Viktor P. Astakhov Ph.D., Dr.Sci.

STATEMENT OF TEACHING AND RESEARCH INTERESTS

TEACHING

Teaching Experience

Thought a wide range of mechanical, manufacturing, industrial engineering courses in Ukraine, Canada, China, Portugal, Russia, USA at the undergraduate and graduate level, including design related courses (Mechanical Drafting – CAD (AutoCAD, Inventor, Catia), Kinematics and Dynamics of Machinery, Mechanics of Materials, Kinamatic Design of Machines and Mechanisms, Machine Elements in Mechanical Design, Machine Design 1 and 2, Machinery Vibration: System and Signal Analysis), manufacturing related courses (Materials and Processes in Manufacturing, Metal Cutting Mechanics, Tool Design and Production, Machine Tool Structure and Stability, High Speed Machining, Advanced Manufacturing Methods), materials related courses (Mechanics of Structures, Deformation and Fracture Mechanics of Engineering Materials, Mechanical Metallurgy, Material Selection, Physics of Strength and Fracture Control), mathematics and statistics related (Advanced Engineering Mathematics, Differential Equations for Engineers, Vector Mechanics for Engineers, Experimental Methods for Engineers, Design of Experiments, Statistical Process and Quality Control).

Teaching Philosophy

I firmly believe that the ultimate goal of an engineering education is to help students discover methods for lifelong learning and develop a sense of responsibility to seek knowledge. The first step is, of course, the transfer of technical knowledge. However, as the saying goes: "Give a man a fish and you feed him for a day; teach a man how to fish and you feed him for a lifetime." This distinguishes an education that spoon-feeds students with information from one that challenges them to think. I am committed to the latter form of education. I believe in rigorous education that equips the students with the skills and experience needed to identify and solve real-life engineering problems. Yet, a more important (and more difficult) task is to instill in the students an inquisitive mind, an independent way of thinking, the courage to explore novel ideas/solutions, and the perseverance to overcome obstacles.

My teaching will be structured around the following principles, which I derive from my own learning and teaching experience:

- **Cultivate active and deep learning**

  I will design labs, assignments and homework that will spark the child-like curiosity in my students, and encourage them to start asking the questions "why?" and "how?". Course projects that reflect relevant real-world problems will help inspire their enthusiasm to learn and apply the theories taught in class. My teaching experience shows that students face difficulty understanding the same theory applied outside of the context with which they are familiar. I call this superficial learning. Unfortunately, it is a common "epidemic" in highly competitive classrooms where the students try to absorb information just to spit it out again in exams without truly digesting it. I would like to emphasize another approach to learning, deep learning, in my teaching. I want to help my students integrate the fundamental theories or math tools they have already learned with the subject material I teach, and help them see the "big picture".

- **Develop a systematic approach to problem solving**

  I have learned from my experience that the best way to teach students how to approach a problem is by example. First, I will show them how to define a problem, which will allow them to narrow the scope and make assumptions when necessary. Then I will teach them how to formulate the problem using the theoretical background they have learned. To avoid superficial learning, I usually call on students to formulate the problem in different ways and to suggest multiple approaches to solving the same problem. When the students are stuck on a particular question, I encourage them to think of conceptual analogies to guide them in the organization of their thoughts.

- **Adopt a broad and interdisciplinary systems perspective**

  As engineering designs get larger and more complex, there is an increasing need for collaboration between experts across multiple disciplines. I encourage my students to expand their boundaries, and stay current with advances outside their discipline. To succeed, they will need to keep an open mind to the suggestions and opinions of others and be able to work in teams. Joint homework assignments, group term projects and peer discussions help them develop the ability to work with and learn from their peers.

- **Integrate independent research**

  Well-defined course projects with specific goals allow all students to participate in independent research. I require written term papers because this forces students to formulate problems in a rigorous way, explain their choice of methodologies, and document their results. In the process, they acquire the skills necessary to conduct scientific research and experiments. Although students sometimes may consider course projects and term papers daunting, they can become excited about their ideas if they get encouraging and enthusiastic guidance along the way.

- **Develop strong communication skills**

  Strong written and oral communication skills are essential in ensuring the successful career of an engineer. I require oral and written presentation of term projects and carefully written homework from my students, to provide them with an opportunity to practice.

