A REVIEW ON SIMULATION OF MULTI PASS SPINNING PROCESS

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Abstract: *Sheet metal spinning process is a plastic working technology and is frequently used for manufacturing axisymmetric shapes. Sheet metal spinning has developed significantly and spun products have widely used for various industrial applications. In the current paper a review is carried on finite element simulation of multi-pass spinning with different path profiles and multi-domain techniques of simulation process. It is also proposed scope for new tool geometries for metal spinning process.*

Keywords: *Metal Spinning, Multi-pass, Simulation, Multi-domain*

1. INTRODUCTION

Metal spinning is a metal forming process where in the diameter of the blank is deliberately given a new shape which is pre-defined without change in the wall thickness. A pioneering work on this process is established by Kobayashi. He established the procedures for analysing flange wrinkling in conventional spinning of cones and he concluded that the initial blank thickness should be fixed and increase in thickness of blank is necessary to prevent wrinkling failures. The most common defects in spinning are wrinkling, circumferential cracks and radial cracks, as illustrated in Fig. 1.

Wrinkling occurs due to high compressive circumferential stresses buckling the flange. To avoid wrinkling, a combination of tensile and compressive stresses in the material needs to be introduced gradually. Both Runge (1994) and Lange (1985) state that conventional spinning must be performed in several passes (multi-pass conventional spinning) in order to form the blank without wrinkling. Further more, high stress in any direction is undesirable. High tensile radial stress may cause circumferential cracks. Radial cracks may formin two different cases; due to circumferential tensile stresses or a combination of circumferential compressive and bending stresses which occur when existing wrinkles are being worked

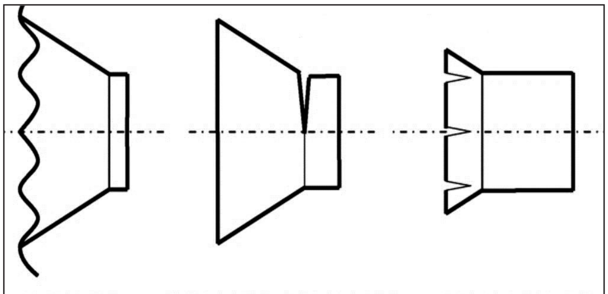

Fig 1. Common Defects in Spinning

2. REVIEW ON METAL SPINNING SIMULATION

Before the proposal of Lin Wanga, Hui [2011] Long, the process design still relieson the trial-and-error approach to determine roller path and passes. The author considered four different roller path profiles, i.e.combined concave and convex, convex, linear, and concave, have been designed and used to carry outspinning experiments and to conduct Finite Element (FE) analysis. The effects of these roller paths on tool forces, part wall thickness and stress variations in conventional metal spinning have been analysed numerically. The results show that the concave path produces highest tool forces among these four roller path profiles. Using the concave roller path tends to cause higher reductions of wall thickness of the

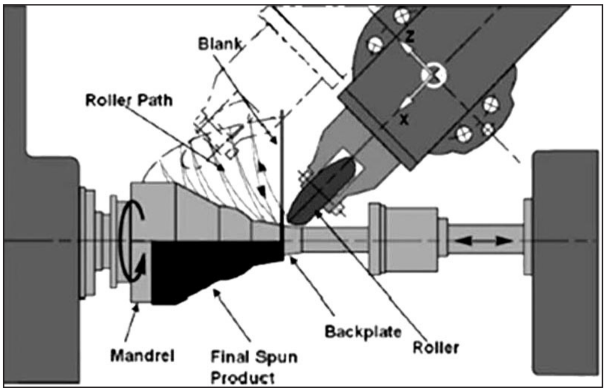

Fig 2. Multi Pass Spinning Process

(a) Spinning in process (b) Final experimental sample

Fig 3. Multi - Pass Conventional Spinning Experiment

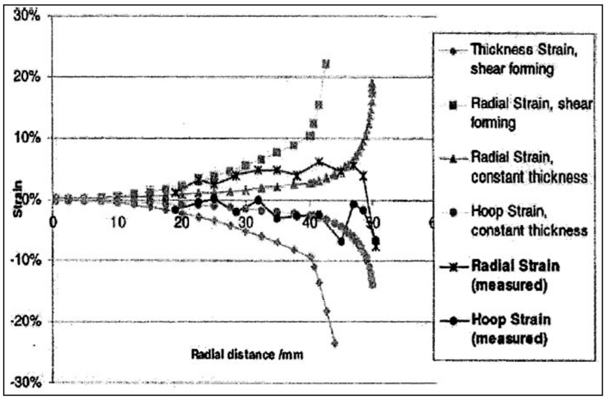

Fig 4. a) Comparison of Measured Strains from Multi-Pass Operation & Calculated Strains

