 fasteners. Its frame is made of an inexpensive tubing that is easily shaped. Standard automotive bearings and bicycle wheels give the chair mobility. The seat is made of canvas. Each foot rest swings away from the front of the chair, turning the footplate sideways into the plane of the side frame. This allows the chair to be folded so that it is small enough to fit in cramped living quarters or to be easily carried on the back of a donkey or atop a bus.

The company is currently promoting manufacture via training workshops and technical and financial assistance to small manufacturing enterprises.

Example 2. **Clean Water**

The major problem throughout much of the Third World is the bacterial contamination of drinking water contamination of drinking water. This example was described in 1991: "We are now designing a hand pump for Haiti. It permits a 10-year-old kid to remove one and a half gallons of water per minute from a well 200 feet deep. Chlorine is being poured into the wells to kill bacteria and then pumped out. To prevent the pump quick wearing (because it is being used by 4000 people daily instead of 10 to 15 families), engineers are designing a modified water pump out of more durable welded-steel components. A motorcycle chain is hooked to the pump handle and connected to the drop rod. As it goes down, the chain wraps around it. This reduces jiggling. These water pumps are also being used in Ecuador, Guatemala, Peru, Lanka and Tunisia".

Example 3. **Solar Cooking**

In some countries, family members are collecting wood to cook a meal, spending the better part of a day. Look at the "curly cooker", so called because of its spiral shape, that has been sold to many missionaries. The rings are concentrating sunlight on a focal point. Here it is. An engineer is trying to simplify the design. The curly cooker is cut from a single piece of material laid atop. The diameter of the outermost spiral is four feet. Mounting points are indicated of expensive aluminium, cardboard with aluminium foil keeps material costs to about $2 per unit. In this photos you can see how easily cookers are being manufactured using handsaws, drills and scissors. And in that photo you can see how a cook is operating. He is adjusting a curly cooker so that the shadow of his hand is falling into the center of the reflector. All utensils are blackened to absorb the solar heat generated. But in Sudan cultural considerations blocked acceptance of the curly cooker. It was considered an ideal market for the cookers owing to the scarcity of fuel and the abundance of sunshine but cooking outdoors shows to neighbors what you are eating, and it is considered an encroachment on the privacy.

Age-old Properties, New Directions: Materials

The Matter

Engineers concerned with the design of various types of structures, machines and products have been selecting a material from a group of possible materials according to their properties which are controlled and modified.

That's why the engineering science has been developing for but the basics (solid, liquid, gas and plasma) remain the same physical states of matter. Solid matter has a definite volume and shape. The structure of a solid is determined by the arrangement in space of its molecules, atoms, ions which cannot moves freely but vibrate about a fixed position.

Fluid matter does not have a fixed shape. The basic property of liquids is its ability to flow along a channel or tube. In the gaseous state, a substance expands to fit the containing vessel. It has a fixed mass, but no fixed volume. The volume changes with temperature and pressure.

Physical properties include size, shape, smell, colour, solubility, melting point, boiling point.

Their constructions are usually subjected to internal and external forces and deformations (stresses and strains). Stress-strain properties of materials are very important because their high values result in the failure of a construction, damage to machines. The tensile mechanical properties for the elastic range represent the ability to resist loads and deformations and the capacity to absorb energy in the elastic range (elasticity, stiffness) resilience.

The tensile mechanical properties for the plastic range define the ability to resist loads and deformations and the capacity to absorb energy in the plastic range (plasticity, ductility, toughness).

Unique Knowledge about Ceramic Composites

The unique processes for growing ceramic – and metal-matrix components inside porous performs of ceramic reinforcement materials.

The high-performance properties of these composites are being tailored for use in many applications. The ceramics engineers have been designing materials of some specific properties. They have been engineering the properties of a ceramic composite – its strength, stiffness, thermal conductivity, coefficient of thermal expansion, wear and corrosion resistance to meet specific design needs and have been choosing processes for their production.

In one of the processes, ceramic composites are grown by way of an oxidation reaction that occurs between a molten metal and a surrounding gaseous reactant inside a porous perform of ceramic reinforcing materials.

In a common system, aluminium is the parent metal, air the oxidant, and aluminium oxide the reaction product. Molten metal is drawn continuously through its own oxidation product to sustain the growth process. The result is a ceramic-reinforced composite with a continuous interconnected ceramic reacting product matrix.

Lanxide Corp. (the USA) has been investigating the use of aluminium oxide (alumina) as a surface profectant for other materials since 1985. Materials engineer Newkirk states they have two processes, one for ceramics and the other for metals. The alloying constituents in the metal (magnesium and silicon) cause it to react with a surrounding vapor phase environment to grow a ceramic material in a directed fashion. When the reaction proceeds to the outer surface of the perform, it comes in contact with a gas-permeable barrier material (calcium sulphate) which is applied to the preform's surface prior to the reaction step, and locally terminates the reaction. The vapor-phase reactant penetrates to the perform void space. The process takes place at a relatively low temperature of 1000 °C (most advanced ceramics are processed at about 2000 °C).

Metal infiltration process is similar to the ceramic process thought it is much faster.

Among the applications are wear resistant components for the mining, chemical process, and electric power-generation industries, gas-turbine components for aerospace applications, electronic components of high thermal conductivity for radars, automotive applications (brake parts, rotors, exhausts).

Lanxide scientists have been working to develop more applications.

Modeling Physical Phenomena

In seeking to understand physical phenomena in complex mechanical or electronic systems, engineers can use empirical testing or model the phenomena on a computer Although each method is used for in a given situation, the unique advantages of computer modeling or simulation increasingly make it the method of choice.

When a design engineer first considers how to represent an object or process (referred to here as the problem), he or she begins with geometric modeling: the problem is thought of as a geometrical object that will change its shape with time or some other physics parameter. The engineer decides, on the basis of various requirements and constraints, whether to model the problem in two or three dimensions. A two-dimensional model represents a surface, which may be flat or curved, or a slice through the object. A three-dimensional model represents the volume of the object.

For either type of problem the engineer begins by dividing (discretizing) the object into many small cells (elements or zones) that are the basic units on which the computer operates. Special codes have been written to generate the lines (or mesh) that define the elements. The lines and intersection points (nodes) are important because they are associated with and behave according to instructions and parametric values specified by the engineer.

Models for Strained Ductile Materials Finite Element

The new finite element code can simulate in the shape and material properties during metal-forming processes.

The scientists and engineers have been improving ability to analyse strain in ductile metals since the advent of Finite Element Analysis. They have been simulating the changes that take place in the shape of a complex metal structure and material properties (elastoplasticity) under stress. They have also been modeling such changes within one specific part of a complex structure. They have been trying to model metal-forming processes (rolling, drawing, extrusion) used to change the size and shape and characterizes of metal.

The key to the improvement lies in rezoning (freezing a numerical calculation at a point of time and changing the finite element mesh to reflect the changes in geometry) whenever the finite element mesh becomes too distorted.

FEA: Choosing the Right Stiffness

Many finite element analysis programs use gap, or interface, elements to handle problems with contact surfaces.

Many structural problems can be related to contact surfaces and friction (bolted joints, electrical contacts, bearings). To address such contact problems, many developers of finite element software have included interface elements in their element libraries which simulate contact between two surfaces by generating contact forces when the two surfaces approach each other and by removing the contact forces when the two surfaces move away from each other.

For some years, AT&T Bell Laboratories have been developing the process of automation for calculating the stiffness of the gap elements and eliminating one possible way of introducing modeling mistakes. They have been defining a characteristic element length, width and depth as functions of the model dimensions and mesh parameters and calculating the characteristic stiffness of the solid elements to calculate the stiffness value for the gap elements.

PAST

Age-old Knowledge, New Promise of Plenty: History of Knowledge

A short overview of the history of technology is given.

The earliest men made tools of wood, stone and bone to make products (axes, knives, needles, spears). Then they began making agricultural tools, pottery for food storage and cooking, invented textiles to dress themselves and produced the first primitive machines. Before 3000 B.C. the smelting and casting of metals were discovered. Then people devised simple methods of calculation, discovered a remarkable accuracy in estimating the length of the year, the position of the sun and stars and took the first step in the creation of science by systematic observation and measurement.

The Greeks were the first to understand science as a body of knowledge logically deducible from a limited number of principles.

Then sciences began to separate more and more.

People were also obliged to experiment to find out by trying things out. The idea of scale came in. The scientific development is going on. Within the life span of one generation scientific discoveries and their application have transformed the world.

Science and technology are moving so fast that it is difficult to foresee all the applications and discoveries.

Knowledge has always been the ability to make true statements and to defend them as true. The statements have included empirical generalizations, hypothesis and theories which has been arising form direct observation or as part of systematic truth.

People observed phenomena (magnetism, mass atmospheric pressure, gravitation, electricity), investigating, exploring their nature and revealed previously unknown facts. There are basic laws or principles in mechanics that enable the skilled user to determine, for example, the manner in which a body would move or deform knowing the nature and distribution of forces acting on it and a knowledge of its given characteristics or predict what would happen and what processes could be used to improve the matter or construction.

The History of a Calculator

When Jack St. Clair Kilby decided to build the first hand-held electronic calculator at Texas Instruments in September 1965, there was no real precedent for the machine.

Logic design had to be invented, along with the outer case, keyboard, power supply and an output device. All had to be made affordable to be sold. Jerry D. Merryman, who was selected as the project manager, came up with the logic designs for the calculator in three days. James H. Van Tassel, who had been working on research and development of semi-conductor, also joined the team. Together they began working on the calculator in October 1965.

On September 29, 1967, the three got the patent for the first handheld calculator in the world. Although the machine did not go into actual production for three years, the prototype had been made.

The calculator's use of integrated circuits was different from anything that had been done before. The semiconductor array incorporated thousands of discrete devices. Modern arrays incorporate millions of devices. The packaging of the integrated circuit was a problem because they had 120 leads. In addition, the display was a bit of a problem. The engineers finally chose a thermal printer, which used relatively low power, as the output device. The machine could add, subtract, multiply as large as 12 digits. The machine's dimensions were about $4^{1/4}$ by $6^{1/8}$ by $3^{3/4}$ inches and it weighed about 45 ounces. The inventors were presented the ASME (the American Society of Mechanical Engineers) Medal in 1989 "for a great and unique act of an engineering nature of timely public benefit".

They could not foresee the status the calculator would hold today, they only wanted to show what they could do with integrated circuits.

Afloat on the Green Ball

Sometimes it can be instructive to see events or objects from a point of view other than our ordinary one.

The great American essayist Ralph Waldo Emerson knew this well: "The misery of man appears like childish petulance when we explore the steady provision that has been made for his support and delight on this green ball which floats him through the heavens". The image of our floating on a giant green ball was always an arresting one. Emerson created his poetical image of the Earth in 1836, well over a century before humans orbited their planet and saw what it looked like. He no doubt would have been interested to view the recent images from the French SPOT 2 satellite (1991). They show different attitudes to nature in the two eras. Emerson was quite positive of Nature's power to make "steady provision" for life on Earth. We are not sure because some resources are diminishing, air pollution in some cities partially masks the noonday sun, there are fires in the rainforest in Brazil and 470 mln U.S. gallons of intentionally spilled oil pollute the ocean.

Emerson understood that "nature is not always adorned in holiday attire". But he would be as shocked as we are at some of the costumes we have given it.

In January 1990, the advanced SPOT was sent into helio synchronous orbit to take pictures of Earth and provide them to lank-use planners, environmental specialists and engineers from all disciplines. It required 26 days to complete coverage of the entire Earth.

The heart of the SPOT system was two high-resolution imaging. Each telescope measured 2,5 m in length and weighed 250 kg. Whenever SPOT was in visible contact with one of its 12 ground stations, it transmitted imaging data at a rate of 24 mln bits per second. As a result of its low level orbit, the satellite was in contact with monitoring stations an average of only one hour per day.