Teaching Interests

My teaching interests include: all aspects of mechanical, materials and manufacturing engineering. With my previous experience in teaching and training, I am well equipped to interact with the more mature students in graduate and executive programs, and the younger students in undergraduate courses.

Teaching is an activity that I enjoy for many reasons. First, there is the simple satisfaction of explaining a topic to students, showing them how it works and why it is important. As a cognitive scientist, I find additional satisfaction in exploring, in a very immediate and practical way, techniques that facilitate learning.

For information on my sense of technical education, please see the attached course description.

RESEARCH

Philosophy

Research is the leading edge for academic and economic growth. The desire to find better solutions to practical problems is an important driving force for research, but good research is just as often driven by curiosity and enthusiasm for the unexplained. Research and scholarship advances creativity as well as critical thinking. The impact of these endeavors improves the overall quality of life for a society. It is essential that any research establishment should provide an enabling environment that fosters both the creativity and the means to bring the results of research endeavors to practical application. This continuum of the discovery process builds the intellectual basis for researched and students at all levels and provides the linkage to solving problems at the local, national, and international level.

Background

Since my graduate study at the Odessa National Polytechnic University (1972), my research work has been focused on cutting tool and machine design. Later on, I understood a simple principal: the productivity of any metal cutting machine and tool depends on what actually happens in the machining zone or on the cutting edge. I have concluded that further progress in the metal cutting tool and machine design can be achieved only through deep understanding of metal cutting theory and practice. This theory became the objective of my PhD study and still in the focus of my attention now. Eventually, my research interests become wider including metal cutting tool and machine design, mechanics of materials and materials science, technical physics (theory of strength and its application in design). At that time I realized the significance of the system engineering approach in the development technical systems.

My vision of system engineering is as follows:

System engineering is beginning to emerge in concept as a generalization of traditional engineering in three important aspects: (1) The scope of engineering projects in considerable enlarged and expanded to include many more system interfaces, such as the man/machine interfaces, man/man interfaces, even system/society interfaces. (2) The scientific bases for engineering decisions are necessarily broadened. (3) Materials from engineering products that are fabricated can no longer be limited and circumscribed.

With the emergence of the concept of system engineering, the traditional role of mathematics in engineering has been broadened or even completely changed. Traditionally, mathematics has been the vehicle by which physical concepts are applied to engineering problems. Nevertheless many engineers have been scornful of mathematical rigor. At the system level, however, an engineer is not much concerned with physics as he is with organization, information, and communication, as well as with the mathematical nature of relationships, whether they are physical or not. At this level, his principal challenge is always the complexity of a system under consideration.

System problems are often aptly described as a “can of worms” because it is difficult to discriminate between the different elements of the problem, such as the system boundaries, components and their various levels, organization and interrelationships between the levels. The whole problem seems to be constantly in motion and hopelessly intertwined, so much so that there may be only one indivisible component. It is difficult to grasp any one of the slippery components, and the problem is partially immersed in obscuring debris.

Only is the mathematical rigor is adhered then the system problems can be dealt with effectively. Therefore, if an engineer is to apply the system concept, he must at least develop an appreciation for mathematical rigor, if not also mathematical competence, as rigorous mathematics is more than a tool by which precisely to apply the concepts from other scientific disciplines to engineering problems. It plays a role of descriptive, inductive, comparative, and, above all, experimental science, providing a scientific basis upon which engineering decisions can be made. The process is somewhat as follows: the system engineer, faced with a problem derived from some system phenomenon, attempts to describe the phenomenon mathematically; he attempts to construct a mathematical model which represents a mathematical structure of some kind. He compares this structure with those existing in mathematics; he experiments with his model both mathematically and deductively, all the while checking the results of such comparison and experiments with the requirements of the problem and experimental or heuristic evidence concerning the phenomenon itself. He modifies the model and experiments more. Finally, he arrives at satisfactory model that he can proceed to analyze with various mathematical and computational techniques in order to arrive at an engineering decision.

As a result of application of the system engineering to my studies of the metal cutting system, I have developed a new theory of metal cutting. My book on metal cutting (Astakhov V.P., Metal Cutting Mechanics, CRC Press, 1998/1999) is a monograph presenting an entirely new approach in the field of physics of metal cutting. It is intended for researches, graduate students and all practicing engineers and metallurgists to improve design and efficiency in the manufacturing industry.