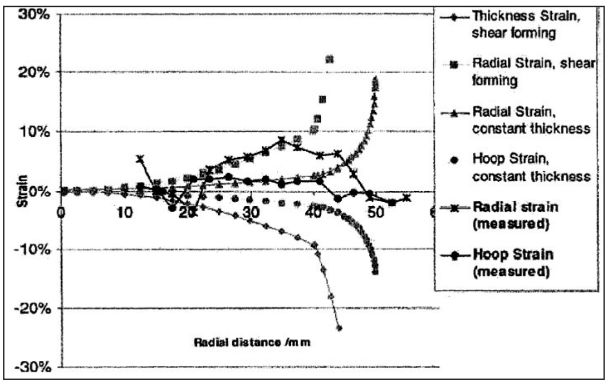

Fig 4b. Comparison of Measured Strains from Single-Pass Operation and Calculated Strains

spunpart and using the convex roller path helps to maintain the original wall thickness unchanged. A greater curvature of the concave path would result in more thinning in wall thickness of the spun part. A tool compensation technique has been proposed and employed in multiple roller passes design, to ensure the workpiecefully conforming onto the profile of a mandrel. The Taguchi method is applied to design experimental tests and analyse the effects of material type, feed ratio and spindle speed on the dimensional variations of the spun parts.

Yanqiu Zhang, 2011, suggest that straight line path trajectory is the worst trajectory under which wrinkling is most likely to occur and too large feed ratio will lead to wrinkling of the outer flange

A Finite Element (FE) analysis model has been developed based on a 5-pass conventional spinning experiment. The explicit Finite Element solution method has been used to model this multi-pass spinning process. Effects of mass scaling and reduced integration linear element used in the FE simulation have been evaluated by using various energy histories obtained from the FE analysis. The numerical results suggest that among three tool force components the axial force is the highest while the tangential force is the lowest. Certain correlations have been found between the FE analysis results and measured dimensions of the spun part. The blank thickness decreases after each forward pass and there are almost no thickness changes during the backward pass. Stress distributions of the local forming zone of the workpiece in both forward and backward passes have also been analysed, which gives an insight into the material deformation during the spinning process.

Quigley and Monaghan conducted experiments on manual lathe with tool rest adapted to provide support for the spinning roller. The strains were obtained by measuring the geometry after spinning of circles of known size, etched on to the blanks before spinning. The comparison of experimental strains in a multi-pass spinning and calculated strains reports that the radial strain is close to the theoretical strains around the centre of the blank but decreases sharply towards the end of the blank. He also proposed multi-domain technique to stimulate the conventional spinning to reduce simulation times. In multi-domain technique, the mesh is divided into super elements and separate processors are selected to solve each division considering the disk as

