A Review of Experimental study of friction in sheet metal forming

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Abstract
Two different techniques were used to assess friction, namely unidirectional crossed cylinders sliding with linear increase of the load and an equipment which allows measuring the friction coefficient under stretch-forming conditions in a sheet metal forming process. The tested materials are a cold-rolled advanced high-strength steel, DP600, and an aluminium 1100 alloy against heat-treated AISI D3 steel. The test protocols were established to allow the study of several effects: sliding speed, the surface roughness, the lubricant effect, the load and the running-in effect. The differences between the two techniques are widely discussed and laser profilometry and scanning electron microscopy are used to help understand the prevalent friction mechanisms.

Key Word- Friction , Tribology , Sheet metal forming

1 –Introduction

Nowadays, numerical simulation has been widely accepted in the optimisation of forming processes owing to the advantage of the notable progress of computer capabilities. Significant benefits can be obtained especially on time-to-market and start-up costs by utilizing simulations. Among these, contact conditions definition in conjunction with friction modeling assumes a decisive role. In fact, tribological properties, and frictional processes, are important factors determining the result of forming . However, tribology itself comprises the interaction of different factors connected to the sheet metal surface. Thus, experimental research in sheet metal forming follows two directions:

- to understand contact conditions during sheet metal forming;
- to assess the influence of specific variables in sheet metal forming operations.

2-Roll Bending

Roll bending provides a technique that is useful for relatively thick work. Although sheets of various sizes and thicknesses may be used, this is a major manufacturing process for the metal bending of large pieces of plate. Roll bending uses three rolls to feed and bend the plate to the desired curvature. The arrangement of the rolls determines the exact bend of the work. Different curves are obtained by controlling the distance and angle between the rolls. A moveable roll provides the ability to control the curve. The work may already have some curve to it, often it will be straight. Beams, bars and other stock metal is also bent using this process.

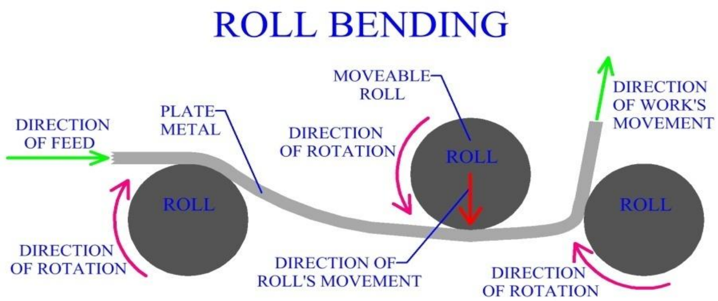

Figure.1.roll bending

3-Metal Tube Bending

Tubes, rods, bars and other cross sections are also subject to metal bending operations. It should be remembered that when bending a metal part, springback is always a factor. Several special manufacturing processes have been developed for the bending of hollow tubes. These operations can also be used on solid rods. Hollow tubes have the characteristic that they may collapse when bent. Tubes may also crack or tear, the material's ductility is important when considering tube failure.

As the bend radius goes down, the tendency to collapse increases. Bend radius in metal tube bending is measured from the tube's centerline. The other major factor determining collapse is the wall thickness of the tube. Tubes with a greater wall thickness are less likely to collapse. Bending a thick walled tube to a large radius is usually not a problem, as far as collapse is concerned. However, as wall thickness decreases and/or bend radius goes down, solutions must be found to prevent tube collapse. One solution is to fill the tube with sand before bending. Another method would be to place a plastic plug of some sort in the tube, then bend it. Both the sand and the plastic plug act to provide internal structural support, greatly increasing the ability to bend the tube without collapse.

Stretch bending is a process in which a tube is formed by a stretching force parallel to the tube's axis and a simultaneous bending force acting to pull the tube over a form block. The block is fixed and the forces are applied to the ends of the tube.

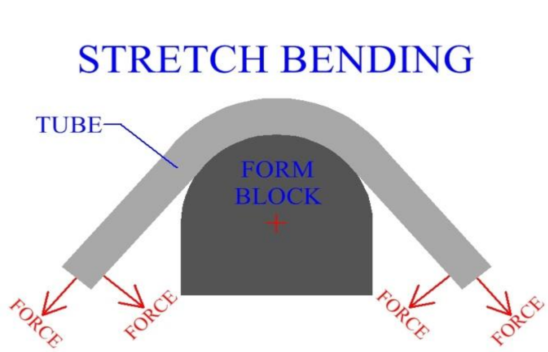

Figure.2.stretch bending

Draw bending involves clamping the tube near its end to a rotating form block. A pressure pad is also used to hold the tube stock. As the form block rotates, the tube is bent.
Compression bending is a tube bending process that has some similarities to edge bending of sheet metal with a wiping die. The tube stock is held by force to a fixed form block. A wiper like die applies force, bending the tube over the form block.

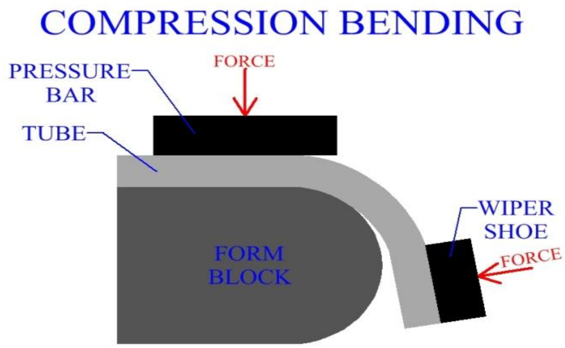

Figure.3. compression bending

4- Literature

This type of test, with point-contact geometry, can be done with a constant normal load or varying the load, using different loadingwaves, during the test. The sliding velocity is another test parameter that can be adjusted. The equipment also allows changing the diameter of specimens, their roughness and the lubrication. Moreover tests can be done applying single or multi-pass conditions.

The equipment developed at the University of Coimbra has a high precision of motion and positioning and is numerically controlled . The sliding motion corresponds to the movement of the horizontal base, where the specimen is fixed on a three-axis piezoelectric load cell. Normal load is applied by a spring, with well-defined constant rigidity, controlling the vertical motion of the upper specimen. Therefore, both the specimen path and the loading wave are numerically controlled. Both normal and tangential forces, measured by the load cell, were acquired in real-time during the test.

This paper is dedicated to a study of pulsed electromagnetic attraction based upon recently developedinductor design – “Inductor System with an Attracting Screen”. The concept of attraction in this inductorsystem is based upon inducing currents flowing in the same directions in the screen and in the sheet metalblank, which, according to Ampere law, results in attraction forces between the screen and sheet metalblank. This system is capable of applying attraction forces to non-ferromagnetic sheet metal materials,for example, stainless steel or aluminum using low frequency discharges. An analytical model basedupon solution of Maxwell equations was developed to estimate the attracting forces for low frequencydischarges. In addition to the analytical model, the described concept is illustrated by the experimentalresults on attraction of sheet metal blanks of stainless steel employing a single turn inductor and a flatscreen.

The primary high volume method for manufacturing automotive body panels and structural parts in contemporary industry is stamping from sheet metal in a two-sided die installed in a single transfer press or in a line of tandem presses. During the era of low oil prices, most automotive parts were stamped from low carbon mild steel. However, the formability of AHSS and especially UHSS is substantially lower than that of mild steel.

Furthermore, due to the significantly increased flow stress, the springback of these materials (defined as the elastic relaxation of a stamped blank that occurs after release from the stamping die) is greatly increased as compared to mild steels if the blank is stamped in cold forming conditions.

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