[Karanjule, 4(11): November 2017] ISSN 2348 – 8034
DOI- 10.5281/zenodo.1067498 Impact Factor- 4.022

GLOBAL JOURNAL OF ENGINEERING SCIENCE AND RESEARCHES

EFFECT OF PROCESS PARAMETERS ON SPRINGBACKDURING MANUFACTURING PROCESSES: A REVIEW AND SCOPE OF SPRINGBACK IN COLD DRAWING

Karanjule D.B.[*1] ,Dr.Bhamare S.S.[2] & Dr.Rao T.H.[3]
[*1]Research Scholar, Sinhgad College of Engineering, Vadgaon, Pune, M.S., India, 411041
[2]Registrar, Dr. Babasaheb Ambedkar Technological University, Lonere, M.S., India, 402103
[3]Former Director, Research and Development Department, Indian Seamless Metal Tubes Limited, Ahmednagar, M.S., India, 414001

ABSTRACT

Cold working is the process of altering the shape or size of a metal by plastic deformation withthe temperature below the recrystallization point. It includes processes like rolling, drawing, pressing, spinning, extruding and heading, it is carried out below the recrystallization point usually at room temperature. Hardness and tensile strength are increased with the degree of cold work whilst ductility and impact values are lowered. Cold drawing of steel significantly improves surface finish. Though cold drawing is most oftenly used process it has some inherent problems faced during processing such as springback. This review paper focuses on springback phenomenon faced during different manufacturing processes in industries. This paper represents effects of various process parameters on springback conducted in past 20 years. This will help the researchers to get an insight about this phenomenon and guideline for further research in springback domain of manufacturing processes.

Keywords: *Cold drawing, Finite Element analysis, springback, optimization, Lubrication, Numerical Simulation*.

I. INTRODUCTION

Cold drawing process is widely used in manufacturing industries for production of seamless tubes because of wide advantages of the process .But during this process many defects are found to occur such as ovulity, tube bending scores on inner diameter (ID) and outer diameter (OD), cracks, springback etc., out of which the springback is severe one.

Since all materials have limited elastic modulus, when load acting on plastic deformation is relieved from the material, it is followed by several elastic improving. Elastic limits of materials are exceeded, but flow limit thereof cannot be exceeded. Therefore, the material still keeps a portion of its original flexibility character. When the load is released, the material on forcing compress side tries to enlarge, whereas the material on tensile side tries to shrink. As a result, the material tries to springback. This tendency of material is called as springback. Springback is a phenomenon that occurs in many cold working processes. When a metal is deformed into the plastic region, the total strain is made up of two parts, the elastic part and the plastic part. When removing the deformation load, a stress reduction will occur and accordingly the total strain will decrease by the amount of the elastic part, which results in springback.

Interest in springback as a research area and application area is substantial and is growing rapidly. Few review reports showed that the word ‘‘springback’’ appeared in virtually no standard dictionaries at the time although the term had been in use since at least the 1940’s. A search of the ISE Web of Science database (Thomson Scientific) identified 396 published technical papers published since 1997. A Google search found 26,800 references to the word springback. Today, many dictionaries include the term ‘‘springback.’’ (Example: Free Merriam-Webster – http://www.merriam-webster.com/dictionary/springback).

II. LITERATURE REVIEW

Many research studies conducted during last two decades underlined the importance of springback in manufacturing industries and suggested ways to reduce this permanent physical variation. The common point of all these research studies is that they attempted to estimate the amount of springback and accordingly designing and later manufacturing stage. This study is of opinion that springback can also be minimized by modifying die design. Failure to estimate springback beforehand lead to wastage of time and material and the most important of all – increase in cost. Therefore, knowing beforehand the springback amount has cardinal importance. Springback varies with composition, material properties and dimensional range of outer diameter and thickness. It is required to control springback to achieve closer dimensions. However springback should be uniform and should fall within accepted tolerance limits. Springback causes deviation from designed target shape, downstream quality problems and assembly difficulties. Numbers of studies on the analysis of drawing process carried out by researchers are discussed below under different criteria.

1. Numerical Simulation

A numerical simulation is a calculation which is run on a computer following a program which implements a mathematical model of the physical system. Generally, these simulations are required to study the behavior of systems whose mathematical models are too complex to provide analytical solutions, as in most nonlinear systems.Tekaslan*et al.* [1] found that keeping the punch load on the material in spite of increasing bending time gives decrease in springback value. Ghaei [2] developed a numerical procedure for implementation for elastoplasticconstative laws assuming that the elastic modulus was defined as function of effective plastic strain. Panthi and Ramakrishnan [3] in their investigation carried out experiments and the results were presented in terms of springback ratio.Carden *et al.* [4] showed that springback is the elastically-driven change of shape of a part after forming, has been measured under carefully-controlled laboratory conditions corresponding to those found in press-forming operations. Li and Wagoner [5] recommended the number of through-thickness integration points (NIP) required for accurate springback analysis following sheet forming simulation using shell elements is a subject of confusion and controversy. Xing *et al.* [6] showed that the springback of hot stamping parts increases when the blank-holder force (BHF) decreases; and it increases when the clearance between punch and dies increases and when the die radius increases. Rui*et al.* [7] proposed the elastic-plastic finite element method to study the springback process of thin-walled tube NC precision bending and the combination of dynamic explicit algorithm and the static implicit algorithm was proposed to solve the whole process of thin-walled tube NC precision bending. Ingarao*et al*. [8] solved the problem of springback investigated through integration between numerical simulations, Response Surface Methodology and Pareto optimal solutions search techniques.

