02. Literature Review

The problems related to sheet metal forming for various types of sheet metals like advanced high strength steel, high strength low alloy steel, aluminum etc are categorized in four points like microstructure, mechanical properties, spring back and formability.

MICROSTRUCTURE:

The study of the effect of different variables, such as chemical composition and processing parameters on the deformation texture are observed. They conclude that the deformation texture development in low and high carbon steels is affected by the difference in the initial texture as well as by the presence and distribution of a second phase such as cementite in higher carbon steels. Deformation texture was simulated for both types of steels [1]. Because of the higher applications in sheet metal forming, medium and high carbon steels present low workability and this condition becomes more critical as the carbon level is increased. A medium carbon steels (0.36% C) has shown that the pearlite lamellar morphology leads to undesirable cold working mechanical properties in highly stressed components [2]. The purpose of this paper is to study the texture of alloy sheet by means of orientation distribution function and to discuss the effects of annealing temperature on the texture [3].

The scanning electron microscopy (SEM) and transmission electron microscopy (TEM) was used for more detailed microstructure analysis and evaluation of minority phases in high strength low alloy steel [4].

Medium carbon steels are mostly used for simple applications; however, new applications have been developed for which good sheet metal formability is required. These types of steels have an inherent low formability. A medium - carbon hot-rolled SAE 1050 steel was selected for this study, on which annealing heat treatment was performed to achieve recrystallization then these samples are tested for mechanical properties [5].

When hot rolled sheets are subjected to cold rolling there is structural changes which are in a direction of principal deformation, due to the deformation, structural and crystallographic texture is formed. Besides changes in the grain character also a
“banding” arrangement of other structural phases, such as inclusions, carbides or pearlitic blocks, is formed [6].

MECHANICAL PROPERTIES:

The anisotropy of mechanical properties of deformed structure is to be removed through heat treatment in the form of annealing the chosen parameters of annealing, mainly temperature and time, have influence on the character of microstructure and hence mechanical properties after annealing. Strength properties of the material decrease with increasing of annealing temperature [7].

Cold rolled annealed HSLA strip steel was taken in the form of samples for three types of annealing mode and then general purpose annealing mode is decided for optimum mechanical properties which are done through tensile test and Brinell hardness test [8].

Progress of ageing in carbon steel is mainly affected by temperature and the temperature-holding time, as the phenomenon is dominated by the movement of carbon and nitrogen atoms, and the mobility changes depending on the temperature. Ageing is applied to carbon steels with various ranges of carbon content [9].

In some metal forming processes, the deformation is high enough to cause ageing dynamically. The deformed geometry or the hardness may be changed by the dynamic ageing. However, there is little research on the topic. In order to solve this kind of problem, both the ageing phenomena in the micro scale and the deformation in the macro scale must be considered at the same time. This type of analysis belongs to the research field of multi-scale analysis [10].

Homogenization methods were also applied as a quantitative prediction method to calculate the mechanical properties of carbon steel based on microstructures but without the effect of aging. It is cleared that micro structural changes will cause the change in mechanical properties [11].

The analytical prediction of forming limits requires the knowledge of material properties such as the strain hardening index (n), strength coefficient (K) and anisotropy(R). For this purpose a study pursued a vision integrated tensile test involving
three different types of standard specimens which is aimed at exploring the possible evolution of unified tensile test for determining the material properties that are essential in modeling of sheet metal forming [12].

A major obstacle in improving quality for any manufacturing process is the variation in the inputs and the changing conditions over time, and hence the sources of scatter for a stamping process are, Material variability Tooling variability Process variability Lubrication Random variability[13].

There is also noise variation which is experienced at a part-to-part level in sheet metal forming and these were segregated into three categories like, material property variation, Blank geometry variation and Process parameter variation [14].

These individual noise sources, throughout the life of a stamped part the variation observed is classified by a series of components, which are often attributed to different sources of variation like part-to-part variation, Run-to-run variation, Begin-to-end-of-run variation, Total variation[15].

Two main sources of part-to-part variation in a stamping process are from the incoming sheet material and from the process itself. The study has shown that part-to-part variation accounted for 21% of the total variation, while the remaining 79% primarily included press-setup variation [16].

Through a study that incrementally introduced material and process-based noise sources in a controlled manner, the development of a new methodology to construct the process’s robustness response window has been developed. A relationship between the effective stress–strain response window and the variation in springback was also established [17].

SPRINGBACK:

The FE analysis software is regularly employed in the design assessment of stamping tooling and dies in automotive industries, and the process simulation approach has been established as a practical methodology in the part formability and stamping failure predictions. [18]
The springback deformation becomes a more critical problem when it comes to high strength steels which are used for making stamping parts, enforce the engineer to consider the effect of springback deformations on the final dimensional tolerances in more details during the earlier design processes [19]

With the enhanced insight into the stamping process, potential problems in the process tooling and die tryout phases may be eliminated in the virtual environment, and both the costs and lead-times can be considerably reduced [20].

A rate-independent anisotropic plasticity model accounting the Bauschinger effect is presented and applied in the FE forming and springback analyses. The developed material model is employed in a U-channel forming process simulation, and a performance comparison in terms of the channel profile angles indicated a better correlation with an enhanced correlation with the average of measurements [21].