Pictures taken by the satellite were as scientifically valuable as they were aesthetically pleasing.

Age-old Attempts: New Technologies

Shape-Memory Alloys

Alloys that change their shape in response to temperature changes are being made into fasteners, clamps and seals that offer low-temperature installation, accurate and predictable stress response, immunity to vibration, shock and wide operating temperature ranges.

Shape-memory alloys are a unique family of metals with the ability to change shape – and return to their original shape – depending on their temperature. This property is ideally suited for use as fasteners, seals, connectors and clamps. They include copper aluminium nickel, copper zinc aluminum, iron manganese silicon, nickel titanium. Depending on the allow and its processing, Tinel (family of nickel titanium alloys) can be deformed five to seven percent in tension, compression or shear. The engineers from Raychem Corp. showed properties of the materials during the workshop.

They were heating the material and showing the unique effect produced by a crystalline phase change known as a martensitic transformation. It was occurring over a range of temperatures, above which the material is in the austenitic phase and below which it is in the martensitic phase. The geometric shape of the material when austenitic is its memory shape. Martensitic was forming on cooling from austenite by a shear process. If stress was not applied to the material during cooling, its macroscopic shape was not changing. Then they were heating the deformed martensite through its transformation temperature range, and those present saw how it was reverting to austenite.

They explained that this cycle of cooling, deformation and shape recovery was the fundamental shape-memory process.

Smart Materials Take On New Shapes

A synthetic muscle-like material that expands and contracts in response to changes in temperature may prove useful in robotic grippers, thermally activated valves and switches, and medical implants.

"Smart" materials (synthetic or fabricated) alter their shape in response to changes in temperature or in the chemical situation of the environment surrounding them.

Now researchers from Alabama had developed a new biopolymer (bioelastic) mimicking the biological processes of living things. During some time they were testing it for a variety of applications. They were sending an electric current through shape-memory alloys that were embedded in the composites to make the material bend. The alloys were responding to heat generated by the current. Other-memory polymers alter their shape in response to changes in temperature. These plastics can be fabricated into one shape at a high temperature, then cooled and re-formed into another shape. The engineers noticed that when their temperatures were increasing again, they were being used in toys in Japan. The new material developed in Alabama is a synthetic muscle-like fiber that contracts and expands in response to temperature or chemical changes in its environment. The new fiber is modeled on elastin, a protein that is the basic constituent of elastic tissue found in the walls of arteries, skin and lungs and is composed of a polymer chain consisting of five amino acids.

Being elastic, biodegradable and nontoxic, the materials are ideal for use in sensors, robotic components, for grasping and releasing medical implants. Fabrication of Stealth bomber from lightweight, strong and stiff composite materials has led to improvements in composites manufacturing.

During the 80es carbon and glass fibers, epoxy-resin matrices, high temperature polyamides and other materials were creating for the plane. A variety of innovative production techniques were developing to shape, cut and fasten the strong lightweight composite structures. In October 1991 specialists stated that they had solved a lot of problems they had been facing from the start of the project concerning, for example, drilling holes and had improved the hole-making process.

A computer-controlled five-axis robotic system accurately drilled high-quality holes and installed fasteners. So far, they had installed more than 50,000 fasteners and had provided better chip evacuation.

Better Materials for Heat Exchangers

The designs that use corrosion resistant materials like plastics, graphite, borosilicate glass were opening up new applications in metals processing and energy recovery.

Heat exchanger technology were undergoing an important evolution. Spurred by today's volatile energy costs, new applications were emerging. For example, heat exchangers were being used to recover waste energy from boilers, a process that was helping factories and power plants reduce their energy expenses.

Exchangers were also seeing service in metal plating, steel pickling, and other chemical processes. They were also recovering heat from processes that produce corrosive flue gas, such as incinerating waste solvents. For these harsh applications, a number of manufacturers had begun making heat transfer tubes out of materials, such as plastics, graphite, and borosilicate glass, that have corrosion-resistance characteristics superior to those of conventional stainless steel and metal alloys.

A strong emphasis was also being placed on the development of methods for the nondestructive sealing of faulty tubes without having to take the exchanger apart. To extend the life of heat exchanger tubes in the presence of harsh process gases, manufacturers were turning to a number of corrosion-resistant materials other than stainless steel. For example, United McGill Corp. (Columbus, Ohio) used graphite or borosilicate glass for its condensing heat exchangers and condensing air heaters. Nonconducting materials were used in the heat exchangers designed by George Fischer Signet Inc. (Tustin, Calif.). For applications involving organic or inorganic acids and acid mixtures, the company fashioned its Calorplast immersion heat exchanger tubes from the corrosion-resistant plastic polyvinylidene fluoride (PVDF). For use with aqueous solutions of salts, nonoxidizing acids, alkalies, and a variety of solvents and detergents, the exchangers were made from polypropylene.

Age-old Desire to Improve the Environment: New Ideas

Putting a Lid on Noise Pollution

Active noise control has moved out of the laboratory to control noise pollution in the environment and the workplace. Environmental hazards to Man (smog, dust, exhausts, pollution, wastes, contamination, oil spills, greenhouse effect, noise, radiation) have become critical and that's why have become key problems for engineers of today.

Within the past decade, noise levels have been gradually increasing while government funding for these programs has decreased. Extensive research into noise cancellation technology has been conducted over the past 10 years, though most of the work has remained in the laboratory.

The concept of active noise control, whereby an interference sound wave is used to reduce the noise level at its source, has been around for over a century. Not until recently, however, with the advent of faster and cheaper microprocessors, has it been economically viable for companies to develop active noise control systems. Several companies are developing products that control noise in the environment and the workplace. They are developing an electronic muffler for cars, others are producing a number of noise reduction products and are also developing active systems that will reduce noise in the interior of vehicles and in aircraft passenger compartments.

Example 1. **Quieter Cars**

A loudspeaker is placed at the end of an automobile exhaust pipe. It picks up a synchronous signal from the engine and relays it to a digital signal processor. The processor calculates the acoustical waveform of the exhaust noise and creates an anti-noise that is 180 degrees out of phase. The antinoise has a mirror – image waveform that is released, via the loudspeaker, in exact opposition to the sound wave created by the exhaust. It results in a 50 % noise reduction.

Example 2. **Sounds of the City**

Audiologist William Clark is citing evidence from ancient Roman law when he says that noise has caused disruption to human activity throughout history. The laws 2000 years ago prevented chariots being driven at night on cobblestone streets. In the 21 st century, the annoyance factor is still a valuable parametre in controlling the disruptive qualities of sound.

An estimated 16.2 mln people in the USA have lately been exposed to an average noise level of 85 dBA over an eight hour day. The main sources of community noise have been motor vehicles, aircraft, rail, industry and building construction, in that order.

A modular precision sound level metre has recently been placed on a sidewalk two feet from the curb in New York. Over a five-minute period, the sound level metre registered a 92.2 dBA maximum sound level, a 70.8 dBA minimum sound level.

Ergonomics in Action

Ergonomics – the study of human capability and psychology in relation to the working environment operated by the worker.

Asarco copper refinery (the USA) was considered both the largest and most modern production in the world in early 80. It produced 99.99 percent pure refined copper. Silver, gold, platinum, palladium, tellurium, selenium and nickel could also be refined.

They stated in 1989:

"A number of safety measures have introduced at that time. The automatic system for the casting unit has recently been installed, Molten copper is poured into molds and cooled to produce shapes. Until 1987 the anodes were removed manually by operators. However, plant management was worried about the potential for employee injury because molten copper reaches temperatures of 2100 ° to 2200 °F.

Safely has also been improved in the refinery's continuous – cast copper operation. A team of process engineers have designed and installed a computerized process control system that monitored temperature, pressure, and other operating characteristics. The system has also incorporated fail-safe start-up controls and warning signals.

To avoid trauma injuries to workers, as well as potential damage to equipment, mechanical manipulators have substituted for human lifting.

Away from the plant floor, efforts to avoid injuries have been extended to computer operators and clerical personnel. Placement of some hand grips and levels has been changed and some job-specific physical and occupational therapy programs for injured workers have been developed.

The refinery is also working to improve environmental safety. Water from rain, snow or wind combined with metal by-products like copper oxides causing contamination of groundwater. Therefore a runoff ditch is dug around the perimeter of the 250 acre site.

Safety improvements have added ergonomics to Asarco image".

Age-old Measurement: New Ways

Hands-off Temperature Measurement

Accurate temperature measurement is of great importance in many industrial processes.

People understood very long ago that they had not only had to describe science but to measure parameters properties of thing and processes: length, width, depth, height, mass, weight, area, volume, density, speed, conductivity, temperature, resistivity.

Precision, approximation, correction, comparison, sufficient, deficient, required, adequate/inadequate, to increase, to decrease, to vary, to verify, to exceed are the words that describe quality that meet or do not meet the requirements.

Manufactures and engineers always stated that they had had problems when attempting to use a contact sensor to collect temperature data on a heated material: fragile materials that may be easily damaged, materials that may move too quickly for contact measurement, material surfaces that may be harsh enough to damage the sensor.

One of the experts described how they had applied noncontact heat-measurement instruments, known as radiation thermometers, in the goes. He told that they had measured the natural radiation being emitted from a heated object and had converted it into a corresponding temperature without contacting the surface. He added that earlier the radiometers typically had comprised mirror systems measuring four to six inches in diameter, usually made of polished Pyrex coated with gold or aluminum and had been very inconvenient devices incapable of maintaining their accuracy over extended periods of time.

Then he explained that miniaturization had made the electronics of the infrared radiation thermometers to as small as an inch square by three inches long so that they could fit into the detector head, the units had been designed for long-term accuracy and the cost of infrared filters and optics had also dropped dramatically. He also remarked that instead of gathering light across the entire spectrum as radiometers had done, radiation thermometers were designed to focus specific infrared wavelengths of the material being studied.

He said that in early goes they could detect temperatures as low as -50 °C to more than +3000 °C and were accurate within ±0,1 percent of the temperature scale they were measuring. Marine and railroad companies use the units to check temperatures in engines. The devices also come in handy for checking refrigerated cars for leaks during inspection, for measuring transformer temperatures. And, in general, they have won recognition in a growing number of industries from steel and glass production to the manufacture of semiconductor chips.

High-Accuracy Flow Measurement

The vortex flowmeter is carving out an important niche as a reliable and accurate measurement technology. As a result, they are seeing service in an increasing variety of process control applications in the semiconductor, paper and pulp, steel manufacturing, fuel, food, beverage and chemicals industries.

Vortex flowmeters are becoming especially popular as retrofits to flow systems. The key advantages of vortex flowmeters, a number of firms are producing, are accuracy and range-ability.

Vortex flowmeters are available for many different pipe sizes and are made with a variety of materials (stainless steel, carbon steel and plastic). They operate according to the same basic principle: they measure the frequency of a fluid's vorticity which is linearly proportional to its velocity. Vorticity is the spin induced in a fluid by shear. When a medium flows from the sharp edge of an element inserted in its path, it forms rolling-up vortices, which are then shed downstream, and flow velocity can be calculated from the vortex frequency.

Leo I'Connor from "Mechanical Engineering" journal told that one of the first meters that employed the vortex technique to measure flow rates had been introduced by Johnson Yokogawa Corp. (the USA). He noted that in early goes Yewlo meters had come with a stainless-steel or carbon-steel cylindrical body, in a variety of different diameters. The vortex shedder which had been a corrosion-resistant solid rod with a trapezoidal cross section, had been installed to span the diameter of the cylinder. The shedding element had extended into a section of the housing that had been formed at right angles to the cylinder's axis. During operation, a fluid had flown until it had reached the flat face of the shedder which had been positioned perpendicular to the path of the flowing medium. As the fluid had diverged around the outer corners of the shedder, vortices had begun to form the opposite sides at regular intervals 180 degrees out of phase with each other. For each vortex, a stress had been induced in the shedding bar. A sensor containing dual piezoelectric elements had been embedded in the vortex shedder in an area hermetically sealed from the fluid flow. They had sensed the individual forces induced by vortices and had converted them to electrical signals which had been passed on to an electronic transmitter for processing. An amplifier inside the transmitter had processed the electrical signals and had output the data to a digital display or an analog meter.

