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REVIEW OF COLD DRAWING PROCESS OPTIMIZATION OF REDUCTION RATIO FOR MINIMIZING THE SPRING BACK DURING COLD DRAWING OF SEAMLESS TUBES

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ABSTRACT

Cold drawing is process of pulling the tube through a die, the size of which determines the outside diameter of the drawn tube. It is widely used metal forming process because ofachievement of closer dimensional tolerances, better surface finish and improved mechanicalproperties. The principal industrial requirement of tube drawing is high reduction ratio per pass,long tool life, better surface finish etc. A compromise solution to the problems of meeting theserequirements is achieved economically by the selection of appropriate tool material, die angle,lubricants, surface treatments of undrawn tubes, heat treatment and drawing conditions such asdraw speed and reduction of area. However ,as there is a continuing and an increasing need toreduce costs i.e. to draw at higher speeds and at higher reductions and to eliminate or minimizesurface treatments different models have been proposed and validated using experimental resultsover a long period of time. In this paper, process details of cold drawing, major analytical,

experimental and numerical studies reported in literature have been reviewed. The reviewfocuses on highlighting the research and developments associated with the tube production,processing machines, drawing technology, lubrication systems that includes improvement in tooldesign, modification in product geometry, process optimization etc. with the use differenttechniques to achieve the high quality standard product.

Keywords: Cold drawing, Optimization, Die, Plug.

INTRODUCTION

Towards the end of the nineteenth century, various processes became available for the manufacture of seamless tube and pipe, with production volumes rapidly increasing over a relatively short period. As the requirements imposed on tubular products continued to increase, not only were the associated manufacturing processes constantly improved, but also appropriate systems for effective production control and quality assurance were introduced(Kopp.1996).Nowadays, tube and pipe manufacturers all have a system in their place enabling the production process from the steelworks to the finished tube to be continuously monitored and documented for total traceability, and effectively controlled on the basis of quality criteria. The mechanical and non-destructive tests stipulated in the relevant technical specifications are carried out by personnel operating independently from the production control department so as to guarantee product of a constantly high quality. The different processes of seamless tube manufacturing include Piercing, Assel, Rolling, Extrusion, Pilgering, Cold Drawing etc. (Avitzur.1968).

1.1.1 Cold Drawing

Seamless precision steel tube has been standardized in DIN 2391 for the diameter range from 4 to 120 mm and wall thicknesses from 0.5 to 10 mm. In addition, however, non-standardized intermediate sizes, and tube up to 380 mm outside diameter with wall thicknesses up to 35 mm, can also be manufactured by cold drawing (Bayoumi, 2001). There are three processes employed for the cold drawing of tube: hollow drawing, stationary or floating plug drawing, and drawing over a mandrel (also known as drawing on the bar).

1.1.2 Defects in Cold drawing process

Following defects are found during cold drawing

- Eccentricity
- Bending
- Internal cracks.
- External cracks.

- Ovality.
- Dimensional Variations Larger and smaller inside / outer diameter.
- Wavy surface.
- Tube thickness oversize.
- ID and OD scores
- Springback

1.1.3 Springback

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. We name this nature of material as springback (Wagoner, 2013). 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 (Chen, 2007). 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.

Many research studies conducted in the last 15 years have indicated that springback has aimportant role in cold drawing industry and studied how this permanent physical variation can be avoided. It has been observed that, the one common point of all these researches is based on estimating or determining the amount of springback beforehand and accordingly designing and later manufacturing of dies to be based on the consideration of this springback amount. Springback can be minimized by means of die design; however it cannot be eliminated completely. If springback cannot be estimated exactly beforehand, in order to find out the value to substitute springback as well as proper shaping parameters tests one after the other are performed to find out springback amount. This will lead to wastage of time and material and the most important of all – increase in cost. Therefore, knowing beforehand that springback amount has cardinal importance (Leu, 2008).

Springback varies with composition, material properties and dimensional range of outer diameter and thickness (Karanjule *et al* 2012). 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.

The solution yields improved dimensional consistency, tighter size and tolerances, improved quality, straightness and machinability, productivity, formability, longer tool life resulting cost effectiveness (Nanu, 2012). Determination of springback by means of trial and error technique not only increases the cost of manufacture and repair of tool but also waste of time causing delay in the development of product.