2. Taguchi Method

Genichi Taguchi, a Japanese engineer, proposed an approach of experimental designs which utilize two-, three-, and mixed-level fractional factorial designs. Large screening designs seem to be particularly favored by Taguchi adherents. Lee and Yang [9] worked on numerical factors influencing springback and have been evaluated quantitatively using the Taguchi method. Peng and Koc [10] provided a rapid and accurate understanding of the influence of the random process variations on the springback variation of the formed part using FEA techniques eliminating the need for lengthy and costly physical experiments. Lee [11] showed a finite element analysis technique is applied to the tube-bulging and folding processes as well as the springback stage by using the Taguchi method. Study of process parameters of bending angle, material thickness and punch radius as well as the finite element method (FEM), in association with the Taguchi method were investigated by Thipprakmasand Phanitwong[12]. Padmanabhan*et al.* [13] developed a process to determine the optimum values of the process parameters, it is essential to find their influence on the deformation behavior. Chun and Bon [14] investigated the springback of L-bending with a step in the die through simulation and experiments for AZ31 magnesium alloy sheets at different temperatures by using the Taguchi method.

3. Finite Element Method

It is a powerful technique originally developed for numerical solution of complex problems in structural mechanics, and it remains the method of choice for complex system.Gomes*et al.* [15] investigated the variation of springback in high strength steels due to material anisotropy using FEM. Thipprakmas andRojananan [16] discovered that the FEM simulation results clearly and theoretically clarified the spring-go phenomenon on the material flow analysis and stress distribution. Li et al. [17] showed the springback is the elastically-driven change of shape of a part after forming, has been simulated with 2-D and 3-D finite element modeling. Thorat*et al*. [18] studied rotary draw tube bending process and the Finite Element Analysis and Simulation of Rotary Draw Tube Bending of a seamless metal tube for the analysis of spring back effect. Wei and Liu [19] used hermite cubic finite elements to approximate the solutions of a nonlinear Euler–Bernoulli beam equation. Livatyali andWu [20] showed that flanging with coining to reduce springback has been investigated and evaluated by FEM for better dimensional control in flanging and hemming processes.Gronostajski [21] studied the method which based on the structure and phase transformation according to phase equilibrium diagrams of investigated alloys. Lepadatu*et al.* [22] showed springback optimization of bending processes using the concept of experimental design and response surface methodology (RSM). Asgari*et al*. [23] focused on development of a finite element method to study statistically forming and springback problems of TRansformation Induced Plasticity (TRIP) through an industrial case study. Narasimhan andLovell [24] worked on a coupled explicit to implicit finite element procedure which outlined for predicting springback deformations in sheet metal forming processes. Rust andSchweizerhof[25] worked on a proper combination of ANSYS and LS-DYNA used to prepare the transient analysis by common preprocessing and static analysis steps. Cho*et al.* [26] were concerned with dynamic effects when used explicit FEM for sheet metal forming analysis. Zein et al. [27] used a Finite Element (FE) model developed for the 3-D numerical simulation of sheet metal deep drawing process. Li*et al*. [28] produced the elastically-driven change of shape of a part after forming which has been simulated with 2-D and 3-D finite element modeling.

4. Lubrication

Lubrication process or technique is employed to reduce friction between, and wear of one or both, surfaces in proximity and moving relative to each other, by interposing a substance called a lubricant in between them. The lubricant can be a solid, (e.g. Molybdenum disulfide MoS_2) a solid/liquid dispersion, a liquid such as oil or water, a liquid-liquid dispersion (a grease) or a gas.Narayanasam and Padmanabhan [29] studied the influence of lubrication on springback in air bending of interstitial free steel sheets with three different orientations namely 0°, 45°, and 90° for the bending analysis. Ragai*et al.* [30] discussed the effect of sheet anisotropy on the springback of stainless steel 410 draw-bend specimens. Carden and Geng[31] produced elastically-driven change of shape of a part after forming, and measured under carefully-controlled laboratory conditions corresponding to those found in press-forming operations. Panthi*et al.* [32] used software to predict the springback in a typical sheet metal bending process and investigated the influence of the process parameters on springback. Xiao et al. [33] used Polytetrafluoroethylene (PTFE) emulsion for die wall lubricant. Sang andYoon[34]focused on the evaluation of springback occurring in the sheet metal flange drawing process by controlling some process factors like the punch corner radius (PR) and die corner radius (DR), the blank-holding-force (BHF), the supporting-force (SF), the lubrication and so on.

