# Systematic Review Based on the Study of Elastic-Plastic Transition Stresses

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**Abstract:**

A systematic review based upon the study of elastic-plastic transition stresses. A worthwhile work about the analysis of elastic-plastic transition stresses in different rotating material by varying different parameters is discussed. In the case of compressible material, the strain rates have a maximum value at the internal surface. It has been observed that radial stress has a higher value at the internal surface of the rotating disc made of incompressible material as compared to circumferential stress with thermal effect and this value of radial stress further increases. With the increase of angular speed, the value of radial stress further increases as compared to the case with no thermal effect. The magnitude of the stresses and pressure reduce with the variation of thickness needed for a fully plastic state. At the inner surface, the effect of heat increases stress for compressible material. The thickness and density parameters decrease the value of angular speed at the internal surface of the rotating disc of compressible material as well as incompressible materials. The radial and the hoop stress, both decreases with the increased value of temperature at the Elastic-Plastic stage, but with the reverse result obtained for a fully Plastic state.

**Keywords:** Stresses, Compressible material, Incompressible material

## 1 Background:

### 1.1 Aim and Rational for current review:

The main aim of this review paper is to find out which material and parameters are best to use in rotating structures in case of elastic-plastic transition Stresses.

### 1.2 Introduction:

Solids Mechanics deals with the mechanical behavior of the deformable bodies subjected to various types of external forces and goes by a variety of names, such as the strength of materials, etc. Under the classical theory of plasticity, the material region is assumed to be divided into two regions: one is elastic and the other is plastic regions. Both are separated by a yield surface depending on the symmetry and other physical considerations [Borah, 1968]. However, its main disadvantages are the following assumptions:

- Although the material at a point has yielded but the material at the adjacent point remains elastic.
- The yield surface of the assumed type separating the elastic and plastic regions exists.
- For any given material there is a function of the three principal stresses which always has a value when yielding begins anyway of the stress state.
- The same functional relationship applies to all materials although the numerical value of the function is different for different materials.

Tresca(1868) identify a transition state, which he called mid-zone exists when the material passes from the elastic zone to the plastic zone and this is, later on, supported by Todhunter and Pearson(1893). The whole of the material participates in the transition state but not simply a selected region or a line as assumed by classical theories. That is expressed by Sir Lawrence and supported by Bragg (1942).

**Seth's Theory:** B.R. Seth (1962) suggests the concept of generalized strain measure and asymptotic solution at turning points of the differential equations defining the deformed field.

**Seth (1962) neglected the following assumptions:**

1. Incompressibility condition
2. A power relationship between Stress and Strain
3. Yield condition such as Tresca or von-Misses.
4. To make inconsiderable strain theory applicable, deformations are assumed to be small.

**Objective:**

- Construction of governing equation, equilibrium equation, transition points.
- Investigation the variation of thickness parameter in a thin rotating disc.
- Determination of Stable thermal stresses in a thin rotating disc of finitesimal deformation with edge loading.
- Evaluation of Transitional stresses investigation in the thin rotating disc for different materials.
- Develop a Mathematical model in a thin non-homogeneous rotating disc for isotropic material with the rigid shaft by using Seth's transition theory.
- Investigation of Elastic-plastic stresses in a thin rotating disc with a shaft having variation in density parameter under steady-state temperature.
- Numerical computation of Steady thermal stresses in a rotating disc with a shaft having thickness variation parameter subjected to the thermal load

### 1.3 Review Question

Our review question.

In what ways different parameters of variation are effecting the elastic-plastic transition?

## 2 Methods used in Review

### 2.1 Approach and Rationale

User group involvement is reflecting inside the work of the review itself, which include the background history, researcher's research and books.

### 2.2 Methods used

User points of view on survey procedure and the temporary report be looked for and viewpoints with clients are incorporated into the last report. Points of interest of this survey have been coursed to various researcher's research, books and papers.