The meters are installed in power stations equipped with gas turbine generators. They are used to monitor the natural gas that powers the turbines, the steam that in created off the exhausts and the water that is injected into the turbines to improve their efficiency.

Pressure Measurement Instrumentation Calibration

Calibration of instrumentation appears to some to be a simple process and to others black magic.

The process is actually a separate technical discipline, well described in terms developed by metrology scientists.

Mechanical design engineers often become involved in system designs requiring pressure measurement instrumentation. Successful system design in these cases requires pressure measurements with specific accuracy and reliability over a wide range of conditions. Pressure transducers have tolerances on accuracy specifications such as environmental effects and aging. These tolerances indicate the level of performance in terms of accuracy, which the instrument was designed to produce. The actual output of a transducer depends on its calibration.

Steven Lonergan from Sentra Systems Inc. explained what more accurate and sophisticated pressure sensor technology is now challenging those he meant. This allows the designer to rely on more accurate measurements without the need for frequent recalibrations.

He told that once the data acquired from higher-accuracy transducers had been represented on an error plot recording the difference between the actual output of the transducer and its theoretical output at a given applied pressure on the vertical axis Calibration data graphed in this form quickly had demonstrated some fundamental test parameters and had represented errors in the output of the transducer. He explained that span error was the difference between the theoretical ratio of applied pressure to transducer output and the actual ratio, zero error was the initial offset of the output data from the theoretical output at the lowest applied pressure and hysteresis was the difference between two readings taken at a specific pressure, when the first reading was with increasing pressure and the second with decreasing. He then explained that they had met another class of potential errors related to the change of environmental conditions.

He also mentioned that high-volume manufactures had used highly efficient calibration and adjustment stations in their assembly process and to prevent unqualified adjustments many devices had been permanently sealed.

FUTURE

Age-old Technologies: New Views

Micro Machining Moves into High Gear

Researchers are looking ahead to mechanical systems on a chip. But turning miniature prototypes into successful production designs will be the biggest challenge in the future.

Micromechanical gears, valves, sensors are getting smaller, smarter and stronger. Today advanced structures are being developed for real-world applications. Engineers are now proving out these designs in automobile suspensions and brakes, instruments and robotics. At the same time, researchers are working hard to construct next-generation components and solve production problems.

In the future, experts predict, their work will lead to advanced micromachined systems. Such designs will consist of numerous sensors and other components machined on a single piece of silicon to form a complete system. "How would you design a mechanical device if instead of having half a dozen motors, you had a thousand of them?" experts asked.

Perhaps the first real-world application of a micromachined silicon gear is now taking shape in a nuclear weapon safety device. The micromachined "strong link", which uses a silicon gear 100 microns in diameter, may replace a 40-year old conventional device the size of a human fist.

The marriage of micromechanics and microelectronics will also lead to increasingly "intelligent" sensors. For example, they will monitor road conditions and a car's speed and load, and adjust the ride.

Researchers and manufacturers are going to see it used for many other things. They think it is an exciting area.

Thermoelectric Power Conversion in Space

The next generation of radioisotope thermoelectric generators will use a single chip incorporating many thermocouples.

Previous applications of thermoelectricity in power generation date back more than a century and a half to Seebeck, who showed in 1822 that a current is obtained when the junctions of dissimilar materials forming a thermocouple loop are maintained at different temperatures. Now it is known that the best materials to use for thermoelectric applications are semiconductors.

NASA's Solar Probe mission will have severe thermal environmental requirements for its instruments and power system. Its radioisotope thermoelectric generators will have to conform to the configurational requirements of this craft, which has a conical thermal shield to protect the spacecraft and its instruments from the sun. A radiatively heated multicouple for use in the next generation is under development. The major improvement of the multicouple will be the use of 20 individual couples within a single cell. Depending on the type of space mission, thermoelectric converters will take different configurations or have design differences. For example, the Voyagers completed the solar system exploration portion of their missions of their missions recently and have provided spectacular data on Jupiter, Saturn, Uranus, and Neptune and their associated moons. These spacecrafts have been powered for well over 10 years with predictable degradation of power. In addition, the Voyager interstellar mission will have sufficient power to last into the next century. The Galileo spacecraft will use two RTGs that provide a total of 570 Walts of electrical power. At Jupiter, it will split into an orbiter spacecraft and a probe which will take atmospheric and other measurements of Jupiter will allow until it is crushed. The orbiter will spend a few years mapping and photographing a significant number of Jupiter's moons.

Lunar and Martian Mannedbase applications will require large power stations to meet life support. Power stations in the multikilowalt and – megawalt categories will be needed to provide power for Various activities (oxygen production, recycling waste products, electrical production).

Thermoelectric conversion power systems will meet these needs. The reactor portion would probably be buried in the lunar soil to provide radioactivity exposure protection to base personnel.

Spaceplanes Get Ready for Takeoff

Teams in France, England and Germany are developing an impressive manned aircraft.

It will be able to reach hypersonic speeds of Mach 25 (Mach 1, the speed of sound, is 700 miles per hour). The spaceplane will have a broad range of applications. It will be capable of launching and retrieving satellites. As a passenger plane, it will reach the opposite side of the globe in one hour. Prototypes of such transports could be finished soon after the turn of the century. Work toward such a plane was begun in the 1960s, but was halted in favour of developing the Space Shuttle. In 1986, the project was revived. Currently the program in divided into three phases: feasibility studies, technology development, flight research and vehicle demonstration.

The preliminary configuration developed by the team has a wide body and small wings to provide lift; the wings also serve as control surfaces. The wide body provides a broad surface that can capture air and route it to the inlets for the plane's three engines. It is designed so that the maximum amount of hydrogen full can be carried. It will be between 150 and 200 feet long and its gross weight will be roughly 300,000 pounds. It will carry a two-man crew. The head of the project says they do not know what it is going to cast to go to phase 3 because what they are doing now is trying to fit it all together and optimize the configuration. The plane would be readied for an initial test flight in 1997 and a first orbital flight in 1997 and a first orbital flight in 1999. Later this year, a materials and structures development program is expected to be completed. The future of the project is unclear. The team is optimistic about building a successful hypersonic vehicle. But there is also a concern that sustaining funding may be as great a challenge as developing the technology. If they get cut, it will end as an academic exercise.

Part 2. MODALITY

Can be or Must be

Можливо чи необхідно!?

Study the texts and:

– explain what situations the underlined verb-forms show;

– explain how they are expressed in Ukrainian and Russian;

– read the text and tell what it is about in Ukrainian. If you fail to do it, turn to the text again and again until you can do it properly;

– now start translating it.

Age-old Energy Problem: New Resources and Applications

Energy can be defined as the capacity to do work, i.e. to move a force a certain distance. During all their history people showed that they could struggle for power: its main or alternative sources.

The first source of energy which the man could use was the energy of fire. During Paleolithic times, the man was able to use resources without conserving or replacing them and because his hunting techniques were highly efficient, large animals disappeared from regions where they could be hunted easily. But the man could change the basis of his economy and develop agriculture. That was the first "energy" crisis the man was able to overcome.

Faced with the shortage of manpower, the Romans could convert their mills to waterpower.

And twelve hundred years later a shortage of wood led to the conservation measures and, as a result, coal which was cheap and plentiful, was substituted as a power source. The superior thermal efficiency of the new full enabled factories to produce their wares in greater quantity at lower cost. Cheaper manufactures goods could then be used more extensively for construction of machinery. As coal came into general use, demand for it rose and it provoked the Industrial Revolution.

Throughout the 17th and 18th centuries scientists and inventors were trying to utilize the power of steam.

We cannot blame the ancient Greeks for failing to recognize that the force which causes a thunderstorm is the same which they observed when rubbing a piece of amber. And it was not only at the end of the 18th century when Volta could invent the first electric battery. And it was only in the last quarter of the 19th century that electricity began to play its part in modern civilization, and the man who could achieve more in this field of practical engineering was Thomas Alva Edison.

It is important to remember that electricity is only a means of distributing energy, of carrying it from the place it is produced to the places where it is used. A generator is no use at all unless it is rotated by a prime mover (the steam-turbine). The steam can be raised by coal, oil, natural gas or atomic energy – but it is the steam turbine or a diesel engine which drive the generators.

There is one source of energy which does not depend on the heat and light of the sun, nor can it be harnessed by a chemical process – the atomic energy.

Now we are beginning to use vast and almost inexhaustible source of energy – the solar energy.

If we compress man's history into one century, we can see that for 98 years man knew only two sources of energy (fire and animals), only two weeks ago man was able to use steam, a few days' time ago man was able to use atomic power.

What will man have then? Thermonuclear? The energy of "anti-matter"?

Another question is how to save, conserve energy.

The operation of any practical machine or mechanical process may involve dissipation of mechanical energy in the form of heat. The bearings can become warm during their operation, a nail can be warmed up by the blows of the hammer. Careful experiments in which mechanical work can be all converted into heat and the quantity of heat measured show that whenever a given amount of mechanical energy disappears, a fixed quantity of heat appears in its place (heat exchange). The relation between heat and work is numerically the same. This is in agreement with a general principle which is called the Conservation of Energy: energy can not be created or destroyed – what disappears in one form must reappear in another. It includes all forms of energy (mechanical, thermal, chemical, etc).

The Marriage of Gas Turbines and Coal

Developing gas turbine systems that have to use coal or a coal-based fuel ensures that the world will, obligatorily, have cost-effective and environmentally safe options for supplying future power generation needs.

Historically, most gas turbines must operate primarily on natural gas or coal-based fuels must lead to erosion of turbine blades, corrosion of metallic surfaces and high levels of ash, sulphur and nitrogen compound contamination.

In the direct– coal– fuel gas turbine, the fuel is either dry pulverized coal a coal-water slurry with a 50 % solid loading. The mean coal particle size is 5 to 40 microns. The air from the compressor is taken to the combustor; then the hot gases from the combustor are returned to the expander. Separators and filters have to be used to met environmental regulations and to protect the expander from erosion.

In the indirect coal-fired, gas turbine, the compressor air heated exchanger is sent to the expander. Thus only clean air is sent to the expander. This eliminates the need for high-temperature contamination control system which should protect the turbine.

The advanced coal-fueled gas turbine technology is the integrated gasification combined cycle which uses air-blown rather than oxygen-blown gasification, eliminating the cost of the oxygen plant.

Cogeneration: Fluidized-Bed Combustion

Fluidized beds have gained wide acceptance for steam generation, cogeneration of steam and electricity. They must increase plant efficiencies and reduce the cost of generating power.

FBC should be considered a useful technology for reducing oil and natural gas consumption. FBC-based systems should generate steam, heat and electric power from coal and other solid fuels of various qualities in an economical and environmentally acceptable manner.

The basic concept is as follows: a fluidized bed contains solid, granular particles supported by a plate. In a fluidized combustor, the solid bed materials are normally made of fuel (such as coal), an inert material (such as sand, stone, or ash) and a sorbent (such as limestone). A stream of air or gas passes through the plate and lest the solid particles. The air velocity must be great enough to counteract the gravitational forces on the particles, but not so great as to transport the whole bed out of the combustor with the air stream. Under these conditions, the bed of solid particles has to behave like a boiling fluid ("fluidized bed"). An important property of fluidized-bed combustors must be the comparatively large area of solid particle surface exposed to the gas. This contact is to facilitate gas/solid heat and mass transfer and coal is to burned at a significantly lower temperature (1500 °F as compared to 3000 °F for conventional units).

The second-generation FBC systems produce about half of their electric power from the steam turbine and half from the gas turbine.

