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Determine the Value of Stress and Strain at Various Values of Exponents

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ABSTRACT
In this present study value of stress as well as strain along tangential and radial direction of a rotating disk is calculated for different value of exponent i.e. n=3, 5,8 by taking volume, temperature and particle size constant. It has been observed that by increasing the value of exponent the stress and strain decreases.

Keyword: Slow Learner Classes, Academic Performance, Mid Exams, Academic Year, Subject.

I. INTRODUCTION

Rotating disks have many engineering applications so rotating disks provide an area of research and studies such as steam, turbo generators, fly wheels, computer hard disk drives, pumps, compressors and aero plans[4,6,7,8]. Material made from two or more material having different physical and chemical properties is called composite material [3]. The composite material have many applications in different field like automobiles are engine cylinder liners, combustion chamber, CNG storage cylinders, brake rotors, drive shafts, diesel energy pistons, flywheels, motorcycle, drive sprocket, pulley. In sub-marine are propulsion shaft, cylindrical pressure hull, composite piping systems, boats hull. In industrial and commercial are computer hard disk drive, needle for carpet-weaving machine, electronic packaging , thermal management, pressure vessels,wind turbine blades, laptop cases, electric motors, MRI scanner cryogenic tubes, Wheel chairs, Eyeglass frames, artificial ligaments, Hip joint implant, camera tripods, Drilling tubes, Musical instruments, Drilling motor shaft, X- ray table, Heart values, Beams, Helmets. In aerospace tools, space structure as well as structures is rocket nozzle, Engines parts, Spacecraft truss structure, Wind tunnel blades, Solar panels, Reflectors, Turbine rotor, Turbine wheels and Space shuttle. In aircraft, Missile structures are wings, Engine casing, Rotary launchers, Drive shaft, Landing gear doors, Propeller blades, Helicopter components, Main rotor blades, and Mast mount. In sports are golf shafts, Tennis rackets, racing bicycle and fishing rod.

FGMs are heterogeneous material which are mixture of homogenous parts and particles of those components having different physical and functional capabilities like light weight, high conductivity, high strength and thermal strength. FGM concept is introduced in Japan in 1984[10].FGM manufactured to work at high temperature environment like light weight, temperature resistant materials for aerospace vehicles. Natural FGM are teeth and bones etc. The FGM has many applications in different field like engineering are steam rotors, gas turbine rotors, clutch plates, brake disks and turbo generator. In automotive are shock absorbers, combustion chamber, racing car brakes. In medicine used in dental, bone replacement. In aerospace used for constructing space components. In defense are bullet proof vests, armour plates.[5]

Wahl et al.[1] calculated secondary creep deformation in revolving disk using Tresca yield criteria as well as von Mises theoretically as well as experimentally. He has concluded that the creep deformations calculated using von Mises criteria are too low in comparison to experimental results, which may be due to the anisotropy of the material used.

Singh et.al. **[5]** investigate the affect of residual stress on rotating disk with Norton's power law as compare with strain rate in the disk with no residual stress. They observed that tensile residual stress fundamentally influences strain rates in disks when contrasted and strain rate in disks without remaining stress. The high estimations of clear stress type and obvious enactment vitality watched for aluminum based MMCs exclude the choice of Norton's capacity to explain creep conduct in these composites. So as to justify strong stress and temperature dependence of creep rate detailed for discontinuously strengthened aluminum/aluminum compound framework composites, the idea of a compelling stress has been utilized.

Singh et. al.[9] examined consistent state creep in rotating disk made of Al-SiCp composite by utilizing isotropic Hoffman yield basis and contrasted the outcomes acquired and those utilizing von Mises yield foundation. It is seen that the distribution of stresses in the disk isn't very much influenced within the sight of stage explicit thermal residual stress. The existence of residual stress prompts increment the unrelated strain rate, especially in district close to the external range of the plate, when contrasted with that saw in a comparable disk yet without remaining stress. The outspread strain rate, which is compressive, changes altogether within the presence of residual stress and even ends up ductile amidst the disk.

Rattan et.al.[10] explored the stable state creep reaction of an isotropic FGM rotating disk of Al-SiC$_P$ particulate composites exposed to molecule inclination utilizing Sherby's law and inferred that the drag conduct in the disk can be constrained by the appropriate circulation of molecule substance as strain rates are least when molecule substance is dispersed illustratively along radial distance of disk.

Thakur et al. **[11]** investigate thermal gradient on the steady state creep response of rotating disk for different cases. At first case disk assume operate at the uniform temperature of 625K while in the second case the temperature is 52K at inner and outer radii as 658K and 588K in the third case the disk operates at 110K by taking 623K inner and 563K outer radii with volume 10%. They observed that in isotropic disks tangential stresses is little higher near the internal radii and slightly decreases near the external radii in presence of thermal gradient as compare to disk without temperature gradient.