1.2 LITERATURE REVIEW

In the past various researches has been carried out on the springback of metal forming processes. Deep *et al.* (1983) pointed out that for a given initial and final tube dimensions the optimum die length and drawing stress are related to each other. It illustrated that the optimum die length decreases with increasing friction factor whereas the related drawing stress increases with increasing friction factor. Um *et al*. (1997) suggested that the optimum die angle which made the drawing shear minimum was mainly determined by the internal shear and the friction. Wagoner (2013) studied effect of Young's Modulus on springback.Kwan*et al*. (2002) found that for a given initial and final tube dimensions friction factor and position of the inflection point of die and plug profiles; there was variation of drawing stress with die length. The optimum die length which minimized the drawing stress is determined by internal deformation and friction. Pietrzyk *et al* (1990) revealed that finite element approaches are used extensively in the modelling of plastic flow, while Sawamiphakdi *et al.* (1991) developed Computer programs and validated with the experimental data for determining appropriate processing parameters to improve quality control capabilities. Al-Qureshi *et al*. (2000) presents analytical results whereby approximate equations are derived to provide a quantitative method for predicting spring-back behaviour and residual stress distributions. Mole (2014) studied the numerical method of forming tool optimization in sheet metal.Jaroslav Mackerle (2002) suggests that Finite Element Methods (FEM) can be applied for analysis from the theoretical as well as practical point of view.

Chin-Tarn Kwan (2002) proposed a generalized kinematically admissible velocity field suitable for axisymmetric tube drawing through arbitrarily curved die with an arbitrarily curved plug and optimal die and plug profiles for tube drawing are determined. Moon *et al* (2003) studied the effect of tool temperature on the reduction of springback amount. As the springback phenomenon is caused by elastic recovery, the control of elastic recovery is important in decreasing the amount of springback.

Slota (2014) explains the effect of friction coefficient; blank holder force and tool geometry on springback in sheet metal work.Tekaslan *et al* (2004) discussed the importance of die design in order to minimize springback and significance of materials to determine this permanent variation. Singh et al. (2004) concludes that the product quality is influenced by tool geometry. Wu *et al.* (2004) suggested that computer simulations are excellent tools to predict and evaluate the tool and process design. Kim *et al.* (2004) considered the effect of the plastic hardening and the effect of the tensile force on the springback phenomena. The process was simulated utilizing commercial finite element analysis program ABAQUS.Ragai *et al (*2005) discussed the effect of anisotropy on the springback. The role that the anisotropy plays in the springback is assessed experimentally as well as through finite element simulations. Daw-Kwei Leu (2006) explained the effects of various process parameters such as geometric ratio, strain hardening exponent and coefficient of friction. Daw-Kwei Leu (2006) studied the squaring processes to shape the circular tube into a symmetric square-tube which are examined by an incremental elasto-plastic finite-element method based on an updated Lagrangian formulation. The highly non-linear problems due to the geometric changes, the inelastic constitutive behaviour and the boundary conditions varied with deformation are taken into account in an incremental manner. Oliviera *et al.* (2007) emphasised on the influence of work hardening modelling in springback prediction. Bayoumi *et al.* (2009) suggested that the forming tool load in plastic shaping of a round tube into a square tubular section has been determined analytically and also numerically by applying finite element simulation. The theoretical results were compared to experimental measurements.Grezee*et al*(2010) his research deals with the experimental and numerical investigation of springbackat different temperatures.

Prete *et al* (2010) in his paper focuses on experimental and numerical activity developments of process simulation through FEM for designing a new process or improving an established one. In the experimental work Panthi *et al* (2010) focuses on various geometrical parameters, material properties and lubrication conditions so as to minimize springback using Finite Element Analysis. Lim *et al* (2012) concludes that the time dependent springback is due to room temperature creep and inelasticity. Nanu *et al*(2012) proposes that the springback is influenced by stress distribution and normal anisotropy influences level of stresses and finally springback intensity. Zhu *et al* (2012) reviewed of development and application of material constitutive model which is applied for springback calculations. Ouakdi*et al* (2012) paper concluded that Springback depends upon entrance radius of die, force and Bauschinger effect. Wagoner *et al*(2012) surveyed the research work focused on plastic constitutive equations, variable Young's modulus.