More computer models ought to be developed that will help the fluidized-bed combustor designer in analyzing some of the complexities of these combustion systems if it is necessary when efficiency or necessary they need to corrections.

MHD Generators in Power Production

MHD power plants must offer significant improvements.

The magnetohydrodynamic (MHD) generator operates as a conventional rotating generator, except that a conducting gas, rather than a rotating metallic conductor, cuts the magnetic field.

The conducting gas is formed by providing combustion products at a high enough temperature that the outer electron possesses more than enough energy to free it from the attraction of the nucleus. Potassium must be used to ionize gas. As the ionized gas passes through the magnetic field, the electric field is generated that is perpendicular to the gas velocity and the direction of the magnetic field. If electrodes are added to the gas, current can be drawn, and thus power extracted.

The MHD generator produces direct current power. Inverters are used to produce the desired alternating current output.

The efficiency of the MHD generator is to be calculated on the First Law of Thermodynamics basis which explains that electrical losses (heating of the had due to current flow through the plasma) go into heating the gaas and do not cause a decrease in generator efficiency.

A typical commercial-size MHD generator would have efficiencies in the 80 to 90 percent range. This contrasts with 30 to 40 percent for a conventional power plant.

The MHD generator has only to be used when the gas temperature is high enough to sustain thermal ionization. For this reason, the concept of the MHD power plant has to include the steam plant to use the remainder of the energy in the gas after it leaves the MHD generator.

The first test program was to be completed by the end of 1993 and the commercial demonstration was to provide the data regarding the application of MHD technology in the future.

Thermal Energy Storage

Thermal energy storage could contribute significantly to meeting society's needs for more efficient, environmentally safe energy for building heating and cooling, space power applications.

Often energy is not used when, or where, or in the same form that is it naturally available. Thus there is a need for energy transmission, conversion and storage. It is possible to store energy in many forms: mechanical energy, as in kinetic energy stored in a rotating flywheel; gravitational potential energy, as in water stored behind a dam; chemical energy, as in a storage battery; elastic potential energy, as in a compressed spring; and thermal energy, as is taken up by a material when its temperature is increased. Perhaps the major utility of energy storage lies in its ability to couple an energy supply with a demand when the supply and demand vary independently over time.

It is convenient to picture a storage system as being functionally located between an energy supply and a load. Ideally, energy is stored during a charging period and released during a subsequent discharge period. These systems can provide a means for capture, storage and reuse of thermal energy that would otherwise be wasted or underused. Thermal energy storage must help in efficient use and provision of thermal energy, wherever there could be problems between energy generation and use. It is possible to name three types of thermal energy storage sensible heat, latent heat and thermochemical.

With sensible heat storage, energy is stored by changing the temperature of a material. The systems can employ water, rocks, earth, ceramic bricks as the thermal storage material and water, air, or possibly oil as the heat transfer media. For example, the high capacity of water often makes tanks of water a logical choice for TES systems that *may operate* in a temperature range needed for building heating and cooling.

In the case of latent heat storage, the storage material changes phase usually between solid and liquid. Thus, if the change in TES temperature includes the melting or freezing point of the storage material, the storage capacity may be greatly increased by the latent heat contribution.

Thermochemical energy storage must involve chemical reactions. Metal hydrides may be applied busing hydrogen as the working fluid and as a means of storing hydrogen at pressures substantially lower than the saturation pressure. Temperatures can be lower than for comparable sensible heat systems so that heat losses can be reduced. Thermochemical storage can be useful in energy transport applications.

There are many TES applications which differ tremendously in their storage capacity, expected thermal levels and charge/discharge periods.

Example 1. **Reducing Industrial Waste Heat**

Industrial production uses about a third of the total energy consumed in the United States, much of it as hydrocarbon fuels. Therefore, energy efficiency improvements in the industrial sector can have a substantial impact on national energy consumption levels. One option for improving industrial energy efficiency is TES. By storing and reusing energy that would otherwise be discharged in flue gas to the environment, less purchased fuel is used, plant thermal emissions are reduced, and product costs associated with fuel use are decreased. The following six industries have the highest potential for energy savings through implementation of TES: aluminum, brick and ceramic, cement, food processing, iron and steel, and paper and pulp. These industries represent approximately 80 percent of the total national industrial energy usage.

Example 2

The ability store thermal energy may be critical for effective use of solar energy in building. For building heating, conventional passive TES materials may include water, rocks, masonry, and concrete. To perform well, these storage materials must be massive because their allowable temperature swing is limited by comfort conditions that must be maintained inside the building. With lightweight building construction practices commonplace in the United States, a lightweight latent-heat TES system that is easily installed in a building would have an advantage. The obvious problem is one of effective and economic containment of the PCM in its liquid phase. Tubes, rods, and canisters containing PCMs that melt in the room temperature range have been studied with varying degrees of success; most have proved uneconomical. A more interesting approach is a wallboard containing a PCM. With the wallboard providing PCM containment as well as serving an architectural function, the economics are improved. Further, the large heat transfer area of the wallboard supports large heat fluxes driven by small temperature differences.

Example 3. **Sensible Heat Storage in Water**

Storage of sensible heat in water at first glance seems straightforward; one simply removes water from the bottom of the tank, heats it, and recirculates it to the top of the tank. In time, the entire tank volume will reach the inlet temperature. Yet if one wishes to charge the tank using a minimum amount of recirculation, or if one wants to keep the temperature of the water exiting the tank cold for as long as possible, a means of keeping the water stratified in the tank is needed. Several methods to accomplish this goal have been studied, including a battery of tanks, a flexible membrane fastened across the tank at midline, a series of weirs and baffles, and thermally induced (density) stratification. While the first three methods have been used with varying degrees of success, they are complex and take up extra space. Thermally induced stratification can be difficult to achieve in a chilled water storage system because the density difference between the supply and return water is small. However, research has determined that storage efficiencies greater than 90 percent can be achieved if TES design and operation are held within acceptable ranges defined by certain stratification parameters (Froude and Richardson numbers). Guidelines involving these stratification parameters are being used successfully to design both hot and chilled water storage tanks and have largely supplanted the use of baffles and membranes.

Electrical Power to Spare: Compressed Air Energy Storage

Surplus power is used to compress air and store it in a high-pressure underground geological formation, where it serves as a supply to help drive a gas turbine during periods when extra generating capacity is needed.

Electric equipment has often to be used beyond its base load requirements during peak-demand periods. The industry has been trying to develop economically feasible solutions to the problem. The initial approach has been to stress consumer conservation. However, it is difficult to get consumers to cooperate. The concept of compressed air energy storage may be an innovative solution which may meet peak-demand requirements. This method might use the power surplus during low – usage periods to compress air and store the high-pressure air in an underground geological formation for turning a gas turbine during peak demand periods.

The basic mechanical components of a simple generating plant are an air compressor, a turbine, a motor/generator unit. All of them are used for similar applications and are available.

The air compressor and turbine are each independently connected to the motor/generator. During peak periods the turbine produces power and during off-peak periods the air compressor charges up the air storage reservoir. It is supposed that during peak-load periods, the plant extracts compressed air from the storage reservoir and directs it to the turbine unit.

The first CAES plant, a 290-megawatt unit in Hanford, Germany, was placed into operation in 1978. The second 25-megawatt plant began operation in Sesta, Italy, in 1986. The places must have been by the availability of geological formations in the places that would accommodate the necessary air storage capacity. It is one of the crucial problems: it must either exist or have the potential for being mined.

It is possible to improve the design of future plants and their economy could be increased. It is likely that the method is appealing because it uses components that are tested and available.

The concept may be the answer that all have been looking for to meet peak in demands.

SUPPLEMENTARY TEXTS FOR TRANSLATION

Francis Moon: Coming to Terms with Chaos

An emphasis on the demonstrable is a hallmark of Francis Moon's work in the typically speculative world of chaos theory.

For 10 years, Moon and his colleagues and students at Cornell University's Sibley School of Mechanical and Aerospace Engineering have been investigating chaotic dynamics in the behavior of real mechanical systems. Professor of Theoretical and Applied Mechanics and director of the Sibley School, Moon began his studies by building and experimenting with a number of simple devices, such as a magnetic rotor with a single degree of freedom, that could be shown to generate chaotic vibrations. From these he progressed to more complicated structures – a lightweight robot arm, for example – in which the ability to characterize chaotic phenomena may have important applications in design.

A dynamical system can become chaotic if it has what mathematicians call "sensitive dependence on initial conditions". This means that no matter how precisely its initial state is defined, there is some irreducible uncertainty in the definition that grows exponentially with time until nothing at all can be said about the state of the system. Since 1963, when the meteorologist Edward Lorenz first demonstrated chaotic behavior in a simplified model of atmospheric air flow, the phenomenon has been noted in dozens of physical systems in chemistry, astronomy, and numerous other fields.

In mechanics and electromechanics, chaotic vibrations arise in systems possessing some strong nonlinearity. One of the simplest of the mechanical paradigms that Moon constructed to demonstrate the phenomenon was the vibrating buckled beam: compression loading causes a thin, elastic beam to deform; then, under periodic excitation, the beam is seen to oscillate, apparently at random, between the two equilibrium positions.

Chaotic vibrations can also arise in aeroelastic systems, magnetomechanical actuators, control systems with nonlinear elements, nonlinear circuits, and robotic manipulators under periodic control. Here, of course, the possibility of chaotic behavior has serious practical implications. An object that vibrates, such as an airplane in motion, will eventually succumb to materials fatigue. If the object behaves periodically, its failure can be predicted with reasonable accuracy and thus forestalled. .But if the vibrations are chaotic, prediction becomes impossible.

Moon seems to take as much delight in randomness and uncertainty as generations of scientists before him did in the predictable, clock-like universe described by Newton 300 years ago. The shelves of his office are filled with toys, which he coaxes into chaotic motion for the entertainment of visitors. And when he points out that the computer-generated images lining the walls represent real physical events, not just abstract equations, he does so with evident satisfaction. In a recent interview at Cornell, Moon expressed his views on the significance of chaos theory for engineering and explained some of the new mathematical concepts that are changing the way engineers study and measure nonlinear vibrations.

NASA and the Air Force want to build large structures in space, and they're worried about the dynamics. They're talking about taking them up in parts and having astronauts construct them in space. So they're likely to have flexible joints and pie possibility of nonlinearity.

Speaking more generally, I think chaos is a minor revolution in physics. Until about a dozen years ago, it was thought that Newtonian physics was dead. We thought the new frontier was quantum mechanics and nuclear physics. We assumed that everything there was to say about Newtonian dynamics had already been said. But chaos puts classical physics in a new light, because it turns out that we don't completely understand it after all. For both science and engineering, the recognition that many deterministic events in classical physics are not predictable has great implications. So the significance really lies in the unpredictability more than in the chaos itself. The message is that in nonlinear systems you can have more than one regular outcome, and you may not be able to predict which one it will be.

Industry Corporate Culture's Role in Attracting and Holding People

Relating culture to the bottom line

There is a very real likelihood that management's view of a company's culture is markedly different than the way employees see it. Upper level executives tend to see their companies in a more positive light than do line level employees – understandably. The view from the top may be very different from the way it looks down in the yard, on the deck of boat, mobile drilling rig, or platform.

Employees at lower levels are much closer to the day-to-day realities. They see the company from its underbelly, and what they see isn't always as pretty as top management's view. As a result, their attitude toward the company, jobs, and customers can suffer, along with corporate culture.

If you really want to know what's on your employees' minds, ask them. Conduct systematic research to find out what they're thinking and feeling. Systematic measurement means repetition over time. A single market research event provides a snapshot of attitudes and perceptions, but by repeating research at intervals of six months or a year over a period of several years, the data begins to reveal trends and patterns. Conducting ongoing research is especially important with regard to building a culture of loyal employees because the results don't necessarily show up in one quarter. Research gives management a foundation of fact-based knowledge for decision makers to build a strong corporate culture. It provides hard numbers that can be correlated to bottom-line performance. Research transforms corporate culture management from a black art into a scientific profit strategy.

