Volume 1 Number 1 January-June 2009

International JOURNAL of ADVANCES IN MACHINING AND FORMING OPERATIONS

Published by

INTERNATIONAL SCIENCE PRESS (INDIA)

EDITORIAL: AN OPENING NOTE

V. P. ASTAKHOV

WELCOME NOTE

Welcome to the inauguration issue of *the International Journal of Advances in Machining and deforming Operations (IJAMDO)*. This journal represents an innovative and exciting effort to bring students, professors and practitioners into direct conversation with each other and promote solution-oriented research. It establishes an academically rigorous platform to allow for discussion and cross-pollination of methodologies between disciplines.

The editorial board hopes that IJAMDO will represent an important contribution to the study of sustainable development and encourage other students to become involved in research activities. Our aim is to utilize accessible medium to promote innovative ideas across disciplines around the world.

The peer review process will match knowledgeable reviewers with submitted manuscripts to produce high quality articles of interest and scientific merit. The process is confidential so that criticisms and revisions are made in the fairest manner possible. The final decision on publication will be made by the editors in chief.

We will look for submissions of interesting and important scientific information that hopefully will have practical application in manufacturing. This focus does not deny the relevance of basic research, it embraces it. Whether there are obvious practical applications or not, high quality research of all types will be nurtured and presented with pride in the journal.

One of the main goals of our endeavor is to cultivate cross disciplinary dialogues to enhance our understanding of metal cutting and deforming processes. The talent and determination of our readers is a resource with unlimited potential and we have this as a motive to produce and foster new scientific thought for the benefit of the manufacturing community. This is the most exciting concept of all.

I look forward to a most interesting future for *the International Journal of Advances in Machining and deforming Operations (IJAMDO)*. Our editorial board includes world leaders in all areas of our field and a comprehensive international distribution. There is every reason to expect that we will set new standards for the study of the most widely used manufacturing process. I thank our editorial board and our contributors and readers for their interest and efforts in advancing this worthy cause.

CHALLENGES

Metal cutting, or simply machining, is one of the oldest processes for shaping components in the manufacturing industry. It is estimated that 15% of the value of all mechanical components manufactured worldwide is derived from machining operations. Unfortunately, despite its obvious economic and technical importance, machining remains as one of the least understood manufacturing operations, which, in a large degree, due to the low predictive ability of the machining models [1, 2]. The old "trial-and-error" experimental method, originally developed in the middle of the 19[th] century (well summarized in [3]) still dominates the metal cutting research and development activities.

A number of books have been published on the topic of metal cutting. These books provided significant insights into the metal cutting process, methodology for metal cutting study, and useful summaries of experimental results. However, none of them provides critical comparison of different theories of metal cutting in discussion of the corresponding models of chip formation, which constitute the very core of the metal cutting theory. After reading these books, a practitioner in metal cutting, such as a tool or process engineer, feels that he is not sufficiently equipped with knowledge on the advantages and drawbacks of different models; so he/she may wonder which particular model of chip formation is to be used in a given practical case. Besides, a great number of papers published on the subject provided contradictive results and thus added more confusion to the matter.

When one tries to learn the basics of metal cutting theory, he/she takes a textbook on metal cutting (manufacturing, tool design, etc.) and then learns that the single-shear plane model of chip formation constitutes the very core of this theory. Although a number of other models are known to the specialists in this field, the single-shear plane model has surpassed all of them and is still the foundation for metal cutting in students' textbooks (e.g. [4, 5]), studies on metal cutting [6], computer simulations programs including the most advanced FEA packages (e.g. [7]). A simple explanation for this fact might be that the single-shear plane model is easy to teach, to learn, and to be incorporated in simplified numerical examples to calculate cutting parameters for student's assignments [8]. Although it is usually mentioned that the model represents an idealized cutting process [9] and that quantitatively the shear-angle relationship has been found to be inaccurate (page 48 in [10]), no information about how far this idealization deviates from reality is provided. It is also interesting to recount the history of this model. It was the first model developed [11], rejected [12], then widely accepted in the early 1950's and remains as 'a paramount' today [13]. Even though a number of more realistic models of chip formation have been developed and verified (for example [14-18]), specialist and practitioners in the field still use the single-shear plane model, a significantly inferior model by this author's opinion [13]. This important issue, having the greatest theoretical significance and wide practical application in the optimization of various cutting process, must be addressed in order to break through in metal cutting research.

One of the major concealed aspects, that have yet to be properly accounted for in the theoretical and experimental studies of metal cutting, is the properties and structure of various work materials. In a way, life in a research lab and in a metal cutting shop would be much simpler if there were only one choice for each type of materials. All process parameters could be optimized around these limited choices. Obviously, this is not the case in real world where a great variety of engineered materials, designed to give predictable performances, have to be machined efficiently. A wide spectrum of their properties and metallurgical conditions are key variables in the manufacture of precision parts.