5. Influence Of Temperature

It is a measure of the warmth or coldness of an object or substance with reference to some standard value. The temperature of two systems is the same when the systems are in thermal equilibrium. Moon *et al*.[35] investigated the effect of tool temperature on the reduction of springback amount of aluminum 1050 sheet. Melton *et al.* [36] invented a method of processing nickel-titanium-base shape-memory alloys to substantially suppress the two-way effect and to a composite structure including a nickel-titanium-base shape-memory alloy.Jeswiet*et al.* [37], explained Sheet forming at elevated temperatures (warm forming) and manufacturing with light-weight materials now are actively used in production processes. Grezee*et al.* [38] studied the experimental and numerical investigation of springback in an aluminum alloy at different temperatures. Kim*et al.* [39], investigated the effect of temperature gradients on the final part quality (i.e., springback) in warm forming of lightweight materials. Kim *et al*. [40] described a warm/hot formability testing apparatus which was designed and fabricated for this study.

6. Influence Of Punch Force

The punch force increases during the process as the entire thickness of the material is sheared at once.Fei*etal.*[41] focused on the springback behavior of cold rolled transformation induced plasticity (TRIP) steels in air v-bending process. Sunseri*et al.* [42], performed experiment using a double-action servo-controlled process and were found to produce the desired results demonstrating both the accuracy of the numerical simulation and the success of the proposed active-binder force control method to obtain net shape. Livatyali*et al.*[43],explained a computer aided design method for straight flanging using finite element method is presented. Samuel [44] described a robust method of predicting springback and side wall curls in 2D operations under plane strain stretching, bending and unbending deformations. Also the effect of tool geometry and blank holder force on the final shape after springback was discussed. Leu*et al.* [45] presented paper to explore the influence of coining force on the spring-back reduction in the V-die bending process. Papeleux*et al.* [46] investigated the impact of several physical parameters including punch force which influences this phenomenon and its numerical prediction parameters on the springback appearing in a 2D U-draw bending. Liu [47], explained quantitative relationships obtained between restraining force and shape deviations, such as springback and side wall curl, in flanged channels made of SKDQ and high strength streets. Gau*et al.* [48], concluded that the influence of the Bauschinger effect on springback is more significant for aluminum AA6111-T4 than for steels.

7. Influence Of Texture

It is the visual or tactile surface characteristics and appearance of something. Oliveira *et al.* [49], evaluated the influence of work-hardening modeling in springback prediction in the first phase of the Numisheet'05 "Benchmark 3": the U-shape "Channel Draw".Raabe*et al.* [50] presented a numerical study on the influence of crystallographic texture on the earing behavior of low carbon steel during cup drawing. Robertson et al. [51], presented a study on how geometry and heat treatment can affect the texture of Nitinol, with specific quantification of the texture of Nitinol tube used for the production of endovascular stents. Chan*et al.* [52], explained by the strong texture in the cold-drawn material and the strain incompatibility among different grains in the coarse-grained material. Geng*et al.* [53] presented springback angles and anticlastic curvatures reported for a series of draw-bend tests. It is analyzed in details using a new anisotropic hardening model, four common sheet metal yield functions, and finite element procedures developed for this problem. Murata*et al.* [54] tried to examine the effect of material property about hardening exponent on tube bending. Andersson[55] discovered a part of an automotive side front section (front side member inner) was studied and a comparison both regarding material behavior and of accuracy of the FE simulations was made.

8. Influence Of Punch Speed On Springback

Firat*et al.* [56], stated the effects of modeling parameters are determined by evaluating influences of the punch velocity and the element size, in order to obtain a numerically calibrated simulation model. Wang *et al*. [57],showed a result that the maximum punch force decreases with the increase in punch speed and grain size. Firat*et al*. [58], presented for the sensitivity analysis of the springback deformations of stamping parts based on the assessment of process conditions. The sheet metal deformations are studied using explicit – incremental and implicit – iterative FE analyses. The proposed approach is employed in the stamping analysis of an industrial part made of high-strength steel.