A well-designed survey instrument can be a one-time investment, used over and over. The questionnaire can be self-administered, and ongoing costs are limited to tabulation and trends analysis. By analyzing the research over time, management can see what parts of a corporate culture development initiative are resonating with the employees, and which ones aren't. Scientific data measures not only the direction at the moment, but the speed, range of variance, rate of change, and probable future direction and speed. The single greatest weakness in virtually every corporate culture the authors have studied is that employees feel they don't know what's going on most of the time.

Be creative in the way information is delivered. Try unexpected and surprising ways to communicate. Hang posters in high-traffic employee areas. Make message frames for bathroom mirrors. Make company newsletters strategic and useful, instead of boring outdated puff that nobody reads. Use technology, where available – e-mail, satellite links, videocassettes, and the like.

Repeat yourself – tell them what you're going to tell them, tell them, then tell them what you told them. For a message to stick, it must be repeated with enough frequency to make an impression that will last. Once is never enough.

Be open – hush-hush secrecy tells employees they can't be trusted. It also divides the "Ins" from the "Outs", splitting the culture. When employees are taken into confidence, you make them partners in your vision, allies in your purpose.

Communication should be a two-way channel. Talk with employees, not at them. You can't learn anything about the culture with your mouth open and your ears closed. Examine criteria for selecting managers. Make sure you're picking the people who can lead. Make sure they have adequate training for the job. You can't expect someone who was a whiz with a wrench automatically to be a great foreman. More than likely, the person will simply behave with the same bad habits learned from previous supervisors. As a group, middle managers are more often than not a barrier that blocks your vision from reaching the lower levels of your organization. Your best intentions can't get past the department heads to touch the rank and file if your middle managers are incompetent.

Perhaps the most insidious of all cultural ills, favoritism breeds organizational incest, rewards "brown-nosers", and undermines quality. When you allow cliques to develop in a culture, you lose control of it. Cliques mean fragmentation into factions. Cultural unity is a threat to them. Promotions, raises, special favors, the best shifts, etc., should be awarded on merit, not on personal relationships. Rewards should be earned based on superior effort, not "who you know". A culture built on quality performance and dedication to the company owns a powerful advantage over a "good-ole-boy" establishment.

Tailor-Made Ceramic-Matrix Composites

Lanxide Corp. has developed unique processes in which ceramic– and metal-matrix composites are literally grown inside porous preforms of ceramic reinforcement materials. The high-performance properties of these composites are being tailored for use in many applications.

Now, a unique process developed by Lanxide is changing that. "With our Dimox directed metal oxidation process," Newkirk said", we can engineer the properties of a ceramic composite – its strength, stiffness, thermal conductivity, coefficient of thermal expansion, and wear and corrosion resistance – to meet specific design needs". The trick, he noted, lies in choosing the appropriate ceramic/reinforcement system and processing details.

Newkirk lifted a foot-long camshaft off the table. It had a metallic core surrounded by a matte-gray outer shell. "This camshaft is a prototype from a German diesel engine", he said. Piston engine designers, he explained, want to use the wear resistance and low-friction characteristics of ceramics in valve trains, but their low fracture toughness, high cost, and propensity to fail catastrophically make this difficult. "This camshaft has a silicon carbide-reinforced aluminum metal-matrix core covered with silicon carbide-reinforced aluminum oxide ceramic-matrix composite. Cams like this one have withstood 100,000 cycles in a test engine; the composite metal core prevents catastrophic failure, while the ceramic composite shell gives you stiffness and wear resistance. It's approximately 55 percent lighter than a steel camshaft, and we can produce it cost effectively. The main reason we can make this type of hybrid component is that our technology allows us to match the thermal coefficients of expansion of both materials.

"That kind of capability is especially significant", he continued, "because almost any technological system you can name today has been engineered to within a short distance of the ultimate potential of the materials from which they've been built. And as global competition accelerates, people are starting to realize that the next major increment of product improvement will not arise from a mere design change with traditional materials, but from totally new materials". In his spare time, Newkirk serves as chairman of the U.S. Advanced Ceramics Association and as a member of the U.S. Council on Competitiveness.

In the remarkably simple Dimox process, ceramic composites are grown by way of an oxidation reaction that occurs between a molten metal and a surrounding gaseous reactant inside a porous preform of ceramic reinforcing materials. In a common system, aluminum is the parent metal, air the oxidant, and aluminum oxide the reaction product. Capillary action draws molten metal continuously through its own oxidation product to sustain the growth process. The result is a ceramic-reinforced composite with a continuous interconnected ceramic reaction product matrix, also typically containing 5 to 15 percent residual aluminum. Parts are limited in size only by the equipment, not by the basic processes, which can be readily scaled up. The technology is generic. It applies to a wide variety of molten metals, vapor-phase oxidants, and reinforcing materials.

A similar process for fabricating metal-matrix composites reinforced with ceramic fillers was developed by Lanxide researchers in 1985. The technique, known as the Primcx pressureless metal infiltration process, involves essentially the same initial setup but the molten metal that infiltrates the ceramic preform is not oxidized into a ceramic; it solidifies. Due to the market's demand for lightweight high-performance materials, the firm fabricates primarily silicon carbide or aluminum oxide-reinforced aluminum alloys with the metal-matrix process. Besides aluminum, Lanxide researchers are investigating metal-matrix composites based on copper (bronze), titanium, intermetallic compounds, and iron.

New Sealant Formulations Hold Their Own

Advanced products and processes taking shape include hot-melt urethanes and silicones to create formed-in-place automotive gaskets, nonhardening sealants that help to absorb vibration, and polyurethane laminates to protect bottled liquids from contamination.

Few materials are called upon to fulfill the wide variety of tasks handled by industrial sealants. Some must be inert enough to protect medicines or analytical samples from contamination, others rugged and heat-resistant enough to hold ingot molds together during the steel-making process. Some sealing agents harden within minutes of exposure to the air, while others remain pliable for years.

Today, sealants are being employed in an ever-widening array of uses, from high-pressure applications, such as steam turbine joints where extremely tight seals are required, to construction, where sealants must be flexible enough to permit a building to sway in strong winds. Recent advances are taking sealants into new territory. New formulations are being developed that combine the strengths of curable sealants with hot-melt adhesives. Researchers have even developed materials that can create a seal between different materials without the need for a separate bonding agent such as silicone.

A leading-edge application is the use of sealants as formed-in-place gaskets that can replace die-cut parts. One such sealant was recently developed by Norton Performance Plastics. Dynafoam was introduced in the United States last year, following its successful European debut in 1988. This curable thermoplastic elastomer creates the formed-in-place gaskets that are formed by pouring the sealant into the desired shape.

The material replaces die-cut gaskets used in automobiles to, for example, seal taillight assemblies. Dynafoam is also seeing service as a gasket around sunroofs, sealing out moisture, wind, and dust.

In addition to providing a less expensive alternative to die-cut parts, Dynafoam was designed to fill a niche between traditional hot-melt adhesives and gaskets, such as butyl rubbers or ethyl vinyl acetates, and curable silicone and urethane sealants. One difficulty when using butyl as a hot-melt material is its vulnerability to high temperatures – butyl softens at temperatures above about 160 °F. A car parked in the sun with the windows closed can easily get that hot, causing the butyl seal to weaken or fail.

Another drawback for a hot-melt butyl sealant is the tendency of its typical formulation to react with other chemicals, such as gasoline in automotive applications or cleaning solutions in appliances. Substituting curable urethanes or silicones for hot melts solves the temperature problems, because these materials can be formulated to have performance ranges beyond 250 ° and 400 °F, respectively. In addition, urethanes and silicones are typically more chemically resistant than butyl. However, the cure rate for these substitute sealants suffers by comparison. "You are doing well with silicones or urethanes if they cure in an hour, as opposed to a minute or less, which is typical for hot-melt cure rates", said Norton Performance Plastics marketing manager Samuel Sher.

Dynafoam will cure within a few minutes of its application and resists softening up to temperatures of 280 °F continuous exposure and 400 °F for periods of an hour or less. These heat-resistance properties are more than adequate for automotive gasket applications. Dynafoam also has good resistance to damage from exposure to chemicals.

Dynafoam can be applied vertically, unlike most other materials, which have a tendency to creep downward. In addition, the way in which Dynafoam cures enhances its compression recovery properties; that is, it returns smoothly to its shape after being squeezed between two surfaces.

A major advantage of Dynafoam is that it can be applied by robots, reducing labor costs and time. In operation, the container of Dynafoam is hooked up to a hot-melt pump where a heated platen, or lid, melts the top layer of Dynafoam to 180 °F. The sealant is then pumped through a hose that is also heated to 180 °F, Dynafoam is mixed under pressure with a dry gas, usually nitrogen, and pumped through a heated hose and nozzle. When the sealant leaves the nozzle it immediately expands to bead size as the nitrogen in the Dynafoam expands.

Starburst Polymers

Because the properties of these concentrically layered polymer nanostructures can be precisely controlled, esigners believe they will be able to create better coatings, adhesives, and lubricants and stronger composite reinforcing materials.

University researchers are developing a new family of polymers that will make possible the design and introduction of novel products with unique properties in the 1990s – new reinforcements for composites, novel coatings, adhesives, lubricants, nonlinear fiber-optic devices, conductive plastics, and drug-delivery systems.

These new materials, called Starburst polymers or dendrimers, are a new family of three-dimensional spherical or rod-shaped structures, ranging up to about 500 angstroms in diameter, roughly the size of proteins and enzymes. They have hollow interiors and densely packed surfaces. What makes the materials radically different is that researchers can control their size, shape, molecular weight, topology, and surface chemistry to a greater degree than is possible with conventional (linear) polymers. The ability to precisely control the production of materials enables designers to create products with the best properties for specific applications.

The new polymers have ramifications for product designers and engineers. The traditional laws of friction, stress, and fatigue are not the same on the nanometer scale as they are in conventional macroscopic materials. The challenge facing engineers and product designers will be not only to communicate their needs to chemists, but to understand what the limits and constraints of materials synthesis are – which properties can and cannot be engineered into such advanced materials as dendrimers. Instead of thinking in terms of foot-pounds of energy to stress or test a part, the engineer will have to measure at the angstrom level to test a part's strength. For example, if an engineer wants to solve a tribological problem, he or she will have to become familiar with dendrimer chemistry to determine how to apply a coating and the quantity needed.

Chemists are working on applications in composite reinforcement, coatings, adhesives, lubrication, fiber optics, and pharmaceuticals.

Starburst dendrimers grow in the same way branches on a tree grow outward from the trunk. The dendrimers have precise branch-like architectures that grow outward from a central initiator core when synthesized. The polymers grow in concentric layers. After several layers, also known as generations, as the branches grow outward their surfaces become densely packed. At the same time, their interiors remain hollow. Unlike conventional polymers that are long and thin like strings of spaghetti, dendrimers resemble marbles. As one would expect, marbles behave differently than spaghetti, and scientists expect that these behavioral differences will lead to novel properties. Because dendrimers circle outward from a core, these materials are not susceptible to changes in their structure and properties.

Dendrimer-based composites should find use in a number of applications, ranging from aerospace and automotive parts to components in appliances and business equipment. In addition, polymer-matrix composites are inherently nonconductive, making them ideal for components that require electrical insulation. High-strength dendrimer composites also may be used in polymer concrete, prefabricated housing, doors, and windows.

Dendrimer-based coatings could lead to the development of new paints with improved mechanical properties. There will be tribological implications. Dendrimers will improve the bonding capability of coatings and their barrier properties, in turn giving added protection and wear resistance to such components as bearings, drill bits, and a variety of machinery parts. Dendrimers also mimic latexes but are an order of magnitude smaller and are more compact, offering improved barrier properties.

