ACADEMICIA

ISSN: 2249-7137 Vol. 11, Issue 9, September 2021 Impact Factor: SJIF 2021 = 7.492

ACADEMICIA
An International Multidisciplinary Research Journal
(Double Blind Refereed & Peer Reviewed Journal)

DOI: 10.5958/2249-7137.2021.01988.1

ANALYZING METAL FORMING PROCESS

Berdiyev D.M*; Yusupov A.A; Abdulayev B.K.*****

*DSc, Professor,
Tashkent State Technical University,
UZBEKISTAN

**Ph.D., Associate Professor,
Tashkent State Technical University,
UZBEKISTAN

***Researcher at Tashkent State Technical University,
UZBEKISTAN

ABSTRACT

In this paper, some of the most important criteria of metal forming process are analyzed and studied. Frequently, work piece material is not sufficiently malleable or ductile at ordinary room temperature, but may become so when heated. Thus, we have both hot and cold metal forming operations

KEYWORDS: *Metal Forming, Plastic Deformation, Yield Criteria, Stress Tensor*

INTRODUCTION

Metal forming processes, also known as mechanical working processes, are primary shaping processes in which a mass of metal or alloy is subjected to mechanical forces. Under the action of such forces, the shape and size of metal piece undergo a change. By mechanical working processes, the given shape and size of a machine part can be achieved with great economy in material and time. Metal forming is possible in case of such metals or alloys which are sufficiently malleable and ductile. Mechanical working requires that the material may undergo “plastic deformation” during its processing. Frequently, work piece material is not sufficiently malleable or ductile at ordinary room temperature, but may become so when heated. Thus we have both hot and cold metal forming operations.

When a single crystal is subjected to an external force, it first undergoes elastic deformation; that is, it returns to its original shape when the force is removed. For example, the behavior is a helical spring that stretches when loaded and returns to its original shape when the load is removed. If the force on the crystal structure is increased sufficiently, the crystal undergoes plastic deformation or permanent deformation; that is, it does not return to its original shape when the force is removed.

Main part

There are two basic mechanisms by which plastic deformation takes place in crystal structures. One is the slipping of one plane of atoms over an adjacent plane (called the slip plane) under a shear stress. The behavior is much like the sliding of playing cards against eachother. Shear stress is defined as the ratio of the applied shearing force to the cross-sectional area being sheared, just as it takes a certain magnitude of force to slide playing cards against each. In other word we can say that a single crystal requires a certain amount of shear stress (called critical shear stress) to undergo permanent deformation. Thus, there must be a shear stress of sufficient magnitude within a crystal for plastic deformation to occur; otherwise the deformation remains elastic. The second and less common mechanism of plastic deformation in crystals is twinning, in which a portion of the crystal forms a mirror image of itself across the plane of twinning. Twins form abruptly and are the cause of the creaking sound ("tin cry") that occurs when a tin or zinc rod is bent at room temperature. Twinning usually occurs in hcp metals.

Yield Criteria

The yield criteria limit the elastic region. It is a mathematical expression to define the combination of component of stress such that when it reaches material no more behaves elastically. Yield criterion gives the onset plastic deformation. In other word if a state of stress satisfies yield criterion, we can say that plasticization may start. It is assumed that initial yielding depends upon only on state of stress and not on how the stress is reached. We can assume that there exist a function f(σij) called yield function such that

Material is elastic if $f(\sigma_{ij}) < 0$ (1)

Or if $f(\sigma_{ij}) = 0 \quad and \quad f(\sigma_{ij}) < 0$ (2)

Where ()ijfσ=0 defines the yield surface in stress space and f (σij)=0 indicates unloading. The latter combination tells us the onset plastification has taken place, but unloading is going totake place elastically. As the yield criterion does not depends upon the path of loading, it does not tell anything about deformation. If the state of stress is already satisfied f (σij) =0,it tells us only the plastifiaction has just started or taken place. But it does not tell whether plasticdeformation has taken place or not. The yield function gives us the information regarding loading.

Material behavior is plastic if

$f(\sigma_{ij})$=0 or $f(\sigma_{ij}) \geq 0$ (3)

Commonly used Yield Criteria

The yield criteria of materials limit the elastic domain during loading where as the failure criteria gives the maximum stress that can be applied. We use the yield criteria for metals alloys and failure criteria for geo material like soil and concrete. Some of the commonly used yield criteria are

- Von Misesyieldcriteria
- Trescayieldcriteria

Von Misesyieldcriteria

Von Mises (1913) suggested that yielding will occur when second invariants of deviatoric stress tensor, J2 reaches a critical value. He does not take J3 into account in the yield criteria. We canwrite the at onset of yielding.

$$2J_2 = S_{ij}S_{ij} = S_1^2 + S_2^2 + S_3^2 = 2K^2 \quad (4)$$

Where S1,S2,S3 are principal deviator stress.We can also write von mises criteria in terms of principal stresses as

$$(\sigma_1 - \sigma_2)^2 + (\sigma_2 - \sigma_3)^2 + (\sigma_3 - \sigma_1)^2 = 6k^2 \quad (5)$$

In terms of components of stress tensor,von Mises yield criteria can be written as

$$(\sigma_x - \sigma_y)^2 + (\sigma_y - \sigma_z)^2 + (\sigma_z - \sigma_x)^2 + 6(\tau_{yz}^2 + \tau_{zx}^2 + \tau_{xy}^2) = 6k^2 \quad (6)$$