From all above discussion it is observed that the springback phenomenon depends upon material properties, tool geometry, and friction and lubrication conditions. The different parameter interrelated to springback: bearing length (land) of die and plug, die and plug angles, material of the tube, die and plug material , lubrication and friction, geometric ratio, strain hardening exponent, collapse ratio, drawing speed, tool temperature, anisotropy, recovery and recrystalization, bauschinger effect, work hardening etc.

After going through Literature it is found that the different authors have focused on spring back by considering two- three parameters. Our aim is to focus on all the parameters simultaneously so as to get optimized tool geometry.

1.3 PARAMETERS AFFECTING THE SPRING BACK

- 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

The credit seminar was aim to identify to find out the research methodology tools and techniques. The seminar carried the detailed study of types of research and research process.

Finally the seminar focus on detailed study of various tools used in research based study. The tools studied are as follows

- Hypothesis testing- one sample test
- Hypothesis testing- two sample test
- Chi squire test
- Analysis of variance
- Regression analysis and correlation

2.2 -COLD DRAWING AND SPRINGBACK: A REVIEW OF LITERATURE

The extensive literature reviews were carried out considering most reputed Journals in the research field.

Table 2.1:List of Journals and their Impact factor

Sr. No	Title	H Index	Impact Factor
1	Journal of Materials Processing Technology	83	2.363
2	International Journal of Mechanical Sciences	57	1.815
3	Materials and Design	48	3.304
4	International Journal of Plasticity	75	4.985
5	International Journal of Machine Tools & Manufacture	70	1.53
6	Computer Methods in Applied Mechanics and Engineering	107	3.117
7	Materials and Manufacturing Processes	25	1.379
8	Procedia Engineering	7	0.272
9	International Journal of Pressure Vessels and Piping	39	1.068
10	International Journal of Mech. Tool Manuf.	15	0.59

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11	Journal of Mechanical working technology	61	1.28
12	Tribology Transactions	38	1.047
13	International Journal ofPolymeric Materials andPolymeric Biomaterials	25	0.57
14	International Journal of Solids and Structures	88	2.105
15	Journal of Nuclear Materials	78	1.237
16	Journal of the Chinese Institute of Industrial Engineers	12	0.602
17	International Journal of Mechanical Sciences	57	1.95
18	International Journal of Fatigue	61	2.397
19	Materials Science and Technology	50	0.83
20	Materials Science Forum	50	0.384

Ample literature is available on spring back. Hundreds of research papers are referred for this study. Out of these 26 papers are found most promising to find out further research direction. The review of 26 papers is presented in tabular format as below.

2.3DETAILED STUDY OF RESEARCH PAPER

The detailed study of the paper is as follows.

Table 2.2 :Literature Survey

Sr. No.	Author	Summery	Remark
1.	N. Mole(2014)	In this paper, an enhanced numerical method for forming tool design optimisation in three-dimensional(3D) sheet metal forming applications considering springback effect	A 3D forming tool optimisation method considering springback and thinning compensation

		is presented	
2	Slota J. et al(2014)	Paper explains effect of friction coefficient, blank holder force, different geometry of tools on springback	Validation Using FEM should be included
3	Wagoner et al. (2013)	Paper surveyed the research work focused on plastic constitutive equations, variable Young's modulus, Through-thickness integration of stress, Advanced high strength steels.	More practices like constitutive model, Friction, Temperature and new technology has to be take into account.
4	Ouakdi et al. (2012)	Paper concluded that Springback depends upon entrance radius of die, force and Bauschinger effect.	Only survey based research, no framework has been developed
5	Zhu et al. (2012)	Paper is review of development and application of material constitutive model which is applied for springback calculations.	Only Elastic behaviour, anisotropy and work hardening are considered.
6	Nanu et al. (2012)	This research proposes that the springback is influenced by stress distribution and normal anisotropy influences level of stresses and finally springback intensity.	To improve material behavior with Bauschinger effect and variation of Young's modulus with plastic strains has to be considered.