The Battle to Build Better Products

Multidisciplinary product development teams that bring together engineers, designers, and marketeers are moving new products from concept to delivery quickly and efficiently by thinking creatively, working collabora-tively, and coordinating concurrent design efforts.

When the management of Chicago-based furniture maker, Allsteel Corp., decided to bring out a new line of office furniture that was price-competitive and suited to high-volume production, it retained David Kelley Design, a product design and engineering consulting firm in Palo Alto, Calif., to develop a key component of the line's office chair: the chair-back tilt mechanism.

Traditional chair recline mechanisms consisted of a coil spring enclosing a shaft and a spring tension knob mounted in a weldment, explained company president David Kelley. Allsteel's requirement was for a simpler and less-costly device that would provide the same level of quality and reliability.

As is standard practice at Kelley's firm, a multidisciplinary product development team of specialists from the company and the consulting group – including mechanical and manufacturing engineers, marketing experts, and industrial designers – was assembled to study and confer on the problem.

"Our designers' proposal was to use an integral elastomeric spring/knob rather than the traditional coil spring/tension adjusting knob combination", Kelley recalled. "At first, the representative of Allsteel's manufacturing department resisted this idea. Because the elastomer spring concept was unfamiliar, untried, and would require relatively high upfront tooling costs, he was concerned despite preliminary indications that the mechanism would meet the specs and the desired production volumes would justify the investment. But our industrial designer and marketing specialist were just as convinced that this new feature was crucial to the success of the product".

These conflicting concerns resulted in something of an impasse. "Finally, the design project leader – an engineer – got the head of Allsteel's manufacturing department into a meeting to discuss the issue", Kelley said. The manufacturing manager was empowered to make such a decision while his deputy was not. "The team leader explained the rationale for the new design, and after some time managed to convince the manufacturing head of its feasibility and worth", he said. "In fact, once he understood the benefits of the new concept, the manager became quite enthusiastic about it. The point is, after the manufacturing manager had bought into the concept and understood why the other specialists believed it was worthwhile for his people to go through the extra pain to build the new mechanism, the project was relatively smooth sailing from then onward".

According to Kelley, who is also an associate professor of engineering at Stanford University, "close communication right from the start helps departments with contradictory goals understand each other's concerns". Team members understand each other's goals, which inspires greater cooperation among them. "It also generates a larger number and wider diversity of ideas," he added.

"A lot of what you're doing in these project teams is confidence building", Kelley said. Being exposed to strong viewpoints from experts in different disciplines helps inspire team members. "The key, especially for the project leader or coordinator, is to understand enough of what the various specialists do to be able to speak their language. I know that sounds like training to be a diplomat, but that's really what's required.

"Our firm and others like it force interaction among the specialties", Kelley continued. "We have done a couple of hundred products by now, so we can say, 'from our experience, it's best to do it like this.' Company managers today realize they have a problem in product development and that their companies have to do better. In recent years, they have become more open to our suggestions. In addition, the most progressive companies are starting to internalize these lessons".

Ceramic-metal Composites: Bulletproof Strength

A family of hard, lightweight, and tough ceramic-metal materials developed for military armor is starting to find commercial and industrial application as researchers pursue practical high-volume processing routes.

Boron carbide is the third hardest material known to man. It's also lightweight, extremely stiff, and less expensive than diamonds and cubic boron nitride – the leading entries on the hardness scale. So it's not surprising that weapons engineers would want to make armor from it. But boron carbide has the weakness common to all hard covalent ceramics: it is quite brittle, making even slightly flawed components fracture relatively easily when stressed.

In the early 1980s, a trio of materials researchers at the University of California at Los Angeles, Ilhan A. Aksay, Danny C. Halverson, and Aleksander J. Pyzik, made great strides in understanding how ductile aluminum could be combined with brittle boron carbide to boost the latter's low fracture toughness. Their research project was funded by the Defense Advanced Research Projects Agency or DARPA (Washington) and administered by the Lightweight Armor Program at Lawrence Livermore National Laboratory (Livermore, Calif). The project's goal: to produce a low-mass, low-cost, high-performance armor material for military vehicles.

After several years of continued development, that fundamental research has yielded a charcoal-gray ceramic-metal composite – or cermet – stronger for its weight than steel, somewhat less dense than aluminum, and several times more resistant to fracture than conventional structural ceramics. More accurately, the work has resulted in a family of composites ranging from 50 to 85 percent boron carbide that can be tailored by processing and, later, heat treatment for desired mechanical and physical properties. For example, the higher the aluminum content, the greater the composite's fracture toughness.

Substantial further study at Liver-more, the University of Washington (Seattle), and The Dow Chemical Co. (Midland, Mich.) has produced several practical and presumably economic manufacturing techniques for the cermet, which generally contains less than 50 percent by volume metal phase. In two of these processing procedures, molten aluminum is infiltrated into sintered porous "sponges" of boron carbide or into boron carbide powder compacts at temperatures below 1200 °C and then heat-treated at lower temperatures to achieve desired properties. The fabrication procedures differ in that one employs temperatures above 2000 °C to form the boron carbide sponge, while in the other, chemical treatment of the powder compact is followed by a low-temperature aluminum infiltration step. Another technique rapidly consolidates aluminum and carbide powders with high impulse pressures and the heat that those pressures generate. In the most recent work, a procedure has been developed in which sandwiches of thin boron carbide-polymer tapes and aluminum foil are layed up like carbon fiber composites into laminated architectures whose design was suggested by the study of anomalously tough, layered microstruc-tures found in certain shellfish.

Though little can be stated about the U.S. Defense Department's classified research on armor performance, the cermet is said to have successfully withstood multiple hits from projectiles in firing tests, proving the material's ability to take the intense shock of ballistic impact. Efforts to perfect the tank armor are reportedly continuing.

Among the proposed uses: lightweight police body armor; low-inertia, dimensionally stable, and low-vibration rotating components for computer hard-disk drives; long-life bearings, races, and other wear parts; premium-performance sporting goods; high efficiency, electron-emission devices; cutting tools for hard-to-machine, silicon-aluminum alloys; and nuclear shielding (boron carbide is an excellent neutron absorber).

Resource Recovery: Turning Waste Into Waste

Each week, the mid-Connecticut resource recovery facility shreds and separates 12,000 tons of garbage to recover combustible fuel that fires an electric power plant.

At the Mid-Connecticut Resource Recovery facility, waste is processed to produce refuse-derived fuel (RDF), which is burned in boilers to produce steam that is used to generate electrical energy. The waste-processing portion of the facility has a nominal capacity of 2000 tons of acceptable waste per day with a guaranteed capacity of 12,000 tons per week.

The facility uses a municipal solid waste (MSW) processing scheme that prepares waste for combustion by removing noncombustible materials such as dirt, metals, and glass and then sizing the fuel for improved combustion. The MSW processing system has five main components: inspection/picking ahead of processing; flail shredding; magnetic separation; screening; and secondary shredding. The facility has two parallel identical processing lines, each with a nominal capacity rating of 100 tons per hour. Weighed incoming trucks are directed to the MSW receiving area where acceptable waste is discharged onto the receiving building tipping floor. Once on the tipping floor, large wheeled bucket loaders are used to stockpile material in quantities up to 20 feet high and to feed the process lines. This initial waste handling provides an early opportunity for the loader operators to spot and remove nonprocessible, bulky, and hazardous material.

After inspection and sorting on the receiving floor, the first and most important step in processing MSW is metering the waste onto the process line at a closely controlled rate. To accomplish this, bucket loaders are used to remove material from the stockpile and load it onto the horizontal feed conveyor at the beginning of the process line.

Three conveyors are used to progressively reduce the material depth so that the waste can be visually inspected for nonprocessible items. The material is then conveyed past a picking station booth where an operator again inspects the waste and removes nonprocessible items.

The synthetic diamonds were first made by GE in 1987 using a combination of the two principal diamond-synthesis techniques – the costly high-pressure method by which industrial diamonds are grown in huge presses (developed by GE researchers in 1955 and perfected for gemstones in 1970) and the inexpensive low-pressure chemical vapor deposition (CVD) route to make polycrystalline diamond films from hydrocarbon plasmas (pioneered by American and Soviet scientists in the early 1960s and further developed by Japanese researchers in the early 1980s).

Though scientists do not know why isotopic purity should produce markedly higher thermal-conductivity properties than current solid-state theories postulate, electronic device engineers are busy dreaming up uses for the new diamond.

For example, computer designers are eager to exploit their development as heat sinks for microelectronic devices. "The single biggest problem in solid-state electronics is the inability to carry unwanted heat away before it can do damage", Robb noted. Natural diamonds are now used widely in high-end computer products to dissipate heat from small high-power semiconductors. For heat-sink applications, the crystallized carbon is sliced up lengthwise into thin slabs that can be attached to microchips. One of the initial applications for the new diamond will be high-thermal fluence heat sinks for microelectronics used in difficult-to-service situations: signal boosters (repeaters) on undersea fiber-optic communications cables, down-well sensors for monitoring oil drilling and recovery operations, and miniaturized electronics in space satellites. Heat sink applications of this type can now cost $20,000 to $30,000 per carat. Later, improved diamond heat sinks may enable microchip designers to pack circuit chips tighter without danger of overheating.

The new material may also make it feasible to use shorter-wavelength, lower-efficiency lasers to do higher-scale (finer) circuit lithography on semiconductor wafers than is currently possible. Improved heat sinks could better remove unwanted heat generated by short-wavelength lasers – a major limitation to their use. The enhanced transparency to light may also lead to improved mirrors and windows for higher-efficiency laser cutting devices and more accurate laser gaging and ranging systems.

Design Errors and Their Consequences

Designers often fail to anticipate all possible uses – and misuses – of their products. The results are sometimes disastrous. These case studies uncover the unforeseen perils of a staircase, running treadmill, auto wrecker, punch press, and telescoping boom.

As well intentioned as designers may be, they are susceptible to the attractive but self-deluding assumption that the people who use their creations will do so only in ways that the designer has anticipated. The designer must consider the strong probability, however, that users will apply their own ingenuity to find what they consider the "best" way to use a product. All such foreseeable uses, misuses, and abuses must be taken into account, and the predictable hazards they represent must be designed out, guarded out, or – if all else fails – warned out of the final design of a product.

The following examples explore the unfortunate results of the frequent neglect of the fact that these products were going to be used by mere humans, as well as a lack of attention to the mechanical details of a design. The key words in all cases are "foreseeable use".

Spiral stairways are frequently installed in situations where access between adjacent floors is desired but there is very limited space available. The prefabricated spiral stairway can be a very economical solution to this architectural problem, and is used in offices, residences, and commercial buildings. There are building code requirements that specify the minimum widths of the stair treads at a prescribed radius, the height of rise between steps, and the headroom to be provided. A foreseeable factor they don't consider is the manner in which people hold their bodies when going up or down a flight of stairs.

In the ascending mode, the body is tilted forward so that the center of gravity of the trunk lines up with the knee and the ball of the foot on the next higher tread. The head is usually erect to permit the eyes to focus on the edges of the steps coming up. When a person is climbing a spiral stairway, one hand is normally on the handrail and the centerline of the body is about 12 in. in from the edge of the stair treads.

When descending a spiral stairway, the body is also tilted forward. However, the head is not erect, but is bowed downward to permit the eyes to focus on the next lower tread. This tends to shorten the overall height of the individual, but not as much as the height of a riser (step), which can be as high as 9? in. This factor becomes critical at the step where the edge of the stair tread lines up vertically with the edge of the ceiling opening. Going up, the erect head position will pass under the required 6 ft, 6 in overhead clearance without interference. But coming down, the clearance is effectively reduced by the height of one riser since the body is on the higher of the two treads with the head thrust forward. Interference is possible for anyone with a descending height of 5 ft, 9 in or more. Such a person will have to duck in order to clear the overhead structure. This human factor is not addressed in the code requirements.