## 3 Analyses of Existing Models (Tables)

| Sr. No. | Year | Author | Title of paper | Rotating Structures | Variation of parameter |
|---|---|---|---|---|---|
| **1** | **2000** | " By S.K. Gupta, Sanjeev Sharma and Sonia Pathak " | " Creep Transition in a Thin Rotating Disc of Variable Density " | Rotating Disc | Angular Speed as well as density |
| **2** | **2007** | "S.K. Gupta and Pankaj" | " Creep Transition in a Thin Rotating Disc with Rigid Inclusion" | Thin Rotating Disc | Angular Speed |
| **3** | **2009** | "Sanjeev Sharma and Manoj Sahni" | " Elastic-Plastic Transition of Transversely Isotropic Thin Rotating Disc" | Thin Rotating Disc | Radii Ratio |
| **4** | **2010** | "Pankaj Thakur" | " Elastic-Plastic Transition Stresses in a Thin Rotating Disc with Rigid Inclusion by...THERMAL SCIENCE " | Thin Rotating Disc | Temperature |
| **5** | **2011** | "Pankaj Thakur" | “Effect of transition Stresses in a disc having variable | Rotating Disc | Thickness and Poisson’s ratio |

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|---|---|---|---|---|---|
| | | | thickness and Poisson's ratio subjected to internal pressure." | | |
| **6** | **2013** | "Pankaj Thakur, Singh S.B. , Jatinder Kaur " | " Thickness Variation Parameter in a Thin Rotating Disc by Finite Deformation" | Thin Rotating Disc | Thickness |
| **7** | **2015** | "Pankaj Thakur, Satya Bir Singh , Jasmina Lozanovic Sajic " | " Thermo Elastic-Plastic Deformation in a solid disk with heat generation subjected to Pressure " | Solid Disk | Pressure |
| **8** | **July 2017** | "Pankaj Thakur, Satya Bir Singh, ShivdevShahi,Nishi Gupta" | "Effect of Mechanical load and thickness profile on creep in a Rotating Disc by using Seth's transition theory " | Rotating Disc | Mechanical load and Thickness |
| **9** | **2017** | "Pankaj Thakur, Gaurav Verma, D.S. Pathania" | " Elastic-Plastic Transition On Rotating Spherical Shells In Dependence Of Compressibility" | Rotating Spherical Shells | Density |
| **10** | **2018** | " S. Sharma* , R. Panchal" | " Elastic-Plastic Transition of Pressurized Functionally Graded Orthotropic Cylinder using Seth's transition theory " | Orthotropic Cylinder | Density and Thickness |
| **11** | **2018** | "Pankaj Thakur, Monika Sethi , Shivdev Shahi, Satya Bir Singh, Fadugba Sunday Emmanuel " | "Exact solution of rotating disc with shaft problem in the ElastoPlastic state of stress having variable density and thickness." | Rotating Disc | Density and Thickness |
| **12** | **Dec 2018** | "Pankaj Thakur, Shivdev Shahi, Satya Bir | "Elastic-Plastic Stress Concentrations | Spherical Shell | Interior Pressure |

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|---|---|---|---|---|---|
| | | Singh, Monika Sethi" | In Orthotropic Composite Spherical Shells Subjected To Internal Pressure." | | |
| **13** | **2019** | "Monika Sethi , Pankaj Thakur, H.P. Singh " | " Characterization of material in a rotating disc subjected to thermal gradient by using Seth's transition theory " | Rotating Disc | Temperature |

## 4 In-Depth Reviews: Results

Thirteen papers meet the inclusion criteria used for the in-depth review.

### Key finding of included studies

1. Gupta et al. (2000) have been derived creep stresses and strain rates for thin rotating disc having variable density by using Seth's transition theory .It has been observed that a disc whose density decreases radically, rotates at high angular speed, thus increasing the possibility of a fracture at the bore, whereas for a disc whose density increases radically, recedes the possibility of a fracture. The deformation is significant for a disc having variable density and rotating at higher angular speed.

2. Gupta &S. K. (2007) have been derived creep stresses and strain rates for thin rotating disc with inclusion using Seth's transition theory .Results have been discussed numerically and depicted graphically. It has been observed that radial stress has maximum value at the internal surface of the rotating disc made of incompressible material as compared to circumferential stress and this value of stress further increases the increase in angular speed. Strain rates have maximum values at the internal surface for compressible material.

3. Sharma et al. (2009) have been derived Elastic-Plastic stresses by using Seth's transition theory .Results obtained have been discussed numerically and depicted graphically. Rotating disc made of isotropic material required high percentage increase in angular speed to become fully plastic from its initial yielding as compared to disc made of transversely isotropic material. Rotating disc made of transversely isotropic material is on the safer side of design as compared to rotating disc made of isotropic material.

4. Thakur (2010) has been observed that radial stress has maximum value at the internal surface of the rotating disc made of incompressible material as compared to circumferential stress and this value of stress further increases the increase in angular speed. With the introduction of thermal effect, it has been observed that radial stress has higher maximum value at the internal surface of the rotating disc made of incompressible material as compared to circumferential stress, and this value of radial stress further increases with the increase of angular speed as compared to the case without thermal effect. Strain rates have maximum values at the internal surface for compressible material.