New challenges emerge from the use of new materials. For example to reduce automobile weight (to improve fuel economy) manufacturing companies must use lighter materials (e.g. aluminum) or thin high gauge high strength steel instead of mild steel. However, such materials are not formable as mild steel and produce more springback [22].

One strategy for controlling sheet metal forming processes through the application of variable blank holder force is process control and punch force is controlled by punch force measurement through manipulating the blank holder force. This type of strategy could produce cups with “optimal” height regardless of initial blank force and friction conditions [23].

The control of material flow into die cavity is crucial to good part quality and consistency, and blank holder force is used to control the material flow. Research has shown that varying the blank holder force during forming can improve part quality [24].

Key issues in process control include process controller and reference force trajectory. There is a systematic approach to design and implementation of a suitable
process controller and an optimal reference force trajectory which includes modeling of sheet metal forming process [25].

FORMABILITY:

As Cold-rolled steel sheet has good formability, these are widely used in outer panels of automobiles and refrigerators and other sheet metal industries. Formability of such type steel sheets can be checked through the r-value measurement, the driving mechanism for the sensor used electromagnetic acoustic transducers and the outline of this system are described. Finally, the results of off-line and on-line evaluation results are presented. Several analysts suggest that dynamic formability should also increase with increasing in sheet thickness and there is some experimental evidence that increasing sample size can improve formability However, the results from these experiments do not provide enough resolution to shed on the development of next-generation high velocity forming methods [26].

High velocity deformation can be quite effective in increasing the forming limits of metal sheets as well as effectively treating some other common metal forming problems, such as wrinkling and distortion. This study examines the high velocity formability of cold rolled sheet steel as developed in impact with a curved punch [27].

Sheet metal forming processes often involve high rates of deformation. Electromagnetic pulse forming (magnetic pulse forming), hydro forming and explosive forming are obvious examples, but also in more conventional sheet forming techniques, such as deep drawing, roll forming and bending, locally high strain rates occur deviating from those used in static material tests [28].

Recently, biaxial tests on cruciform specimens have become the most promising method to realize various strain states for assessment of FLDs. These biaxial tests have several advantages like one single specimen geometry for all strain states, friction effects have no influence on the results and complex strain paths can be applied [29].

In some metal forming processes, strain is independent of material properties. But material properties for sheet metal forming are stress–strain relations describing the
work-hardening of the material and forming limits describing how much the material can be deformed without cracking. This study is focused on the forming limit properties. An improved method for material characterization of sheet metal is a field that has gained a larger focus during the last years [30].

A fundamental problem in sheet metal forming is fracturing. It is therefore essential to be able to predict the risk of fracture with high accuracy. The forming limit curve (FLC) is the most commonly used fracture criterion for sheet metal forming applications. New fracture criterions have been developed but no one has yet come to general practical use in the automotive industry [31].

In the method of bending of sheet metal, bending apparatus having bending bar act as a punch with bottom adjustable die. For analyzing the bending behavior of sample sheet metal having certain material thickness and quality is determined and stored as a reference for the curve trace. At later stage of bending of the material having same thickness and the quality of material with different loading condition can be analyzed and compared with the stored reference curve trace. The position of the die can be adjusted with the difference of these two experiments [32].

An investigation that was made to determine the effect of controlling the punch and die temperatures on the draw ability of cylindrical sheet metal cups. Tooling temperatures may reach 100 to 200°C in commercial press forming operations due to the work of deformation and interference friction. For this reason, circular blanks of aluminum-killed drawing quality (AKDQ) steel sheet were press formed into cylindrical cups using various punch and die temperature combinations in an attempt to control the strength and draw ability of the sheet metal [33].

In this invention, for producing bake hardenable cold rolled steel sheet which is having the carbon range about 0.003-0.1wt. % includes two stage batch or box annealing. In first stage, temperature will be in between $A_1$ and $A_3$ that is known as an intercritical batch annealing and second stage will be known as subcritical batch annealing in which temperature will be below $A_3$ and above 900°F with a slow controlled cooling from
intercritical temperature to subcritical temperature and from subcritical temperature to ambient temperature. As bake hardenable cold rolled steel sheet is inexpensive and it is having good formability, non aging property and it is widely used in automotive industries [34].

There is invention related to manufacturing of cold rolled steel sheet which is having number of steps like rough rolling a slab using rough rolling unit then this slab will be finished in rolling sheet bar using a continuous hot finishing rolling mill. After this hot rolled strip will be cooled on a runout table and then this cooled hot rolled strip will be coiled and finally annealing of cold rolled strip will be done [35].

A steel should have the composition as 0.05 to 0.15% of C, 0.02 to 0.30% of Si, 0.10 to 1.5% of Mn, 0.02 to 0.07% of Al and a total of 0.02 to 0.15% of Nb/V/Ti/Zr should be included and this sheet will be hot rolled and coiled at a temperature not more than 750°C. After this coiled rolled sheet will be cold rolled steel sheet will be subjected to annealing at a temperature between 670°C and 900°C for 20 seconds to 10 minutes for producing high strength cold rolled steel sheet [36].