The consequences of this oversight were brought home with a bang when a secretary in a medical office was taking some papers from the lower to the upper floor She had climbed up to the critical step where the treads came out from under the overhead structure when she remembered she had forgotten something She turned around on the critical step and began to descend, but with her mind on something else, she forgot to duck Her head struck the bare steel structural supports for the upper level landing She was momentarily dazed, lost her balance, fell down the remaining steps, and suffered a concussion It was foreseeable that someone would forget to duck, and the hazard resulting from this real possibility was not designed out of this product.

Are Wired Wall Composites the Way of the Future for Tubulars?

In the future wired tubulars will be the rule rather than the exception. As extended reach drilling and extended tiebacks become more common, the advantages of sending a direct signal, or power through tubulars will become very attractive.

Composites in the drilling industry have made huge progress in recent years, driven by deepwater exploration and production. Riser joints, flowlines, and line pipe made of these materials are stronger and lighter than steel and otter the advantage of resisting corrosion. This means they are a cost competitor to 13 % chromium steel currently used in corrosive environments. Beyond these advantages fiber composite tubulars can be spooled and are practically weightless compared will steel.

Conoco first took an interest in the process, but Halliburton has plans for applications of these materials that take the technology a step further. First, the company looked at constructing immense lengths of carbon fiber composite tubulars. Halliburton took a position in what it says is an industry leader, Fiberspar, and began constructing 21,000-ft continuous lengths of the tubulars. These are the longest length of 2 7/8-inch pipe ever made. Fiberspar and Halliburton jointly developed the process over the last two years as part of the Anaconda drilling system.

Composite tubulars are constructed in two sections. There is an internal core made of plastic, which seals in liquids and pressure. This is surrounded by an outer carbon fiber layer that provides the strength. This outer layer is composed of carbon fibers, similar to a yarn, and polymers.

The thermoplastic core is extruded, then the outer layer is woven onto it. For short joints, this weaving is a complex operation, but tor 21,000-ft lengths, it is a major undertaking. Rao said the technology used to build these tubulars is more akin to textile work than fabrication.

The lengths of thermoplastic tubulars are wound onto two facing spools, one at each end of a 450-11 long bay. The weaving and curing of the fibers begins on one end of the tubular. As the fibers are woven onto the tubular it advances into the curing ovens, then onto the other spool. As one spool unwinds the other takes up the completed tubular.

APPENDIX 1

Grammar Charts

TIME LINE

Past	Present	Future
in the past	at present	in the future
recently so far lately up to now not … yet already	now currently at the moment	in the near future
last morning last afternoon last night	this morning this afternoon tonight	next morning next afternoon next night
the day before yesterday yesterday	today	tomorrow the day after tomorrow
last week last month last year last decade last century last millennium	this week this month this year this decade this century this millennium	next week next month next year next decade next century next millennium
once then formerly ago previously long ago	from … and now since … and now	in two days by the end of (the month)

Time When?	Time How?			
	Simple	**Progressive**	**Perfect**	**Perfe**
Present	I, we, you, they *study* He, she *studies* **Do? Does?**	I ***am** studying* He, she ***is** studying* We, you, they ***are** studying*	I, we, you, they ***have** studied* He, she ***has** studied*	I, we, yc ***been** stu* He, she, *studying*
	always usually often sometimes seldom occasionally never every day (week, month, year)	now still currently at the moment	this week already just recently lately	**from** 2] **since** 2 (**for** 2 ho
Past	**Did?** I, he, she, it, we, you, they *studied*	I, he, she ***was** studying* We, you, they ***were** studying*	I, he, she, we, you, they ***had** studied*	I, he, sh they ***ha***
	yesterday last week the day before … ago	yesterday **at** 4 p.m., when we came, they …	**by** some time in the past	**for** som
Future	***will** study*	***will** be studying*	***will** have done*	***will** hav*
	next week tomorrow in 2 hours	**at** 4 p.m. tomorrow	**by** the end of the week	**for** som future

Time When?	Time How?			
	Simple	**Progressive**	**Perfect**	**Per**
Present	1) permanent situations; 2) routines and frequencies; 3) scientific facts; 4) programs and timetables (always, usually, sometimes…).	1) action at the moment of speaking; 2) current projects; 3) slow changes; 4) temporary situations (now, currently, at the moment).	1) a present situation which is a result of smth that happened at an unspecified time in the past; 2) an action that has taken place very recently (just, recently, already, not … yet); 3) for since.	1) a star the hap
Past	1) completed actions in the past at a definite time; 2) actions whose time is not given but which occupied a period of time now terminated.	1) an action or activity that was in progress at a particular moment of time in the past; 2) an action or activity that was in progress, and which was interrupted by another action.	1) a completed action that happened before other event in the past.	1) a beg tim the con tim
Future	1) an action that expresses the speaker's opinions about the future (prediction); 1) habitual actions in the future; 2) decision at the moment of speaking.	1) an action that will be in progress at a particular moment of time in the future; 2) an action that expresses a future without intention.	1) a completed action that will happen by some moment of time in the future.	1) a beg con futu

THE PRESENT

Time	Tense		
	Simple	**Progressive**	**Perfect progressive**
Present	I, we, you, they *study* He, she *studies* **Do? Does?**	I ***am*** *studying* He, she ***is*** *studying* We, you, they ***are*** *studying*	I, we, you, they ***have been*** *studying* He, she, it ***has been*** *studying*
	always, usually, often, sometimes, seldom, occasionally, never, every day (week, month, year)	now, still, currently, at the moment	from 2 p.m., since 2 o'clock,for 2 hours

THE PAST

Time	Tense			
	Simple	**Progressive**	**Perfect**	**Perfect progressive**
Past	I, we, you, they, he, she, it *studied* **Did?**	I, he, she ***was*** *studying* We, you, they ***were*** *studying*	I, he, she, we, you, they ***had*** *studied*	I, he, she, we, they, it ***had been*** *studying*
	yesterday, the day before, last week … ago	yesterday at 4, when we came	by some time in the past	for some time in the past

THE FUTURE

Time	Tense			
	will	**be going to**	**Present Progressive**	**Present Simple**
Future	1) prediction: Tomorrow will be warm; 2) I think, I guess; 3) polite requests Will you stay in this evening? 4) decision at the moment of speaking	1) is going to happen; 2) plans, decisions, firm intentions have decided but not arranged; 3) polite requests Are you going to stay in this evening? (pressing for a decision)	1) personal arrangements, fixed plans (time, date, place) have decided and arranged; 2) prediction Look out! We're going to crash	1) timetables, routines, schedules, programs; 2) to give or ask for instructions Where do I pay?

Time	Tense			
	Future Progressive	**Future Perfect**	**I am to**	**shall**
Future	1) smth will be going on at a certain time in the future; 2) polite enquiries Will you be doing it this afternoon?	1) smth will have been completed by certain time in the future: How long you have been learning English?	1) smth is to happen (official plans, fixed personal arrangements). They have to come at 10 p.m.	1) asking for smb's opinion: Shall I open the window?

Modality

Modal meaning	English equivalents	Ukrainian equivalents
absolute obligation, a very strong opinion	must	має бути зроблено обов'язково необхідність, обов'язок, впевненість
necessity obligation	have to	маю, змучений, доведеться, мусимо зробити, треба необхідність, обов'язковість дії, зумовлене обставинами
prearranged necessity	be to	треба, необхідно наказ, інструкція, необхідність, яка обумовлена порядком, розкладом, планом
advice obligation	should should like to I advise to … needn't had better should (perf.)	треба, слід, краще моральний обов'язок (з точки зору того, хто говорить); порада, рекомендація
reproach	ought to should (have done) had better	міг би, повинен був, слід було зробити докір, несхвалення, дія, що відбулася як небажано з точки зору того, хто говорить
obligation necessity	ought to	рекомендується, слід порада, рекомендація
necessity	need	треба, потрібен необхідність

asking for instructions, obligation, necessity	shall I do it? I shall do it	повинен, треба, належить, забов'язан зробити це? наказ, попередження, обіцянка, перестрога, розпорядження, вказівка з метою дістати
prohibition (strict)	You can't cross the street. You may not do it. You are not to leave the room. You must not do it.	нема потреби, необхідності, зовсім не треба заборона
absence of necessity	needn't do needn't have done didn't have to do	не треба, ні в якому разі відсутність необхідності
permission	may can be allowed to	можна, дозволяється, незаборонена дозвіл, ввічливе прохання
physical or mental ability	can be able to be capable of it is impossible	буде здатний фізична розумова, здатність можливість виконати дію при певних обставинах
volition	want should like to will would	охоче, залюбки бажання
polite requests	will would can could would you mind do you mind if … ing	дозвольте, будь ласка не заперечується ввічливе прохання, запрошення
preference	would rather I'd prefer (perf) we'd love to	зробив би, віддав би перевагу, краще би я ..., перевага
related action in the past	would (тільки дія) used to (стан, ситуація)	бувало дія або стан, які повторювалися в минулому

uncertainly surprise doubt	it is impossible it is possible I don’t believe can’t/couldn’t probably must be perhaps maybe may/can	повинно бути, напевно, певна річ, хто знає, невже, не може бути, можливо, могло би, навряд чи припущення, здогад, невпевненість, здивування, невіра, сумнів

Ability

розумова, фізична здатність, можливість	→	can be able to, capable of it is (im)possible
можливість виконати дію при певних обставинах		вміє може спроможний зробити

Necessity

Необхідність

must	have to	be to	should	ought	need	shall I …
треба мусить бути має бути впевнений	треба маю зробити змушений доведеться мусимо	треба планується має повинно є намір	треба слід краще бажано	треба бажано слід рекомендується	треба потрібен необхідно	(Треба) зробити ...? (Повинен) зробити ...,
необхідність обов'язок впевненість	необхідність, обов'язковість дії, зумовленої обставинами	наказ інструкція	моральний обов'язок (з т. зору того, хто говорить) порада рекомендація	необхідність рекомендація	необхідність	наказ попередження погроза обіцянка пересторога
absolute obligation, necessity, a very strong opinion	necessity	order, prearranged necessity	a good advice	obligation necessity advice	necessity	obligation, necessity, asking for instruction

Probability

припущення
здогад
сумнів
здивування
невіра
невпевненість

probability
possibility
supposition
doubt
speculating about the future

Adjectives/Adverbs		Verbs
probably	likely	must + do, be doing
perhaps	unlikely	must + have done
maybe		may, can + do, be doing
it is (im)possible		may, can + have done
it is (in)probable		might, could
it is (un)likely		

хто знає
повинно би
напевно
певна річ
невже
не може бути
можливо
могло би бути

APPENDIX 2

The Thesaurus of Basic Engineering Notions

Change

Maximize: multiply (number), add (number), swell (volume), expand (area), broaden, widen (width), extend, lengthen (length);

unite, amplify (energy), rise, heat (temperature), strengthen (force), accelerate (speed), improve (quality, performance);

Minimize: shorten (length), narrow (width), contact (area), compress (volume), subtract (number), divide (number);

worsen (quality, performance), slow, down (speed), weaken (force), drop, cool, freeze (temperature), abate (energy), separate.

Matter

material, substance, element, solid, body, fluid, liquid, property, entity, powder, paste, foil, consistency, nature, feature, behaviour;

physical, chemical, biological, biochemical, gaseous, natural, artificial, available, discrete, pure, elastic, impure, granular, granulated, mobile, stationary, plastic, aggregate, ductile, consistent, porous, perforated, coloured, colourless, transparent, dense;

contain, consist of, integrate, disintegrate, be composed of.

Measurement

sum, total, precision, accuracy, approximation, scale, zero, magnitude, correction, quantity, amount, unit, ratio, proportion, increase, increment, decrease, decrement, nothing, rate, convention, symbol, standard, constant, variable, consistency, inconsistency, reading, result, determination, range;

correct, standardize, normalize, measure, record, determine, tabulate, verify;

total, entire, partial, complete, precise, accurate, exact, correct, approximate, acceptable, fine, coarse, imprecise, inaccurate, inexact, quantitative, specific, critical, negligible, positive, negative, uniform, consistent, regular, irregular, steady, average, arbitrary, excessive, ample, adequate, inadequate, deficient, insufficient, scarce, rare.