9. Optimization In Spring Back

Optimization is finding an alternative with the most cost effective or highest achievable performance under the given constraints, by maximizing desired factors and minimizing undesired ones. Cho *et al.* [59], presented at the numerical investigation on spring-back characteristics to the major process parameters. A description of process formulation and finite element approximation is also presented.Teimouri*et al.* [60], indicated results that the radial basis network fulfills precise prediction of process rather than the other developed models. Meinders*et al.* [61], presented article an optimization scheme which is capable of designing optimal and robust metal forming processes efficiently.Brandstatter*et al*. [62] represented an analogy between the movement of a swarm member and a mass-spring system developed and tested against other stochastic algorithms.Lingbeek*et al.* [63] elaborated two different ways of geometric optimization, the smooth displacement adjustment (SDA) method and the surface controlled over bending (SCO) method. Chou et al. [64] showed several springback reduction techniques used in the U-channel bending processes were analyzed with the finite element method, which included arc bottoming, pinching die, and spanking and movement techniques.Palaniswamy*et al*. [65] performed experimentation in order to study the interrelationship of the blank dimensions and interface conditions on the springback for an axisymmetric conical part manufactured by flex forming. Shu*et al.* [66], presented first to use the finite element method to analyze the relationship between springback and the forming variables, and then to combine an optimization technique with the finite element analysis to find the optimum forming parameters to reduce the springback.Ling *et al.* [67] represented results provide a better understanding of how die parameters like die clearance, die radius, step height and step distance affect springback.Choi *et al.* [68] illustrated the design optimization of deep drawing process proposed to control the final shape of workpiece after elastic springback. Lee *et al*. [69] presented Spring-back predictions using the resulting material model compared with experiments and with single-surface material models which do not account for permanent softening. Jakumeit*et al.* [70] explained a parameterization of a time-dependent blank-holder force was used to control the deep-drawing simulation. Liew*et al*. [71], presented an evolutionary algorithm that is capable of handling single/multiobjective, unconstrained and constrained formulations of optimal process design problems.Kayabasi*et al.* [72], studied the effect of using double binder on springback, wrinkling and thickness reduction and the use of optimization method in further improving formability of the automobile panel.

10. Spring Back Effect In Forming Process

Lee *et al* [73] worked on Springback of forming which is one of the key factors influencing the quality of stamped sheet metal parts in sheet metal manufacture. Baba *et al.* [74], studied case of forming a sheet into cylindrical surface by stretching the sheet in circumferential direction under various conditions, the effects of time and magnitude of stretching are studied experimentally and theoretically. Lee *et al*. [75], performed simulations and experiments for the unconstrained cylindrical bending, the 2-D draw bending and the modified industrial part (the double-S rail). Gau*et al.* [76] proposed based on the foundations for isotropic hardening and kinematic hardening, Mroz multiple surface model, plane strain assumptions, and experimental observations, a new incremental method and hardening model.Li*et al.* [77], predicted springback accurately for R/t greater than 5 or 6, while solid elements were required for higher curvatures.Kim*et al.* [78], showed that both design and process parameters can significantly affect the amount of spring-back. Scanning electron microscopy (SEM) was also carried out for the observation of delamination or cracking in the bent zone.Karafillis*et al.* [79] examined for materials covering a range of steel strength and hardening, and is found to produce parts with negligible shape error. Chan *et al*. [80], presented a study of spring-back in the V-bending metal forming process with one clamped end and one free end. Karafillis*et al*. [81], proposed method demonstrated for two cases of forming of channel geometries (two-dimensional and three-dimensional) with an aluminum alloy sheet. Ho *et al*. [82], studied Springback effects for aluminum shapes single curvature cylindrical component and the other is a doubly curved spherical component.Narasimhan*et al.* [83], worked a coupled explicit to implicit finite element procedure is outlined for predicting springback deformations in sheet metal forming processes.

III. DISCUSSIONS

From above literature review the parameters affecting springback are identified and are listed as

- Die and plug land
- Die and Plug angles
- Material of the tube
- Die and Plug material
- Lubrication and friction
- Reduction Ratio
- Drawing speed
- Tool temperature
- Recovery and recrystallisation
- Bauschinger effect
- Work hardening
- Anisotropy

These parameters can be classified and shown in fishbone diagram as shown in figure 1.