The machine, cutting tools, tool holders, fixtures and cutting fluids all play critical roles in the metal cutting process. Nevertheless, it is the material being cut that determines the choice of tool material, the type and geometry of the cutting tool, the setting for cutting speed and feed, the formulation of the cutting fluid and etc. Understanding the basic metallurgical, physical and mechanical properties of the work material relevant to the cutting process is essential to obtain reliable results of the metal cutting research (theoretical, numerical and experimental) and to apply the results in metal cutting practice for particular cutting conditions. In addition, certain physically based but simple and practical measures (matrixes or indexes) that characterize the machinability of the work materials should be developed.

In industrial applications, one expects that the high cost of poor machinability, great scatter in tool life (that is particularly detrimental for automated production lines and manufacturing cells with no or minimum human attendance) and great scrap rate would bring about attention from practical manufacturing engineers to the properties of the work material. Unfortunately, this is not the case even at the most advanced manufacturing facility. This is particularly true in the automotive industry where the losses due to misunderstanding and/or underestimating the discussed issue could lead to losses of tens of millions of dollars.

Due to variety of reasons, OEMs (original equipment manufacturers) and their manufacturing engineers have been reluctant to hold materials suppliers to a narrow range of chemical composition and hardness variation in the materials supplied. The variations in the chemical composition and hardness make it very difficult to specify the optimum tool geometry, suitable grade of the tool material, and optimal machining regime. Moreover, it is next to impossible to implement the results of metal cutting studies under these conditions as the experimentally obtained data and model parameters accordingly developed cannot be relevant for the whole range of the properties of the work materials. Some common causes for poor material specification in manufacturing and research practices are:

- The lack of knowledge and readily available data on the correlation of the properties (both mechanical and metallurgical) of work material and their machinability.
- False perceptions that tighter specifications and control of metallurgical properties would always result in higher cost of blanks (casting, forgings etc) and materials. There are two major misunderstandings: (a) often, the tightened specification reduces the usage of some very expensive materials as for example in gray cast iron; requirements to increase the harness of gray cast iron lead to the reduced annealing time that, in turn, reduces the energy (natural gas or electricity) spent, (b) the automotive industry shifts rapidly from the consideration the cost of individual components (blanks, tool, parts, etc) to that of the cost per unit including reliability of the processes and the final products. In such a context, even if the cost of blanks or raw materials is higher, the overall saving on the tool and process cost, benefit of process stability, chip disposal, better quality of the machined part, and assembly structures would overshadow this increased cost, sometimes from ten to a hundred times.
- Many automotive companies developed standards on material specification more than 20 years ago so these standards do not reflect the advances made in material production and control. To change any particular specification is a cumbersome process that requires persistence, patience and a great deal of diplomacy

When it comes to research and development, the following causes can be listed:

- The lack of knowledge on the relevant properties of the work material germane to metal cutting in general and to the metal cutting tribology, in particular. The know books and papers on machinability of materials (for example [19, 20]) are of a little help in such understanding.
- High cost of metallographic equipment. Many Universities and research laboratories cannot afford to have the equipment needed. Unfortunately, in application of equipment grants for metal cutting studies this metallographic equipment is not considered as needed in metal cutting studies by many grant committees
- Difficulties in altering and/or tailoring metallurgical and mechanical properties of the work material.

Normally, the influence of alloy additions on mechanical and physical properties, corrosion and chemical behavior, and processing and manufacturing characteristics are considered by mechanical and physical metallurgy. Although the detrimental effects of minor elements or residual (tramp) elements included in charge materials or resulting from improper melting or refining techniques is studied, such discussions are of qualitative nature and relates primarily to mechanical and physical properties. It is a common practice in the automotive industry to add some minor alloying elements and elements in traces to improve cast ability, formability, heat treatment properties, or some minor working properties of responsible parts. The crankshaft is a good example.

Unfortunately, possible changes in the machinability of various modified work materials (castings, forgings, bar stocks etc) are not considered. This is because there are very few studies that relate the influence of minor alloying components and components in traces to the mach inability. Therefore, engineers specialized in tooling, manufacturing, process and quality controls are not aware as regards the strength of the discussed correlation. As a result, a wide range of variations of these components is allowed by common specification of materials used in the automotive industry. When the allowed range is changed or part designers add a minor component to the specifications of a material the manufacturing and process specialists often are not informed about this change.