Singh et al. [12] compared selective properties of composite material they examine Al-SiC have been best material, having high dissolving element, over the top thermal and electric conductivity and erosion resistance. Al-SiC have over the top tensile, right exhaustion, break habitations, high dissolving element, extreme flexibility, electric conductivity and great erosion resistance .Steel have malleable, over the top capacity to weight proportion due to this that has unnecessary vitality in saving through unit mass, metal gadgets may be small and light weight, never again like different building substances, steel can be impacts manufactured and generation colossally, bendy, sensibly estimated however steel is an alloy of iron. Silicon carbide (SiC) has high hardness, high thermal stability, low thermal increment, electric conductivity. SiC has many advantage utilized for high voltage, high temperature utility.

Gupta et al. [13] investigate the value of stress and strain in the rotating disk at various angular speed $\omega = 13000$ and $\omega = 15000$ at constant temperature T=623K and V=10%. They observed that by increasing the angular speed, radial and tangential stress and strain is increased over entire radii in the isotropic disk operate at the different angular speed.

In this paper the disk is operate under uniform temperature T= 625K with volume V=20% and particle size P=17.5μm having inner radii a=20mm and outer radii b=130 mm having angular speed $\omega = 16000$ with exponents n=3,5,8.

II. ESTIMATION OF CREEP PARAMETERS

The secondary stage deformation Al-SiC$_P$ composite of different composition be describe in conditions of Sherby threshold stress based model known as

$$\dot{\varepsilon} = [M(\bar{\sigma} - \sigma_0)]^n \qquad (1)$$

Where,
$$M = \frac{1}{E}\left[\frac{AD_L\lambda^3}{|\vec{b}_r|^5}\right]^{1/n}$$

where, $\bar{\sigma}$ effective stress, "M" material creep constant, D_L lattice diffusivity, "A"constant, $|\vec{b}_r|$ magnitude of Burger's vector, λ sub grain size ,"E" young's modulus, σ_0 threshold stress.

The standards creep parameter "M", σ_0 take from creep outcomes of Al-SiC$_P$ composite disk given by **(Pandey et. al, 1992)**

$$InM = -34.91 + 0.2112InP + 4.89InT - 0.591InV \qquad (2)$$

$$\sigma_0 = -0.02050P + 0.01378T + 1.033V - 4.9695 \qquad (3)$$

Where P is particle size, T is temperature and V is volume content.

III. MATHEMATICAL FORMULATION

Let aluminum silicon carbide particulate composite disk having inner radii and outer radii are "a" and "b" respectively.

Constitutive general eq^{n} used for deformation in isotropic composite obtain in following type as suggestion frame is use as along principal directions r, θ and z

$$\dot{\varepsilon}_r = \frac{\dot{\bar{\varepsilon}}}{2\bar{\sigma}}[2\sigma_r - \sigma_\theta]$$

$$\dot{\varepsilon}_\theta = \frac{\dot{\bar{\varepsilon}}}{2\bar{\sigma}}[2\sigma_\theta - \sigma_r]$$

$$\dot{\varepsilon}_z = \frac{\dot{\bar{\varepsilon}}}{2\bar{\sigma}}[-(\sigma_r + \sigma_\theta)] \tag{4}$$

where, $\dot{\varepsilon}_r, \dot{\varepsilon}_\theta, \dot{\varepsilon}_z$ are strain rates and $\sigma_r, \sigma_\theta, \sigma_z$ are stresses rates resp. equally inside the direction r,θ,z as indicate by subscripts.

The effective stress use for biaxial condition of stress as well as effective stress, $\bar{\sigma}$ is base on mises criterion (1913), be known as,

$$\bar{\sigma} = \frac{1}{\sqrt{2}}\left[\sigma_r^{\ 2} + \sigma_\theta^{\ 2} + (\sigma_r - \sigma_\theta)^2\right]^{1/2} \tag{5}$$

Using equations (1) and (5) in equation (4), we gets,

$$\dot{\varepsilon}_r = \frac{d\dot{\mu}_r}{dr} = \frac{[M(\bar{\sigma} - \sigma_0)]^n (2u - 1)}{2[u^2 - u + 1]^{1/2}} \tag{6}$$

$$\dot{\varepsilon}_\theta = \frac{\dot{\mu}_r}{r} = \frac{[M(\bar{\sigma} - \sigma_0)]^n (2 - u)}{2[u^2 - u + 1]^{1/2}} \tag{7}$$

$$\dot{\varepsilon}_z = \frac{-[M(\bar{\sigma} - \sigma_0)]^n (u + 1)}{2\left[u^2 - u + 1\right]^{1/2}} \tag{8}$$