7	Lim et al. (2012)	This paper concludes that the time dependent springback is due to room temperature creep and inelasticity.	Simulated results over estimate time dependent springback using steady state creep law and under estimate using time hardening or strain hardening creep law
8	Panthi et al. (2010)	Papers focus on various geometrical parameters, material properties and Lubrication conditions so as to minimize spring back using Finite Element Analysis.	The research can extended by studying the impact of more parameters.
9	Prete et al. (2010)	The paper focuses on experimental and numerical activity developments of process simulation through FEM for designing a new process or improving an established one.	Authors are investigating the chance to analyze the generated data in a different way trying to evaluate possible cross relationships among considered variables using new data analysis tools like Engineering Intelligence.
10	Grezeet al. (2010)	This research deals with the experimental and numerical investigation of springback at different temperatures.	Determination of optimal operating temperature needs further investigations.
11	Bayoumi et al.(2009)	The forming tool load in plastic shaping of a round tube into a square tubular section has been determined analytically and also	The finite element Simulation results were in agreement only at small deformation with the experimental results.

		numerically by applying finite element simulation.	
12	Kim et al.(2008)	The results show the effect of temperature gradients on springback.	Research needs to be extended to more complex heating modes where a sharp temperature gradient is required on the tooling surface.
13	Oliviera et al. (2007)	Paper emphases on the influence of work hardening modelling in springback prediction.	One model can predict larger springback for some materials and smaller for other ones.
14	Daw-Kwei Leu (2006)	This study is the squaring processes to shape the circular tube into a symmetric square-tube are examined by an incremental elasto-plastic finite-element method based on an updated Lagrangian formulation. The highly non-linear problems due to the geometric changes, the inelastic constitutive behavior and the boundary conditions varied with deformation are taken into account in an incremental manner.	Still to find out two kinds of collapse and investigate the effects of various process parameters on the occurrence of collapse during the process
15	Daw-Kwei	Author explains the effects of	Further study is needed to

	Leu (2006)	various process parameters such as geometric ratio, strain hardening exponent and coefficient of friction	investigate the effects of various process parameters on the occurrence of collapse.
16	Ragai et al. (2005)	This paper discusses the effect of anisotropy on the springback. The role that the anisotropy plays in the springback is assessed experimentally as well as through finite element simulations.	The importance of the Bauschinger Effect and its proper description is still under investigation.
17	Kim et al. (2004)	The analytical calculation was done on the basis of beam theory and elastic–perfectly Plastic material property. The analysis model has considered the effect of the plastic hardening and the effect of the tensile force on the spring back phenomena. Apart from the analytical approach, finite element analysis was carried out to investigate Methodological comparison and the quantitative evaluation of the spring back. The process was simulated utilizing commercial finite element analysis program	Springback can be reduced to the allowable limit by the application of tensile force. However; excessive tensile force can induce the ovality and tube thickness reduction.

ABAQUS.

18	Wu et al. (2004)	This paper is related to process optimization.Computer simulations are excellent tools to predict and evaluate the tool and process design.	It is found that the calculated loads and real loads are different.
19	Singh et al. (2004)	This paper concludes that the product quality is influenced by tool geometry.	The effect of tool penetration the is also important. Under the conditions employed significant errors occurs in the product
20	Tekaslan et al. (2004)	Paper discusses the importance of Die design in order to minimize spring back and significance of materials to determine this permanent variation.	During Experimental work uniform spring back is not observed.

21	Moon et al. (2003)	This study is related to the effect of tool temperature on the reduction of springback amount. As the springback phenomenon is caused by elastic recovery, the control of elastic recovery is important in decreasing the amount of springback. Therefore, any combination of tool temperature that can reduce elastic recovery can be effective in reducing the amount of springback. The experimental verification can reduce the amount of springback up to 20% .	In case of tool temperature control, proper speed is important for the reduced springback because the effectiveness of the tool temperature control depends on how well the metal can be heated or cooled
22	Chin-Tarn Kwan (2002)	Paper proposes a generalised kinematically admissible velocity field suitable for axisymmetric tube drawing through arbitrarily curved die with an arbitrarily curved plug and optimal die and plug profiles for tube drawing are determined.	Work piece material is assumed to be rigid-perfectly plastic. The effect of die length, friction factor has to be considered.
23	Jaroslav Mackerle (2002)	Finding suggests that Finite Element Methods (FEM) can be applied for analysis from the theoretical as well as practical point of view.	The sample of this study is limited to review purpose only.

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24	Al-Qureshi et al. (2000)	This paper presents analytical results whereby approximate equations are derived to provide a quantitative method for predicting spring-back behavior and residual stress distributions. Comparisons between experimental and theoretical results of spring-back have shown good agreement.	The transition from handcraft To technical control has necessitated a careful study of the basic mechanics involved in bending tubes.
25	Sawamiphakdi et al. (1991)	Computer programs were developed and validated with the experimental data for determining appropriate processing parameters to improve quality control capabilities.	Flexibility of die material is taken into account.