Trying to apply the system engineering approach to the practical design of mechanical and manufacturing systems, I arrived to a conclusion that the development in these areas is not possible without deep fundamental knowledge of the properties of engineering materials. So I extended my research interests in the area of materials science.

From today’s standpoint, standard methods of ensuring strength, reliability and durability have already exhausted their potential. The development of these methods follows a curve with negative the first and second derivatives. The time, when a qualitatively new stage in the development of design methods should be introduces to support technical progress has passed. Because existing methods and concepts have no reserves left, qualitatively new principles of ensuring technogenic safety need to be introduced.

This was in the focus of my attention for the last years. I have led a few teams of researches in the area of physics of solids and materials science. The first result is a book “ PHYSICS OF STRENGTH AND FRACTURE CONTROL: Fundamentals of The Adaptation of Engineering Materials and Structures” SRS Press, Sept.2002, which introduces a new physical concept in the science of the resistance of materials to external effects, a concept that opens completely new avenues for improving the strength and safety of engineered objects. Based on a thermodynamic equation of state of solids, the approach provides a general methodology for treating all the physical and mechanical properties of materials, regardless of their nature and physical state. It is shown that this approach enables the control of the stressed-deformed state both to prevent failures and fractures and to promote them for easier shaping of materials. He uses this methodology to present and discuss non-traditional but practical ways of solving real-world problems. Of enormous theoretical and practical significance, this groundbreaking work ushers in a new stage in the science of material strength.

Future Research Activities

Among many others, the design of manufacturing systems is most significant part of my agenda for the future. It includes:

1. Thermomechanics, Dynamics and Efficiency of Machining Systems. This is an integrated experimental, computational, analytical study of thermomechanical and dynamic coupling in machining and deforming of metals. At the heart of this study is the development of a novel direct and generalized methodology for modeling, predicting and monitoring machine-tool chatter.
2. Wave Mechanics of Metal Cutting and other Deforming Processes. This is essential for any high-energy rate forming processes, which involves high strain rate and high process temperature. Owning to the fact that energy propagates in waves, a novel concept of interaction between the deformation and heat waves will be used to optimize these processes.
3. Develop MetCutSoft® Software (http://metcutsoft.tripod.com/). The proposed simulation software package *MetCutSoft*® offers entirely new approach. It is based on the latest advances in the physics of machining and utilizes the power of the Similarity Theory. The software package takes the physical data (the mechanical and thermal properties of the work and tool materials, proper tool geometry parameters and machining regime) as inputs to perform simulations. It does not need any empirical data from actual machining tests whereas the other simulation programs in the field cannot operate without empirical data.
4. Materials, Resource and Reliability. Continue development of the breakthrough approach in the mechanics of solids that leads to a fundamental understanding of the relationship between materials structure, processing, and properties. Practical realization of the results in the design of manufacturing systems.

INDUSTRIAL EXPERIENCE - ACCOMPLISHMENTS

R&D Studied, developed and implemented a series of new special cutting tools by applying a novel theory of metal cutting, system engineering approach and morphology design analysis, improving efficiency by 300% and productivity by 200%.

Problem solving Improved the performance and production of broaching tools for the automotive industry resulting in 2 times reduction in the production time, 40% improvement in the accuracy of broaching, and a 50% reduction in scrap.

Analyzing Proposed a distinctive way to analyze the performance of different tool materials resulting in a 400% reduction of testing time and 1000 to 50 reduction of the number of tool vendors.

Testing Developed and implemented a series of novel methods for testing and evaluation of different tools and machine parts resulting in significant reduction (1000%) of test time and cost, improved reliability of the test data (50+%).

Training Trained a group of technical specialists (design and application) and shop floor operators (cutting tool production) resulting in higher quality and efficiency of production (30%), better conformance with the instructions and regulations imposed by ISO and QS standards, improved failure analysis (the root cause analysis) and corrective action system (30% reduction in RMAs).

Presenting Presented numerous technical advances, project progress data and results to leading automotive companies resulting in multiple join R&D projects, sales orders, upgrading supplier status.