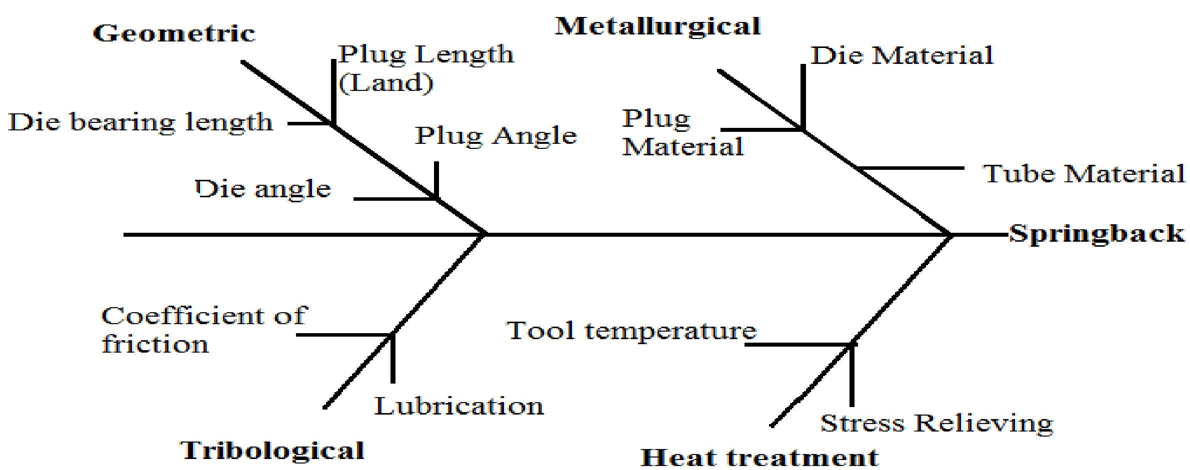

Figure 1: Parameters affecting springback

IV. CONCLUSIONS

Managing quality is crucial for small businesses. Quality products help to maintain customer satisfaction and loyalty and reduce the risk and cost of replacing faulty goods. This paper is a review on literature published in the context of springback during different manufacturing processes, which are used for manufacturing high quality products that have wide variety of applications in different sectors of engineering. It helps in understanding the research and developments carried out over a period of time for different problems associated with manufacturing and the different factors associated with this severe phenomenon.

REFERENCES

1. *Tekaslan, O., Seker, U., Ozdemir, A. (2006),"Determining springback amount of steel sheet metal has 0.5 mm thickness in bending dies."Journal of material and design; vol 27; pp 251-258.*
2. *Ghaei, A. (2012), "Numerical simulation of springback using an extended return mapping algorithm considering strain dependency of elastic modulus." International journal of mechanical science; vol 65; pp 38-47.*
3. *Panthi, S.K., Ramakrishnan, N., Pathak, K.K., Chouhan, J.S. (2007), "An analysis of springback in sheet metal bending using finite element method (FEM)."Journal of Materials Processing Technology; vol 186; pp 120-124.*
4. *Carden, WD., Geng, LM. Matlock, DK. (2002), "Measurement of springback." International Journal of Mechanical; vol 44; pp 79-101.*
5. *Li and Wagoner (2007), "Simulation of springback through-thickness integration."International Journal of Plasticity; vol 23; pp 44-86.*
6. *Xing, ZW. Bao, J., yang, YY. (2009), "Numerical simulation of hot stamping of quenchable boron steel."Journal of material science and engineering; vol 499; pp 28-31.*
7. *Rui-jie, Yang He, Zhan Mei, Heng LI (2006), "Springback of thin walled tube NC precision bending and its numerical simulation." Journal of transactions of non-ferrous metals society of china; vol 16; pp s631–s638.*
8. *Ingarao, G., Lorenzo, R.D., Micari,F. (2009), "Analysis of stamping performances of dual phase steels: A multi-objective approach to reduce springback and thinning failure."Journal of Materials & Design; vol 30; pp 4421-4433.*
9. *Peng, C., Koc, M. (2007), "Simulation of springback variation in forming of advanced high strength steels."Journal of materials processing technology; vol 190; pp 189-198.*