Movement

motion, stationary, mobile, motionless, divergent, convergent;

impel, propel, activate, turn, conduct, transmit, shift, remove, replace, displace, substitute, exchange, actuate, travel, move, deviate, diverge, incline, decline, deviate, deflect, divert, reflect, transfer, transport, carry, flow.

Process

operation, method, procedure, routine, preparation, production, behaviour, mode, way, manner, action, function, accessory, application, association, condition, factor, feedback, effect, consequence, requirement;

derive, operate, provide, manufacture, prepare, produce, form, maintain, control, regulate, compensate, act as, apply, obtain, attract, repel, use, expend, consume, exploit;

operative, operational, complex, complicated, intricate, straightforward, available.

Relationships

contrast, reference, conformity, accordance, agreement, identity, classification, category, class, specimen;

relate, depend on/upon, correspond, conform, compare, contrast, match, classify, sample, represent;

relative, reciprocal, mutual, proportional, directly proportional, inversely proportional, different, distinct, dissimilar, contrasting, similar, identical, appropriate.

Shape

form, deformation, distortion, deformability, arrangement, structure, system, pattern, hierarchy, network, mesh, defect, flaw, fault, deficiency, disorder, tube, pipe, duct, channel, groove, edge;

distort, deform, restore;

initial, final, intermediate, ultimate, deformed, distorted, perfect, ideal, imperfect, non-ideal, concentric, rectangular, triangular, trapesoidal, circular, annular, cylindrical, tubular.

Space

place, position. point, boundary, limit, extent, path, range, course, spread, scope, surface, area, region, zone, volume, plot, track, location, dislocation, surroundings, environment, isolation, site;

extensive, voluminous, spatial, regular, marginal, isolated, single, sole, solitary, unique, adjacent, interconnected;

junction, joint, bond, combination, cluster, bunch, clump, blend.

Structure/Constitution

whole, part, portion, detail, component, ingredient, constituent, member, item, aggregate, content, essential, integral;

separate, include, comprise;

continuous, discontinuous, inclusive, exclusive.

Time

period, duration, interval, event, occasion, age, lifespan, epoch, era, origin, source;

interrupt, elapse, repeat;

latent, temporary, permanent, durable, perpetual, sudden, abrupt, instantaneous, rapid, fast, quick, brief, periodic, intermittent, slow, following, successive, consecutive, continuous, continual, simultaneous, preceding, obsolete, modern, up to date.

APPENDIX 3

Vocabulary of Basic Engineering Words

A

accommodate	*пристосувати, улаштувати*	приспособить, устроить
accuracy	*точність, вірність*	точность, правильность
adjust (ment)	*регулювання, улагодження*	регулирование, улаживание
angle	*кут, рухатись під кутом*	угол, двигаться под углом
approximation	*наближення, точність*	приближение, точность
arc	*арка, дуга, іскра*	арка, дуга, искра
area	*площа, простір, ділянка*	площадь, пространство, участок
arrange	*упорядкувати, пристосовувати*	упорядочить, приспособить
arrangement	*упорядкування, систематизація*	упорядочение, систематизация
assembly	*комплект, агрегат, монтаж*	комплект, агрегат, монтаж
average	*середнє число (величина)*	среднее число (величина)
axis	*геометрична вісь*	геометрическая ось

B

boiling	*кипіння, кип'ятіння*	кипение, кипячение
boiling point	*точка кипіння*	точка кипения
by product	*побічний (проміжний продукт)*	побочный (промежуточный) продукт

C

capacity	*потужність, місткість*	мощность, вместимость
circle	*цикл, круговорот, круг*	цикл, круговорот, круг
clamp	*затискач, скоба, клема*	зажим, скоба, клемма
combustion	*горіння*	горение
composite	*суміш, сполука*	смесь, соединение
compress	*стискувати*	сжимать
conductivity	*електропровідність*	электропроводимость
connector	*з'єднувальна ланка, муфта*	соединительное звено, муфта
constituent	*складова частина, елемент*	составная часть, элемент
contamination	*забруднення, зараження*	загрязнение, заражение
conventional	*стандартний, серійний*	стандартный, серийный
convert	*перетворювати*	преобразовывать
correction	*виправлення*	исправление
corrosion-resistant	*стійкий до корозії*	не поддающийся коррозии
cross-section	*поперечний перетин, профіль*	поперечное сечение, профиль
(electrical) current	*електричний струм*	электрический ток
curve	*кривизна, вигиб, крива*	кривизна, выгиб, кривая

D

design	*креслення, конструкція*	чертёж, конструкция
drafting	*креслення*	чертёж
drafting tools	*креслярські приладдя*	чертёжные принадлежности
drawing board	*креслярська дошка*	доска для черчения
determine	*вимірювати, обчислювати*	измерять, вычислять
drill	*бур, свердел*	сверло, дрель
ductile	*гнучкий, податливий*	гибкий, эластичный
ductility	*гнучкість, еластичність*	гибкость, эластичность
drawing	*волочіння, протягування*	волочение
diminish	*зменшувати, скорочувати*	уменьшать, укорачивать
drilling	*буріння*	бурение, сверление
depth	*глибина*	глубина
density	*щільність, концентрація*	плотность, концентрация
digital	*цифровий*	цифровой
device	*пристрій, механізм*	устройство, механизм
dilute	*розбавлений, розріджений*	разбавленный, разряженный
discharge	*розвантаження; випускний отвір*	разгрузка

E

efficiency	*віддання, коефіцієнт корисної дії*	отдача, коэффициент полезного действия
elastic	*гнучкий, пружний*	гибкий, упругий
elasticity	*гнучкість*	упругость
eliminate	*усувати, виключати*	устранять, исключать
engineering	*техніка, проектування*	техника, проектирование
environment	*оточуюче середовище*	окружающая среда
equipment	*обладнання*	оборудование
error	*помилка, погрішність*	ошибка, погрешность
evaluate	*оцінювати*	оценивать
exhaust	*вихлопна труба, випускати*	выхлопная труба, выпускать
expand	*розширювати, розвальцьовувати*	расширять, развальцовывать
expansion	*розширювання, розвальцьовування*	расширение, развальцовывание
thermal expansion	*теплове розвальцьовування*	тепловое развальцовывание
extrusion	*видавлювання, витиснення*	выдавливание, вытеснение

F

fail-safe	*надійний, безперебійний*	надёжный, бесперебойный
failure	*аварія, пошкодження*	авария, повреждение
fastener	*скоба, затискач*	скоба, зажим
finite (element)	*скінчений, обмежений*	конечный, ограниченный
fix	*укріплювати, установлювати*	укреплять, устанавливать
flat	*плоскість, плескатий*	плоскость, ровный
flow-meter	*витратомір, водомір*	расходомер, водомер
fluid	*рідина, текучій*	жидкость, текучий
foil	*фольга, плівка*	фольга, плёнка
fold	*згинати, фальцювати*	сгибать, фальцевать
freezing	*замерзання, застигання*	замерзание, застывание

G

generator	*генератор, джерело енергії*	генератор, источник энергии
gravitation	*тяжіння, сила ваги, гравітація*	притяжение, тяготение
gravity	*вага, сила ваги, тяжіння*	тяжесть, сила тяжести

H

hardware	*залізні вироби*	металлические изделия
handle	*ручка, рукоятка; правувати, вантажити*	ручка, рукоятка; управлять, грузить
handsaw	*ручна пилка, ножівка*	ручная сила, ножовка
heat	*нагрівання, теплота; нагрівати, розпікати*	нагрев, теплота; нагревать, накаливать
height	*висота*	высота
heat-exchange	*теплообмін*	теплообмен
heat-exchanger	*теплообмінник*	теплообменник
hydride	*воднева сполука елемента*	водородное соединение элемента

I

image	*зображення, копія, відбиття*	изображение, копия, отпечатывание
inject	*вдувати, упорскувати*	вдувать, впрыскивать
interactive	*взаємодіючий, взаємний, обопільний*	взаимодействующий, взаимный, обоюдный

J

jiggling	*похитування, погойдування*	покачивание

L

length	*довжина*	длина
light-weight	*легкий, легковагий*	легкий
liquid	*родина*	жидкость
load	*навантаження; навантажувати*	нагрузка; грузить

M

manufacturing	*виробництво, виробка*	производство, выработка
matter	*речовина, матеріал*	вещество, материал
melting	*плавлення, виплавка*	плавление, выплавка
melting point	*температура плавлення*	температура плавления
mobility	*маневреність*	манёвренность
monitoring	*контроль, дозування*	контроль, дозировка
mass	*велика кількість*	большое количество
muffler	*глушитель, модератор*	глушитель, модератор
measurement	*дозування, вимірювання*	дозирование, измерение

machining	*механічна обробка різанням*	механическая обработка резанием
misuse	*неправильне вживання, зловживання*	неправильное применение, злоупотребление

N

noise (pollution)	*гуркіт*	шум

O

overload	*перевантаження, переобтяження*	перегрузка
oxidant	*окиснювач*	окислитель
oxidation	*окиснення, оксидація*	окисление, оксидация
oxide	*оксид, окис, окисел*	оксид, окись

P

particle	*частка*	частица
pollution	*забруднення*	загрязнение
power	*потужність, сила; приводити до дії*	мощность, сила; приводить в действие
precision	*точність, чіткість*	точность, чёткость
pressure	*тиск*	давление
property	*властивість, якість*	свойство, качество
pump	*насос, помпа*	насос, помпа

Q

quality	*якість, властивість*	качество, способность
quantity	*кількість*	количество

R

rectangular	*прямокутний*	прямоугольный
reflector	*рефлектор*	рефлектор
reinforce	*надавати жорстокості*	обеспечивать жесткость
reliable	*надійний*	надёжный (в работе)
resilience	*ударна в'язкість*	ударная вязкость
resistance	*опір*	сопротивление
resistivety	*питомний опір*	удельное сопротивление
re-use	*повторне використання*	повторное использование
rolling	*обертання*	вращение, прокатка

S

safety	*безпека*	безопасность
seal	*ізоляція*	изоляция, уплотнение
shape	*форма, стан*	форма, состояние
simulate	*імітувати, моделювати*	имитировать, моделировать
software	*забезпечення (програмне)*	обеспечение
solid	*тверде тіло*	твердое тело
solubility	*розчинність*	растворимость
space	*космос, площа, простір*	космос, площадь, пространство
speed	*швидкість*	скорость
spring	*пружина*	пружина
stain	*пляма*	пятно, краситель
steam	*(водяна) пара*	пар
stiffness	*жорсткість*	жесткость
storage	*зберігання*	сбережение, хранение
supply	*постачання*	поставка
surface	*поверхня*	поверхность
switch	*вмикання/вимикання*	включение/выключение

T

tracing	*простежування, запис (прибору)*	прослеживание, запись (прибора)
transducer	*перетворювач*	преобразователь, датчик
transmit	*передавати, пропускати*	передавать
trapezoidal	*трапецеїдальний*	трапецеидальный
triangular	*трикутний*	треугольный

V

valuable	*цінний, корисний*	ценный, полезный
value	*оцінювання, величина, значення*	оценка, величина, значение
vapour	*водяна пара*	пар водяной
visible	*видимий*	видимый
volume	*об'єм*	объём

W

waste	*збитки, витрачати*	отходы, потери; бесполезно расходовать
wear	*зношування*	износ
weigh(t)	*вага*	вес
wheelchair	*крісло на колесах*	кресло на колёсах

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THE WONDERWORLD OF GRAMMAR THROUGH THE WONDERWORLD OF ENGINEERING

Навчальний посібник

(англійською мовою)

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