5.Thakur(2011) have been derived Elastic-Plastic transitional stresses in an annular disc having variable thickness

and possion's ratio subjected to internal pressure has been derived by using Seth's transition theory . The thickness variation reduces the magnitude of the stresses and pressure needed for fully plastic state. It is seemed for fully plastic state that circumferential stresses is maximum at the outer surface.

6.Thakur et al. (2013) has been observed that Seth's transition theory is applied to the problem of thickness variation parameter in a thin rotating disc by finite deformation. For flat disc compressible material required higher percentage increased in angular speed to become fully plastic as compared to disc made of incompressible material. Effect of thickness variation increases the value of circumferential stress at the external surface for fully plastic state.

7. Thakur et al. (2015) has been derived that Seth's transition theory is applied to the problem of elastic-plastic deformation in a solid due to heat source subjected to pressure. Neither the yield criterion nor associated flow rule is assumed here. The result obtained here is applicable to compressible materials. If the additional condition of incompressibility is imposed, then the expression for stresses corresponds to those arising from Tresca's yield condition. Effect of heat increased values of stress for compressible material at the inner surface.

8. Thakur et al.(July 2017) ) has been observed that stresses increases with increase in mechanical load and maximum value ofstrain rate further increases at the internal surface for compressible materials.It is concluded that,rotating disc is likely to fracture by cleavage close to the shaft at the bore.

9. Thakur et al.(2017) the purpose of this paper is to establish the mathematical model on the elastic-plastic transitions occurring in rotating spherical shells based on compressibility of materials. It has been observed that rotating shells made of the incompressible material are on the safer side of the design as compared to rotating shells made of the compressible material. With effect of density variation parameter, rotating spherical shells start yielding at the internal surface with the lower values of the angular speed for compressible / incompressible materials.

10.Sharma et al.(2018) In this paper the radial deformation and the corresponding stresses in a functionally graded orthotropic hollow cylinder with the variation in thickness and density according to power law and rotating about its under pressure is investigated by Seth's transition theory .The material of the cylinder is assumed to be non-homogeneous and orthotropic. Results have been mentioned analytically and numerically. It has been concluded that cylinder made up of orthotropic material whose thickness increases radically and density decreases radically is on the safer side of the design as circumferential stresses are high for cylinder made up of isotropic material as compared to orthotropic material .

11. Thakur et al. (2018) has been observed that observed that rotating disc made of the compressible material with an inclusion requires higher angular speed to yield at the internal surface as compared to the disc made of incompressible material , and a much higher angular speed is required to yield with the increase in radii ratio. The thickness and density parameters decrease the value of angular speed at the internal surface of the rotating disc of compressible material as well as incompressible materials. The models proposed in this paper are used in mechanical and electronic devices.

12. Thakur et al. (Dec 2018) has been observed that Elastic-plastic stress concentrations in spherical shells subjected to internal pressure are of much significance in the theory of structural components. It has been seen that the spherical shell of orthotropic composite material requires higher values of pressure at the inner surface as compared to shell of transversely isotropic material.

13. Sethi et al. (2019) has been observed that a disc made of materials as: saturated clay, copper , or cast iron, yields at the outer surface at higher angular speed as compared to the disc of rubber material at steady state temperature, whereas the disc made of clay, copper ,cast iron , as well as rubber material ,yields at the lesser angular speed as compared to the rotating disc at room temperature. With the introduction of temperature, the radial- as well as the hoop stress, both decreases with the increased value of temperature at the Elastic-Plastic stage, but with the reverse

result obtained for a fully Plastic state.

## 5 Conclusions

In the end, it is conclude that radial stress has a maximum value at the internal surface of the rotating disc made of incompressible material as compared to circumferential stress, and this value of stress further increases with the increase in angular speed. A rotating disc made of transversely isotropic material is on the safer side of design as compared to a rotating disc made of isotropic material. Effect of thickness variation increases the value of circumferential stress at the external surface for a fully plastic state. With the effect of density variation parameter, rotating spherical shells start yielding at the internal surface with the lower values of the angular speed for compressible/incompressible materials. Effect of heat increased values of stress for compressible material at the inner surface. It has been concluded that a cylinder made up of orthotropic material whose thickness increases radically and density decreases radically is on the safer side of the design as circumferential stresses are high for cylinders made up of isotropic material as compared to orthotropic material.

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