Preface: Theory and applications of sheet forming and sheet folding

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During the past two decades, advances in materials, heat-treatable alloys, composite structures, sheet folding and associated manufacturing processes have impacted many products, especially those of the automotive industries, aerospace and appliances. These advances lead to weight and volume reductions and an increase in the preferred mechanical properties, while improving conditions for the efficient and economical forming and folding of sheet material processes and technologies.

As important as these advances are and will be, researchers in the sheet forming and folding community need to aggressively approach the future by designing and implementing new composites, materials and processes that will have a greater impact on this area. This special issue of the *International Journal of Materials & Product Technology* (*IJMPT*) was thought of as a result of the National Science Foundation (NSF) Composite Sheet Forming Workshop, held at the University of Massachusetts Lowell in September 2001. The recent innovations in sheet forming and sheet folding theory and manufacturing technologies and their applications have been accelerated in recent years due to the introduction of new materials and composites. The significant reduction in manufacturing cost and time has also accelerated the use of these technologies in many applications that require significant volume and weight reduction with increased mechanical properties. This issue includes 14 papers which address these issues as well as the problems associated with sheet forming and folding. A brief summary of the main contributions is discussed below.

Potter's paper presents a reappraisal of the deformation properties of woven and other reinforcements through considerations of geometry, as applied to the aerospace industry. Emphasis is placed on the deformation properties required to drape these features both manually and mechanically. Tebbe and Kridli's paper reviews the existing knowledge of warm forming of aluminium as a way to improve its formability. They also discuss the recent developments in constitutive material modelling as well as experimental work. Soni *et al.* combine experimental, analytical and numerical studies to understand the failure mechanism and behaviour of SCS-6/Ti-15-3 MMC joints at room temperature and 650°C. They applied a polyester film on the specimens to examine its effects on the failure mode and load at room temperature and their preliminary test results show the polyester film extends the life of the joint as the failure mode changes from net-tension to bearing type. Li *et al.* investigate the shear behaviour of woven fabric composites using both a finite element model and experimental testing, and demonstrate that the finite element model can reasonably be used as predictor of shear mechanical behaviour without the need to conduct experimental testing. Liu *et al.* compliment the analysis of shear mechanical behaviour by investigating the validity of a non-orthogonal constitutive equation that has been developed for simulating the deformation behaviour of woven fabric thermoplastic (FRT) composites. Like Li *et al.*'s study, they show a reasonable agreement between the experimental results and the theoretically derived non-orthogonal constitutive equation. Marumo and Saiki show interesting results when hard aluminium square blanks were drawn using tools with an optimum large corner radius and geometry: the reduction in friction in the corner flanges prevented localised fracture due to slip bands unique to hard aluminium sheets, and improved deep drawability.

In their first paper, Singh and Kumar show that higher drawability and a more uniform thickness distribution could be achieved using hydro-mechanical deep drawing than by using a traditional deep drawing processes. They validated this conclusion through both finite element and experimental testing. Hamouda *et al.* address and investigate the springback phenomenon associated with V-shape bending which is caused by the elastic recovery of bending deformation in metal sheets upon unloading. They utilised finite elements to predict the final geometry of the part after springback so that the appropriate tools are designed in order to compensate for springback They validated the finite element model by conducting laboratory experiments which indeed agreed with its results. Unlike the finite element approach, Buranathiti and Cao's paper presents an analytical approach in order to predict springback for a straight flanging process. They also validate the analytical results through experimentation. Of course, it is extremely difficult, if not impossible, to develop analytical models for complex shapes and one has to resort to finite element models. Similar to springback, wrinkling during forming is a major problem and efforts are made to eliminate or reduce the wrinkling phenomenon. Kinsey *et al.* show that a segmented binder process, which varies the force applied to the materials, is shown to be effective at reducing wrinkling in a Tailor Welded Blank application. They also present a technique to quantify wrinkling in finite element simulations, for Tailor Welded Blanks as well as uniform material blanks. In their first paper, Basily and Elsayed investigate a recently developed innovative sheet folding theory and manufacturing processes in designing impact energy absorbing structures with superior properties to existing structures, such as honeycomb, while achieving a volume reduction between 40 and 50%. In their second paper, Singh and Kumar compare several training algorithms in an attempt to find an ideal artificial neural network-training algorithm that models hydro-mechanical deep drawing accurately. A comparison was made between ANN trained and experimental results of hydro-mechanical deep drawing using low carbon extra deep drawing (EDD) grade steel sheets of 0.96 mm thickness. Jain and Wang present a parametric study which investigates the effectiveness of dual hydroforming on various material properties and process conditions. They conclude their study by stating that dual tube hydroforming can significantly improve the strain distribution and reduce thickness variation and the advantages of dual tube hydroforming are best shown in materials with low anisotropy value and in high friction condition. Finally, Elsayed and Basily, in their second paper, develop a novel approach for a continuous folding process where sheet material is progressively folded in two dimensions, through a set of rollers, followed by a configured roller for the final folding in the third dimension. The final roller can be designed for longitudinal folding, cross-folding and angular folding to produce the desired folded pattern. This process is more economical than traditional forming processes.

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