10. Lee, S.W. (2002), "Study on the forming parameters of the metal bellows."Journal of Materials Processing Technology; vol 130-131; pp 47-53.
11. Thipprakmas, S., Phanitwong, W. (2011), "Process parameter design of spring-back and spring-go in V-bending process using Taguchi technique."Journal of Materials & Design; vol 32; pp 4430-4436.
12. Asgari,S.A.,Pereira, M., Rolfe, B.F., Dingle, M., Hodgson, P.D. (2008), "Statistical analysis of finite element modeling in sheet metal forming and springback analysis."Journal of Materials Processing Technology; vol 203; pp 129-136.
13. Padmanabhan, R., Oliveira,M.C., Alves, J. L., Menezes, L.F.; (2007), "Influence of process parameters on the deep drawing of stainless steel"Journal of Finite Elements in Analysis and Design; vol 43; pp 1062-1067.
14. Chun-Chih Kuo, Bor-Tsuen Lin (2012), "Optimization of springback for AZ31 magnesium alloy sheets in the L-bending process based on the Taguchi method"The International Journal of Advanced Manufacturing Technology; vol 58; pp 161-173.
15. Gomes, C., Onipede, O., Michael, Lovell. (2005), "Investigation of springback in high strength anisotropic steels."Journal of Materials Processing Technology; vol 159; pp 91-98.
16. Thipprakmas, S., Rojananan, S. (2008), "Investigation of spring-go phenomenon using finite element method." Journal of Materials & Design; vol 29; pp 1526-1532.
17. Li, KP. Carden, WP. Wagoner, RH. (2002), "Simulations using solid and shell elements have been compared with draw-bend measurements presented in a companion." International Journal of Mechanical; vol 44; pp 103-122.
18. Thorat, S.G., Rajpal, J., Kothavale, B.S. (2015),"Finite Element Analysis and Mathematically Calculation Of Spring back In Rotary Draw Tube Bending." International Journal of Mechanical;vol 3; pp 123-131.
19. Wei, D., and Liu, Y. (2012), "Analytic and finite element solutions of the power-law Euler–Bernoulli beams"Journal of Finite Elements in Analysis and Design; vol 52; pp 31-40.
20. Livatyali, H., Wu, H.C., Altan, T. (2002), "Prediction and elimination of springback in straight flanging using computer-aided design methods: Part 2: FEM predictions and tool design"Journal of Materials Processing Technology; vol 120; pp 348-354.
21. Gronostajski, Z.J. (2001), "Correlation between stress–strain relation and phase transformation in copper alloys"Journal of Materials Processing Technology; vol 119; pp 244-250.
22. Lepadatu, D.,Hambli, R., Kobi, A., Barreau, A.(2005), "Optimisation of springback in bending processes using FEM simulation and response surface method"The International Journal of Advanced Manufacturing Technology; vol 27; pp 40-47.
23. Asgari,S.A.,Pereira, M., Rolfe, B.F., Dingle, M., Hodgson, P. D.; (2008), "Statistical analysis of finite element modeling in sheet metal forming and springback analysis"Journal of Materials Processing Technology; vol 203; pp 129-136.
24. Narasimhan, N., Lovell, M. (1999), "Predicting springback in sheet metal forming: an explicit to implicit sequential solution procedure" Journal of Finite Elements in Analysis and Design; vol 33; pp 29-42.
25. Rust, W.,Schweizerhof, K. (2003), "Finite element limit load analysis of thin-walled structures by ANSYS (implicit), LS-DYNA (explicit) and in combination" Journal of Thin-Walled Structures; vol 41; pp 227-244.
26. Chung, W.J., Cho, J.W., Belytschko, T. (1998), "On the dynamic effects of explicit FEM in sheet metal forming analysis"Journal of Materials Processing Technology; vol 15; pp 750-776.
27. Zein, H., Sherbiny, M.E., Abd-Rabou, M., shazly, M.E. (2014), "Thinning and spring back prediction of sheet metal in the deep drawing process"Journal of Materials & Design; vol 53; pp797–808.
28. Li, K.P., Carden, W.P., Wagoner, R.H. (2002), "Simulation of springback"International Journal of Mechanical Sciences; vol 44; pp 103-122.
29. Narayanasam, R., Padmanabhan, P. (2010), "Influence of Lubrication on Springback in Air Bending Process of Interstitial Free Steel Sheet"Journal of Materials Engineering and Performance; vol 19; pp 246-251.
30. Ragai, I., Lazim, D., James, A. (2005), "Anisotropy and springback in draw-bending of stainless steel 410: experimental and numerical study"Journal of Materials Processing Technology; vol 166; pp 116-127.
31. Carden, W.D., Geng, L.M., Matlock, D.K., Wagoner, R.H. (2002), "Measurement of springback"International Journal of Mechanical Sciences; vol 44; pp 79-101.
32. Panthi, S.K., Ramakrishnan, N., Ahmed, M., Singh, S.S., Goel, M.D. (2010), "Finite Element Analysis of sheet metal bending process to predict the springback" Journal of Materials & Design; vol 31; pp 657-672.

[Karanjule, 4(11): November 2017] ISSN 2348 – 8034
DOI- 10.5281/zenodo.1067498 Impact Factor- 4.022