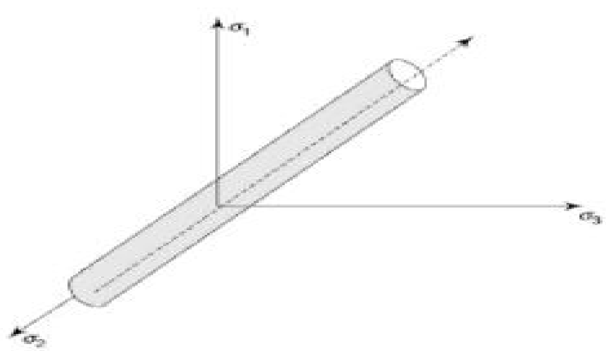

Fig. 1. Let effective stress σ eff corresponding to stress tensor σas

$$\sigma_{eff} = \sqrt{\frac{3}{2}s_{ij}s_{ij}} = \sqrt{\frac{3}{2}s : s} \quad , (7)$$

Where s_{ij} is the components of deviatoric stress tensor S.von Mises criteria can be written as σ eff −σ y = 0

where σ y is the yield stress of the material in uniaxial tension or compression.

Trescayieldcriteria

According to the tresca yield criteria, yielding of material begin to occur when maximum shearing stress at a point reaches a critical value. If σ1, σ2,σ3, are the principal stresses arranged in descending order, we can write Tresca criterion as

$$\frac{1}{2}|\sigma_1 - \sigma_2| = K_T \quad , (8)$$

where K_T is the material dependent parameter determined experimentally.Ifσ y be the yield stress, the maximum shear isσ_2/2.Tresca condition can be written as

$$\rho \sin\left(\theta + \frac{\pi}{3}\right) = \sqrt{2k} \quad , (9)$$

The maximum shear stress at appoint does not change when the state of stress at the point is changed hydrostatically. Tresca yield criteria represents a hexagonal cylinder in principal stress space.

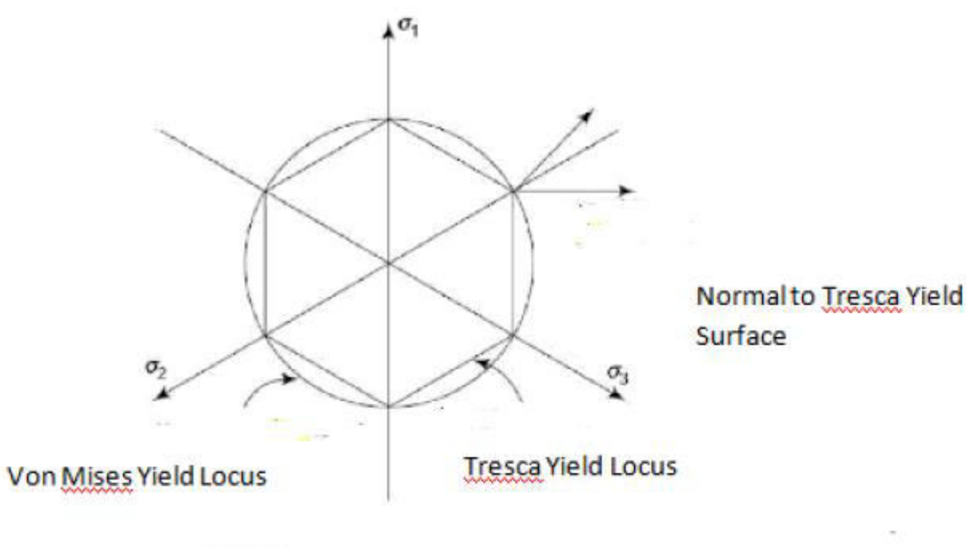

Fig .2. Locus of tresca von Mises yield criteria on deviatoric plane

CONCLUSION

By mechanical working processes, the given shape and size of a machine part can be achieved with great economy in material and time. Metal forming is possible in case of such metals or alloys which are sufficiently malleable and ductile. Mechanical working requires that the material may undergo “plastic deformation” during its processing.

REFERENCES

1. USCAR, 1995, Taking on the Springback ‘‘Challenge‘‘, United States Council for Automotive Research, fall newsletter.
2. Venner M.L, 1982, ―An analysis of springback on the punch corner radius in channel forming‖, General motors research report.
3. Sunseri M, Cao J, Karafillies A.P, Boyce M.C, 1996, ―Accommodation of Springbackerrorusing active binder force control: Numerical simulations and experiments‖ Transactions of ASME, Vol 118.
4. Vallance and Matlock D.K, 1992, ―Application of bending under tension friction testtocoated sheet steels ― Journal of Manufacturing Engineering and performance. Vol.1(5), pp685-693.
5. Zhang L.C, Lu G, and Leong S.C, 1997, ―V-shaped sheet forming by deformable by deformable punches‖, Journal of Material Processing Technology, Vol.63, pp 134-139.
6. Karafillis A.P, and Boyce M.C, 1996, ―Tooling and Binder Design for Sheet Metal Forming Compensating Springback Error‖, Int. J. Mach. Tools Manuf., Vol. 36, pp. 503–526.
7. Song N, Qian D, Cao J and Liu W. K, 2001, ―Effective Models for Prediction of Springback In Flanging,‖ J. Eng. Mater. Technol., Vol.123, pp. 456–461.
8. Gan W, Wagoner R.H, Mao K, Price S and Rasouli, F, 2004, ―Practical Methods for theDesign of Sheet Formed Components,‖ J. Eng. Mater. Technol., Vol.126, pp. 360–367.
9. Gardiner F. J, 1957, ―The Springback of Metals,‖ Trans. ASME, Vol.79(1), pp.1–9.