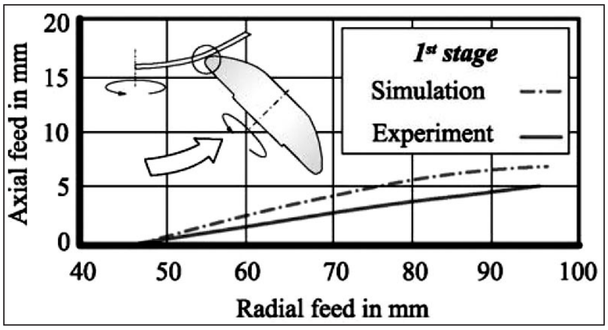

Fig 5a. Real and FEA-contours of Stages 1

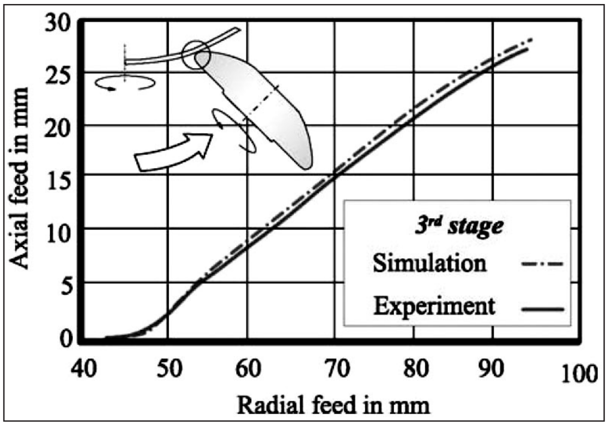

Fig 5b. Real and FEA-contours of Stages 3

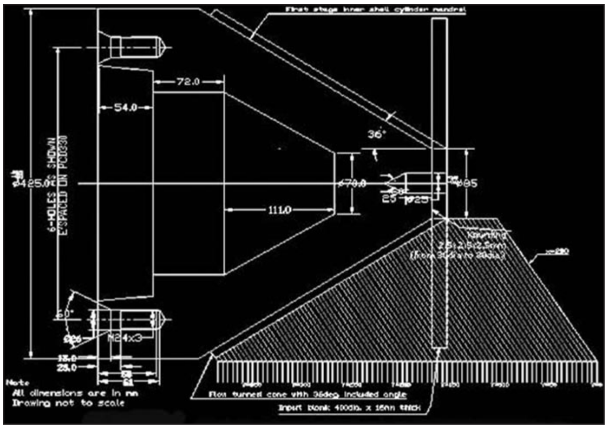

Fig 6. Formation of Flow Turning Cone Curve

deformable body and the mandrel, roller and tailstock as rigid bodies.

G. Sebastiani a,*, A. Brosius a, R. Ewers a, M. Kleiner a, C. Klimmek b discusses the key issues of setting up a 3D-finite-element-simulation of the sheet metal spinning process. The scope of simulation covers the first three stages of the tool path, each consisting of two consecutive movements. Modelling of the process was related to the experimental setup. The latter provides input parameters as well as geometrical data of the specimens used for a validation of the simulation results. Numerically and experimentally obtained shapes of the workpiece are compared to develop guidelines for modelling and validation of spinning-simulations in process design.

The basic scientific method of simulation is the numerical one, e.g. FEM, which is very used also in metal spinning. But this method is a rather complicated one, which demands good knowledge of plastic behaviour of materials, mathematics etc. and it needs a relatively expensive dedicated software. This paper proposes a simplified graphical simulation of the roller's trajectory, during the process of metal spinning by multi-pass path. The simulation is based on previous research, developed by the authors for the manufacturing process of metal spinning of hollow parts. The authors chose for the simulation the Auto CAD environment, because it is one of the most known basic CAD software. Besides the drawing possibilities, this software provides an integrated programming environment, Visual LISP, For simulation purposes there was designed an integrated application. The user can view a simple simulation of the process of metal spinning and better understand the influence of the geometrical and technological parameters on the roller's trajectory. The application was developed under the Auto CAD environment, which is very suitable for graphic simulations, because it has drawing capabilities and anintegrated programming language, Visual LISP, which can be used for designing user applications. The application, named Edu Spin1.0, integrates three user functions for the simulation of the roller's trajectory in three cases studied by the authors:

– TraCil – for flangeless cylindrical parts;

– TraCilFl – for cylindrical parts with a flange;

– TraCon – for conical parts.

The application has a modular structure. This kind of programming assures an easy debugging and easier future developments

B Ravikumar, Dr. S Gajanana, Dr. K Hemachandra Reddy and K N Nigam Developed coordinate retrieval system for a manual feeding of coordinates for the required shear forming. This involves painstakingly measuring distances in the CAD drawing with reference to the equipment, whose axes are at an angle of 1200 to one another. This process of manual retrieval of coordinates to be entered, requires a laborious

18hrs of operator time for every new trial..A standard program in Auto Lisp, which gives only the end points of a polyline, was re-written to give coordinates of points at every 1 mm distance. This developed system brings down operator time per cycle from 18hrs to less than 15 min.

3. CONCLUSION & FUTURE SCOPE

Based on the above discussions it is observed that mostly research was oriented towards development of various path profiles, multi domain techniques in the area of multi pass spinning. There is a scope for the development of various tool geometries such as double radii roller and double and single roller combinations and their contribution to the multi pass spinning.

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