2.4 RESEARCH GAP

After reviewing most promising papers in the area of springback effect, following research gap has been noted.

- After reviewing literature, it is found that, most of the authors have considered single parameter for optimisation of tool geometry.
- Most of the work is done on springback in sheet metal and very less work in cold drawing.
- Though some author considered combined parameter it is not exceeding three parameters out of 12 parameters of tool geometry.

- All the selected parameters by author in their research articles does not mentioned interrelationship of parameters with each other.
- Most of work is simulation based and the work is not validated by experimental work.
- It is research activity of Research and Development (R & D) team to optimize tool geometry so as to minimize the spring back as possible as to manufacture more and more precise and accurate tubes.
- Nobody has done the Metallurgical and Microscopic Behaviour of the Seamless tubes.
- Die wear and Degradation is the most important topic which has to be studied.

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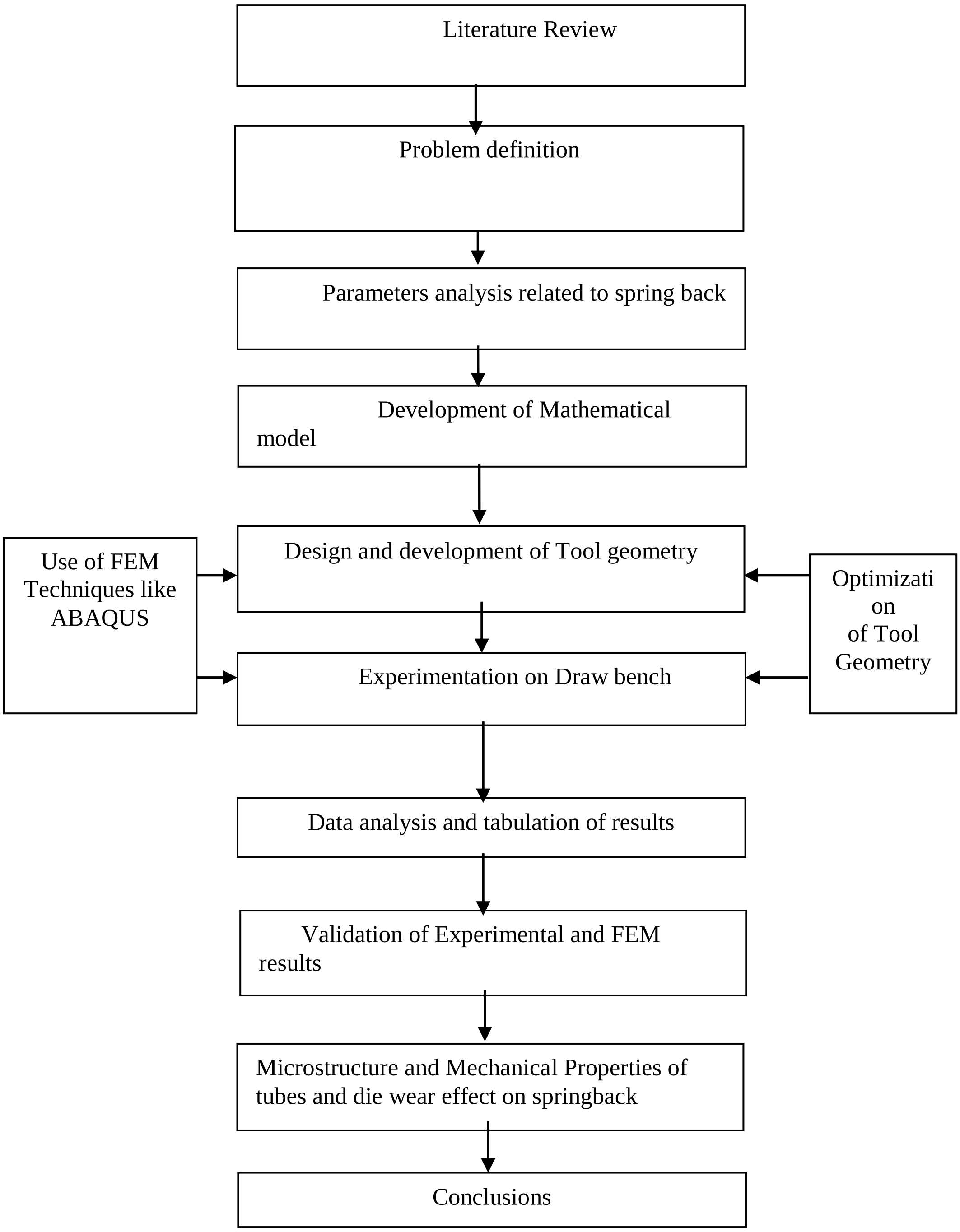
2.5 RESEARCH PLAN