The foregoing discussion suggests that the studies on metal cutting and machinability of engineering materials are very important to meet the challenging requirement of the today's competitive marketplace. The International Journal of Advances in machining and deforming Operations aims to publish the results of the pertinent studies on these important topics, to provide valuable assistance to teachers, researchers and practitioners working in the field of metal machining.

Another important and close related research and engineering area to be covered by the journal includes deforming process and deforming operations. Because the most forming operations involve combinations of deferent types of forming: bending, stretching, plane-strain stretching, drawing, coining etc, the paper dealing with various combination of these and other types of forming are encouraged. The major problems to be addressed are fracturing, buckling and wrinkling, shape distortion, undesirable surface texture etc as related to the properties of work materials, part and tooling design as will as the process parameters.

References

[1] Usui, E., Shirakashi, T. *Mechanics of Metal Cutting - From "Description" to "Predictive" Theory.* In *On the Art of Cutting Metals - 75 Years later.* 1982. Phoenix, USA: Production Engineering Division (PED), ASME.

[2] Usui, E., Progress of "Predictive" Theories in Metal Cutting, *JSME International Journal*, 31 (1988), 363-369.

[3] Armarego, E.J.A. *Predictive Modeling of Machining Operations - A Means of Bridging the Gap between the Theory and Practice - A Keynote Paper.* in *The 13th Symposium on Engineering Applications of Mechanics.* 1996. Hamilton, ON, Canada: CMSE.

[4] DeGarmo, E. P., Black, J. T., Kohser, R. A., Materials and Processes in Manufacturing. Ninth Ed., John Wiley and Sons, New York, 2003.

[5] Kalpakjian, S. and S.R. Schmid, Manufacturing Engineering and Technology, Prentice-Hall, New Jersey, 2001.

[6] Shaw, M. C., Metal Cutting Principles. 2nd Edition, Oxford University Press, Oxford, 2005.

[7] *AdvantEdge*. 2004.

[8] Gorczyca, F. Y., Application of Metal Cutting Theory, Industrial Press, New York, 1987.

[9] Shaw, M. C., Metal Cuting Principles, Oxford Science Publications, Oxford, 1984.

[10] Armarego, E. J., Brown, R. H., The Machining of Metals, Prentice-Hall, New Jersey, USA, 1969.

[11] Time, I., Resistance of Metals and Wood to Cutting (in Russian), Dermacow Press House, St. Petersbourg, Russia, 1870.

[12] Zorev, N. N., ed. *Metal Cutting Mechanics.* 1966, Pergamon Press: Oxford.

[13] Astakhov, V. P., on the Inadequacy of the Single-shear Plane Model of Chip Formation, *International Journal of Mechanical Science*, 47 (2005), 1649-1672.

[14] Jawahir, I. S., Balaji, A. K., Stevenson, R., van Luttervelt, C.A. *Towards Predictive Modeling and Optimization of Machining Operations.* in *Manufacturing Science and Engineering. Proc. 1997 ASME International Mechanical Engineering Congress and Exposition.* 1997. Dallas, TX: ASME.

[15] Jawahir, I. S., Zhang, J. P., An Analysis of Chip Curl Development, Chip Deformation and Chip Breaking in Orthogonal Machining, Transactions of NAMRI/SME, XXIII (1995), 109-114.

[16] Fang, N., Jawahir, I. S., Oxley, P. L. B., A Universal Slip-line Field Model with Non-unique Solutions for Machining with Curled Chip Formation and a Restricted Contact Tool, *International Journal of Mechanical Science*, 43 (2001), 557-580.

[17] Fang, N., Jawahir, I. S., Analytical Predictions and Experimental Validation of Cutting Force Ratio, Chip Thickness, and Chip Back-flow Angle in Restricted Contact Machining using the Universal Slip-line Model, *International Journal of Mach. Tools and Manufact.*, 42 (2002), 681-694.

[18] Fang, N., Jawahir, I. S, Oxley, P. L. B., A Universal Slip-line Model with Non-unique Solutions for Machining with Curled Chip Formation and a Restricted Contact Tool, *Int. J. Mechn. Science*, 43 (2001), 557-580.

[19] Mills, B., Redford, A.H., Machinability of Engineering Materials, Applied Science Publishers, London, 1983.

[20] Rao, R.V., Gandhi, O.P., Digraph and Matrix Methods for the Machinability Evaluation of Work Materials, *International Journal of Mach. Tools and Manufact.*, 42 (2002), 321-330.

V. P. ASTAKHOV
Editor-in Chief
Michigan State University
Department of Mechanical Engineering
2453 Engineering Building
East Lansing, MI 48824-1226, USA
E-mail: astakhov@msu.edu