33. *Xiao Z, Y, Ke, M. Y.,Fang, L., Shao, M., Li, Y.Y. (2009), "Die wall lubricated warm compacting and sintering behaviors of pre-mixed Fe–Ni–Cu–Mo–C powders"Journal of Materials Processing Technology; vol 209; pp4527–4530.*
34. *Sang-Wook Lee, Yoon-Tae Kim; (2007), "A study on the springback in the sheet metal flange drawing"Journal of Materials Processing Technology; vol 187-188; pp 89-93.*
35. *Moon, Y. H., Kang, S. S., Cho, J. R., & Kim, T. G. (2003), " Effect of tool temperature on the reduction of the springback of aluminum sheets",Journal of Materials Processing Technology, Vol132(1), pp.365-368.*
36. *Melton, Keith N. "Supression of the two-way effect by cold working and annealing." U.S. Patent No. 4,654,092. 31 Mar. 1987.*
37. *Jeswiet, J., "Metal forming progress since 2000." CIRP Journal of Manufacturing Science and Technology 1.1 (2008): 2-17.*
38. *Grèze, R., Manach, P. Y., Laurent, H., Thuillier, S., & Menezes, L. F. (2010), "Influence of the temperature on residual stresses and springback effect in an aluminium alloy. "International journal of mechanical sciences, 52(9), 1094-1100.*
39. *Kim, Hong Seok, and MuammerKoç.(2008),"Numerical investigations on springback characteristics of aluminum sheet metal alloys in warm forming conditions." journal of materials processing technology. Vol.204,pp. 370-383.*
40. *Kim, Hyung Jong, (2008),"Experimental determination of forming limit diagram and springback characteristics of AZ31B Mg alloy sheets at elevated temperatures." Materials transactions, vol.49, pp.1112-1119.*
41. *Fei, Dongye, and Peter Hodgson,(2006),"Experimental and numerical studies of springback in air v-bending process for cold rolled TRIP steels." Nuclear Engineering and Design,vol.236, pp.1847-1851.*
42. *Sunseri, M., Cao, J., Karafillis, A. P., & Boyce, M. C. (1996)," Accommodation of springback error in channel forming using active binder force control: numerical simulations and experiments", Journal of Engineering Materials and Technology, Vol.118 (3), pp.426-435.*
43. *Livatyali, H., and T. Altan,(2001),"Prediction and elimination of springback in straight flanging using computer aided design methods: Part 1. Experimental investigations." Journal of Materials Processing Technology, vol., pp.262-268.*
44. *Samuel, M., (2000),"Experimental and numerical prediction of springback and side wall curl in U-bendings of anisotropic sheet metals." Journal of Materials Processing Technology vol.105, pp.382-393.*
45. *Leu, Daw-Kwei, and Chung-Ming Hsieh, (2008),"The influence of coining force on spring-back reduction in V-die bending process." Journal of Materials Processing Technology vol.196, pp.230-235.*
46. *Papeleux, Luc, and Jean-Philippe Ponthot, (2002),"Finite element simulation of springback in sheet metal forming." Journal of Materials Processing Technology, vol.125, pp. 785-791.*
47. *Liu, Y. C.(1988),"The effect of restraining force on shape deviations in flanged channels." Journal of Engineering Materials and Technology, vol. 110, pp.389-394.*
48. *Gau, Jenn-Terng, and Gary L. Kinzel (2001),"An experimental investigation of the influence of the Bauschinger effect on springback predictions." Journal of Materials Processing Technology, vol.108.3, pp.369-375.*
49. *Oliveira, M. C., Alves, J. L., Chaparro, B. M., & Menezes, L. F. (2007), "Study on the influence of work-hardening modeling in springback prediction", International Journal of Plasticity, vol.23 (3), pp.516-543.*
50. *Raabe, D., Wang, Y., &Roters, F. (2005). Crystal plasticity simulation study on the influence of texture on earing in steel. Computational Materials Science, vol.34 (3),pp. 221-234.*
51. *Robertson, S. W., Imbeni, V., Wenk, H. R., & Ritchie, R. O. (2005), "Crystallographic texture for tube and plate of the superelastic/shape-memory alloy Nitinol used for endovascular stents", Journal of Biomedical Materials Research Part A, 72(2),pp.190-199.*
52. *Chan, W. L., and M. W. Fu. "Experimental studies of plastic deformation behaviors in microheading process." Journal of Materials Processing Technology 212.7 (2012): 1501-1512.*
53. *Geng, Lumin, and R. H. Wagoner.(2002), "Role of plastic anisotropy and its evolution on springback." International Journal of Mechanical Sciences, vol.44 (1), pp.123-148.*
54. *Murata, M., Kuboki, T., Takahashi, K., Goodarzi,M.,Jin, Y. (2008), "Effect of hardening exponent on tube bending"Journal of Materials Processing Technology; vol 201; pp 189-192.*