From the research gap the research plan is developed to fulfil the research objectives. The research plan is shown in Figure 2.1



Die and plug Angle

Table 2.3: Construct for *Die and plug Angle* and literature support

Die Angle: The angle of die at which the area reduction of the tube takes place is called as Die angle. Generally Die Angle is expressed as semi-die angle and denoted by 'α'.	"Influence of die semi-angle on mechanical properties of single and multiple pass drawn copper tube" "Simulation and experimental validation of multiple-step wire drawing processes" "Study of cold tube drawing by finite-element modeling" "A new analytical solution for prediction of forward tension in the drawing process" "Numerical and Experimental Analysis of Tube Drawing With Fixed Plug"	1. Castro *et.al* (1996) 2. Celentano *et.al*(2009) 3. Gonza lez Rojas *et.al*(2008) 4. Karnezis *et.al*(1998) 5. Neves *et.al* (2005)

Plug Angle: The angle of plug at which the inner area reduction of the tube takes place is called as plug angle. Generally Plug Angle is expressed as plug semi-angle. Its diameter is slightly smaller than the tube inner diameter. The plug semi-angle in the work zone is smaller than die semi-angle. It is defined to be 2 degrees or smaller than die semi-angle.	"Numerical and Experimental Analysis of Tube Drawing With Fixed Plug" "Energetic analysis of tube drawing processes with fixed plug by upper bound method" "Design and analysis of direct cold drawing of section rods through a single die"	1. Neves *et.al* (2005) 2. Rubio *et.al* (2006) 3. Wang *et.al*(2005)

Table 2.4: Construct for land width and literature support

The bearing length and cross section size determine the size and surface finish of the drawn material. Too high a bearing length will spoil the surface finish and too low a bearing length will cause excessive die war. The length of bearing is kept longer for drawing material with high tensile strength and	"Influence of die semi-angle on mechanical properties of single and multiple pass drawn copper tube" "Simulation and experimental validation of multiple-step wire drawing processes" "A new analytical solution for prediction of forward tension in	1. Castro *et.al*(1996) 2.Celentano *et.al*(2009) 3. Gonza *et.al*(2008) 4. Karnezis *et.al*(1998) 5. Neves *et.al*(2005)

shorter for low strength materials.	the drawing process" "Study of cold tube drawing by finite-element modeling" "Numerical and Experimental Analysis of Tube Drawing With Fixed Plug"	

Land width(Bearing Length)

- ***Drawing speed***

Table 2.5: Construct for drawing speed and literature support

The drawing speed is proportional to the drawing forces and more the drawing forces or speed more is the friction. Attempts to reduce the friction s done. An optimum Drawing speed promotes pressurized lubrication and to reduces drawing forces.	" Wire drawing at elevated temperatures using differentdie materials and lubricants" "Numerical and Experimental Analysis of Tube Drawing With Fixed Plug" " Cold drawing of 316L stainless steel thin-walled tubes: experiments andfinite element analysis"	1. Hillery *et.al*(2005) 2. Neves *et.al*(2005) 3.. Palengat*et.al*(2013)

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Table 2.6: Construct for Tool temperature and literature support

It isthe Temperature generated during deformation. Tool temperature highly affects the product quality,	"Wire drawing at elevated temperatures using differentdie material and lubricants" "Numerical investigations on springback characteristics ofaluminum sheet metal alloys in warm forming conditions" " Effects of degrees of deformation and stress-relief temperatures on themechanical properties and residual stresses of cold drawn mild steel rods"	1. Hillery *et.al*(2005) 2. Kim *et.al (2008)* 3..Alawode *et.al*(2005)

- ***Tool Temperature***

Table 2.7: Construct for material of the tube and literature support

St 52,16MnCr5,ASTM A106,EN19,SA179,SAE 1008,SAE 1026,SA 213 T11,15 Mo3 are commonly used materials for Seamless Tubes	"Numerical modeling and experimental validation of steel deep drawing processes"	1. Garcia *et.al*(2006)

Material of tube

Table 2.9: Construct for Re-crystallisation and literature support

Recrystallization is a process by which deformed grains are replaced by a new set of undeformed grains that nucleate and grow until the original grains have been entirely consumed. Recrystallization is usually accompanied by a reduction in the strength and hardness of a material and a simultaneous increase in the ductility.	"Shear localization and recrystallization in dynamic deformation of 8090 Al-Li alloy"	1.Xu *et al*(2001)

- ***Re-crystallisation***

Bauschinger Effect

Table 2.10 :Construct for Bauschinger effect and literature support

The Bauschinger effect refers to a property of materials where the material's stress/strain characteristics change as a result of the microscopic stress distribution of the material. The Bauschinger effect is normally associated with conditions where the yield strength of a metal decreases when the direction of strain is changed.	"Sheet metal forming analyses with an emphasison the springback deformation" "The influence of coining force on spring-back reduction in V-die bending process"	1.Firat*et.al*(2008) 2.Leu *et.al*(2008)

Lubrication and Friction

Table 2.11 :Construct for Lubrication and Friction and literature support

- ***Work hardening***
- ***Reduction Ratio***

Table 2.13 :Construct for Reduction ratio and literature support

The ratio of change in cross section after unloading to the original cross section. $\gamma = \frac{A_i - A_o}{A_i}$ A_i = Cross section at inlet.	"Inflences of Reduction Ratio on Mechanical Properties and Transformation Temperature of NiTi Drawn Wires"	1.Noonai *et.al*(2011)

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Table 2.14: Construct for anisotropy and literature support

A_o = Cross section at exit.

- ***Anisotropy***

Normal anisotropy *R* of the sheet, a measure of the resistanceto through thickness thinning, can be represented by theplastic strain ratio of width to thickness in a simple tensile test	"Simulation of springback variation in forming of advanced high strength steels" "Sheet metal forming analyses with an emphasis on the springback deformation" "The influence of coining force on spring-back reduction in V-die bending process"	1. Chen *et.al*(2007) 2.Firat*et.al(2008)* *3.*Leu *et.al*(2008)

- ***Material of Die and Plug***

Table 2.15: Construct for Material of die and plug and literature support

D2 or D3 Steel is an air hardening, high-carbon, high-chromium tool steel. It has high wear and abrasion resistant properties. It is heat treatable and will offer a hardness in the range 55-62 HRC, and is machinable in the annealed condition.	Wire drawing at elevated temperatures using differentdie materials and lubricants". "Simulation of springback variation in forming of advanced high strength steels"	1. Hillery *et.al*(2005) 2.Chen *et.al*(2007)

CONCLUSIONS

Drawing process has been analytically studied for several years. Different approaches canbe quoted. Different studies were proposed, highlighting the importance of physical parameters.This paper is a review on literature published related to cold drawing process; which is used formanufacturing high quality products. It helped in understanding the research and developmentscarried out over a period of time for different problems associated with cold drawing and different approaches involved in problem solving .interfaces are in good agreement with theexperimental results.

REFERENCES

1. Alawode, A. J., & Adeyemi, M. B., (2005), "Effects of degrees of deformation and stress-relief temperatures on the mechanical properties and residual stresses of cold drawn mild steel rods", *Journal of materials processing technology*, vol.*160,no.*2,pp. 112-118.
2. Alexander, J. M.,(1965), "Hydrostatic Extrusion of Wires," *Journal of the Institute of Metals*, Vol. 93, pp. 366–369.
3. Anggono,A., Siswanto,W., Omar,B.,(2012), "Algorithm Development and Application of Spring back Compensation for Sheet Metal Forming",*Research Journal of Applied Sciences, Engineering and Technology*,Vol. 4,no14,pp.2036-2045
4. Antonio Del Prete, Teresa Primo, Matteo Strano,(2010), "The use of FEA packages in the simulation of a drawing operation with springback in the presence of random uncertainty", *Finite Elements in Analysis and Design* , vol.*46 ,pp.527-546.*
5. Avitzur B.,(1968), "Metal Forming: Processes and Analysis", McGraw-Hill, New York, NY, pp. 162-65 and 221-29.
6. Bayoumi L., Attia A.,(2009), "Determination of forming tool load in plastic shaping of a round tube into a square tubular section", *Journal of Materials ProcessingTechnology*, vol.209, pp.1835-1842.