55. Andersson, A. (2005), "Numerical and experimental evaluation of springback in a front side member" Journal of Materials Processing Technology; vol 169; pp 352-356.
56. Firat, M., Mete, O. H., Kocabicak, U., &Ozsoy, M. (2010), "Stamping process design using FEA in conjunction with orthogonal regression. Finite Elements in Analysis and Design, vol.46 (11), pp. 992-1000.
57. Wang, C. J., Guo, B., Shan, D. B., Wang, Y. Z., Zhou, J., & Gong, F. (2011). Investigation of forming process for micro-socket connecters. Materials Research Innovations, vol.15, pp.225-229.
58. Firat, M., O. H. Mete, and U. Kocabicak. "A sensitivity analysis of springback deformations in stamping process." 4th International Conference and Exhibition on Design and Production of Machines and Dies/Molds, Cesme, Turkey. 2007.
59. Cho, J. R., Moon, S. J., Moon, Y. H., & Kang, S. S. (2003), " Finite element investigation on spring-back characteristics in sheet metal U-bending process", Journal of Materials Processing Technology, vol.141(1), pp.109-116.
60. Teimouri, R., Baseri, H., Rahmani, B., &Bakhshi-Jooybari, M. (2014), "Modeling and optimization of spring-back in bending process using multiple regression analysis and neural computation", International Journal of Material Forming, vol.7 (2), pp.167-178.
61. Meinders, Timo, (2008), "Numerical product design: springback prediction, compensation and optimization." International Journal of Machine Tools and Manufacture vol.48, pp.499-514.
62. Brandstätter, Bernhard, and Ulrike Baumgartner,(2002), "Particle swarm optimization-mass-spring system analogon." Magnetics, IEEE Transactions on 38.2, pp.997-1000.
63. Lingbeek, R., Huetink, J., Ohnimus, S., Petzoldt, M., &Weiher, J, (2005), "The development of a finite elements based springback compensation tool for sheet metal products", Journal of Materials Processing Technology, vol.169 (1), pp.115-125.
64. Chou, I-Nan, and Chinghua Hung,(1999),"Finite element analysis and optimization on springback reduction." International Journal of Machine Tools and Manufacture, vol.39, pp.517-536.
65. Palaniswamy, Hariharasudhan, Gracious Ngaile, and Taylan Altan,(2004),"Optimization of blank dimensions to reduce springback in the flex forming process." Journal of Materials Processing Technology, vol.146, pp.28-34.
66. Shu, Jaw-Shi, and Chinghua Hung,(1996),"Finite element analysis and optimization of springback reduction: the "double-bend" technique." International Journal of Machine Tools and Manufacture 36.4 (1996): 423-434.
67. Ling, Y. E., H. P. Lee, and B. T. Cheok (2005),"Finite element analysis of springback in L-bending of sheet metal." Journal of Materials Processing Technology, vol.168, pp.296-302.
68. Choi, Kyung K., and Nam H. Kim,(2002),"Design optimization of springback in a deep drawing process." AIAA journal, vol.40, pp.147-153.
69. Lee, Myoung-Gyu, (2007),"A practical two-surface plasticity model and its application to spring-back prediction." International Journal of Plasticity, vol 23.7, pp.1189-1212.
70. Jakumeit, J., M. Herdy, and M. Nitsche,(2005),"Parameter optimization of the sheet metal forming process using an iterative parallel Kriging algorithm." Structural and Multidisciplinary Optimization, vol.29, pp.498-507.
71. Liew, K. M., Tan, H., Ray, T., & Tan, M. J. (2004), "Optimal process design of sheet metal forming for minimum springback via an integrated neural network evolutionary algorithm", Structural and Multidisciplinary Optimization, vol.26 (3-4), pp.284-294.
72. Kayabasi, Oguz, and BulentEkici,(2007),"Automated design methodology for automobile side panel die using an effective optimization approach." Materials & design, vol.28, pp.2665-2672.
73. Lee, S. W., and D. Y. Yang,(1998),"An assessment of numerical parameters influencing springback in explicit finite element analysis of sheet metal forming process." Journal of Materials Processing Technology, vol.80, pp. 60-67.
74. Baba, Akijiro, and Yasuhisa Tozawa (1964), "Effect of tensile force in stretch-forming process on the springback." Bulletin of JSME, pp.834-843.
75. Lee, Myoung-Gyu, (2005),"Spring-back evaluation of automotive sheets based on isotropic–kinematic hardening laws and non-quadratic anisotropic yield functions, part III: applications." International Journal of Plasticity vol.21, pp. 915-953.

76. *Gau, Jenn-Terng, and Gary L. Kinzel, (2001),"A new model for springback prediction in which the Bauschinger effect is considered." International Journal of Mechanical Sciences vol.43, pp.1813-1832.*
77. *Li, K. P., W. P. Carden, and R. H. Wagoner,(2002), "Simulation of springback." International Journal of Mechanical Sciences, vol.44, pp.103-122.*
78. *Kim, Se Young, Won Jong Choi, Sang Yoon Park (2007), "Spring-back characteristics of fiber metal laminate (GLARE) in brake forming process." The International Journal of Advanced Manufacturing Technology, vol.32, pp.445-451.*
79. *Karafillis, A. P., and M. C. Boyce (1992),"Tooling design in sheet metal forming using springback calculations." International journal of mechanical sciences, Vol.34, pp.113-131.*
80. *Chan, W. M., (2004),"Finite element analysis of spring-back of V-bending sheet metal forming processes." Journal of materials processing technology, vol.148, pp.15-24.*
81. *Karafillis, Apostolos P., and Mary C. Boyce (1996),"Tooling and binder design for sheet metal forming processes compensating springback error." International Journal of Machine Tools and Manufacture, vol.36.pp. 503-526.*
82. *Ho, K. C., J. Lin, and T. A. Dean (2004),"Modeling of springback in creep forming thick aluminum sheets." International Journal of Plasticity, vol.20, pp. 733-751.*
83. *Narasimhan, Narkeeran, Michael Lovell (1999),"Predicting springback in sheet metal forming: an explicit to implicit sequential solution procedure." Finite Elements in Analysis and Design, Vol 33, pp. 29-42.*