7. BlazynskiT.Z.,(1976), "Metal Forming Tools Profiles and Flow", The Macmillan Press Ltd.
8. Caddell, R. M. and A. G. Atkins,(1968), "The Influence of Redundant Work When Drawing Rods through Conical Dies," *Journal of Engineering for Industry*, Vol. 90, pp. 411–419.
9. Campos, H. B., &Cetlin, P. R. ,(1998), " The influence of die semi-angle and of the coefficient of friction on the uniform tensile elongation of drawn copper bars",*Journal of Materials Processing Technology*,vol*80*,pp 388-391.
10. Carpinteri, A., Brighenti, R., &Vantadori, S., (2010), " Influence of the cold-drawing process on fatigue crack growth of a V-notched round bar", *International Journal of Fatigue*, vol.*32*,*no*.7,pp. 1136-1145.
11. Celentano, D. J., Palacios, M. A., Rojas, E. L., Cruchaga, M. A., Artigas, A. A., & Monsalve, A. E., (2009), " Simulation and experimental validation of multiple-step wire drawing processes",*Finite Elements in Analysis and Design*, Vol.*45*,*no* 3, pp163-180.
12. Celentano, D. J., Rosales, D. A., Pena, J. A., (2011), " Simulation and Experimental Validation of Tube Sinking Drawing Processes", *Materials and Manufacturing Processes*, vol *26*,*no*.5,pp. 770-780.
13. Chen, P., & Koç, M., (2007), " Simulation of springback variation in forming of advanced high strength steels", *Journal of Materials Processing Technology*, vol.*190*,*no*.1,pp 189-198.
14. Chin – Tarn K.,(2002), "A generalized velocity field for ax symmetric tube drawing through an arbitrary curved die with an arbitrary curved plug". *Journal of MaterialsProcessing Technology*,vol. 122,pp 213-219.
15. Daw Kwei Leu, (2006), 'The shaping of circular tube into a symmetric square tube by finite element modelling', *Journal of Materials Processing Technology, vol.78, pp.287-296.*
16. Deep G., Farge J. C., Chollet P., Gervais E.,(1983), "Tool angle optimization in rod and tube drawing ", *ASME*, Montrel, Canda, Vol2, no.4 ,pp.264-270.
17. Dieter G., "*Mechanical Metallurgy*" McGraw-Hill, 1988.
18. Dixon, R. F.,(1987), "Company Works to Develop Die-Less Drawing Process," *Wire Journal International*, Vol. 20, No. 10,pp. 25–26 and 28,
19. Firat, M., Kaftanoglu, B., & Eser, O., (2008), " Sheet metal forming analyses with an emphasis on the springbackdeformation",J*ournal of materials processing technology*, vol.*196*,*no*1,pp 135-148.

20. Flanders, N. A. and E. M. Alexander.(1979), "Analysis of Wire Temperature and Power Requirements on Multi-Pass Drawing Productivity," *Wire Journal International*, Vol. 12, No. 4, pp. 60–64.

21. Fowler, T. and P. R. Lancaster. "Factors Limiting Speed in Wire Drawing," *Wire Industry*, Vol. 50, No. 592, pp. 208-211.

22. García, C., Celentano, D., Flores, F., Ponthot, J. P., & Oliva, O., (2006), " Numerical modelling and experimental validation of steel deep drawing processes: Part II: Applications", *Journal of materials processing technology*, vol.*172,no.*3,pp. 461-471.

23. González Rojas, H. A., Calvet, J. V., &Bubnovich, V. I. ,(2008), " A new analytical solution for prediction of forward tension in the drawing process", *Journal of Materials Processing Technology*, vol.*198,no*1, 93-98.

24. GrandemangeF.,(Executive Engineer)(1982), "*Manufacturing Process of Seamless tubes*." Manual Vallource.

25. Greze,R, Manach,P.,LaurentH,ThuillierS.,Menezes L., (2010), "Influence of the temperature on residual stresses and springback effect", *International Journal of Mechanical Sciences,* vol.52, *pp.1094-1100.*