Wherever u= σ_r / σ_θ is ratio of radial stress with tangential stress on eqns.(6) , (7) can be used to find σ_θ which is written below,

$$\sigma_\theta = \frac{(\dot{u}_a)^{1/n}}{M}\psi_1 + \psi_2 \tag{9}$$

Where,

$$\dot{u}_a^{1/n} = \frac{\int_a^b M\sigma_\theta dr - \int_a^b M\psi_2 dr}{\int_a^b \psi_1 dr} \tag{10}$$

$$\psi_1 = \frac{\psi}{\left[u^2 - u + 1\right]^{1/2}} \tag{11}$$

$$\psi_2 = \frac{\sigma_0}{\left[u^2 - u + 1\right]^{1/2}} \tag{12}$$

$$\psi = \left[\frac{2\left[u^2 - u + 1\right]^{1/2}}{r(2-u)} \exp \int_a^r \frac{g}{r} dr\right]^{\frac{1}{n}} \tag{13}$$

also

$$g = \frac{2u - 1}{2 - u} \tag{14}$$

Inside radial direction forces of equilibrium are,

$$\frac{d}{dr}\left[r\sigma_r\right] - \sigma_\theta + \rho\omega^2 r^2 = 0 \tag{15}$$

Integration equation (15) taking limits r= "a" to "b" and by taking boundary circumstance $\sigma_r = 0$ at r= "a" also $\sigma_r = 0$ at r= "b" we gets,

$$\int_a^b \sigma_\theta dr = \rho\omega^2 (b^3 - a^3)/3 \tag{16}$$

In the first iteration, $\sigma_\theta = \sigma_{\theta_{avg}}$, where $\sigma_{\theta_{avg}}$ is the average tangential stress on cross section of disk, therefore eqs.(10) write in the given form,

$$\dot{u}_a^{1/n} = \frac{\sigma_{\theta_{avg}} \int_a^b M dr - \int_a^b M\psi_2 dr}{\int_a^b \psi_1 dr} \tag{17}$$

The value of σ_r can be calculating by taking integration of equations (15) By using limits r=a to b w.r.t. "r" are given below,

$$\sigma_r = (1/r)\int_a^r (\sigma_\theta)dr - \frac{\rho\omega^2(r^3 - a^3)}{3r} \tag{18}$$

Finding the values of σ_θ from equation (9), σ_r is radial stress find by equation (18) at various point in disk moreover strain rate $\dot{\varepsilon}_r$ and $\dot{\varepsilon}_\theta$ be calculated from equations (6) and (7) respectively.

IV.DISCUSSION AND GRAPHICAL REPRESENTATION:

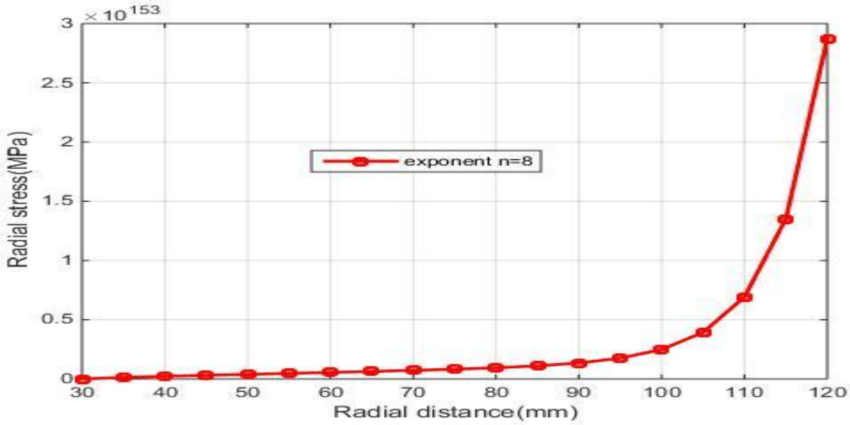

Figure.1. The change of radial stress at various radius with disk at exponent n=8

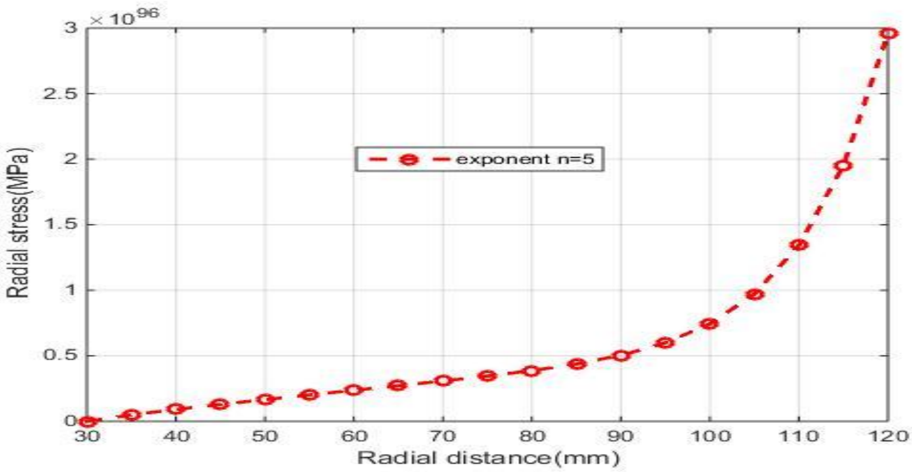

Figure.2. The change of radial stress at various radius with disk at exponent n=5

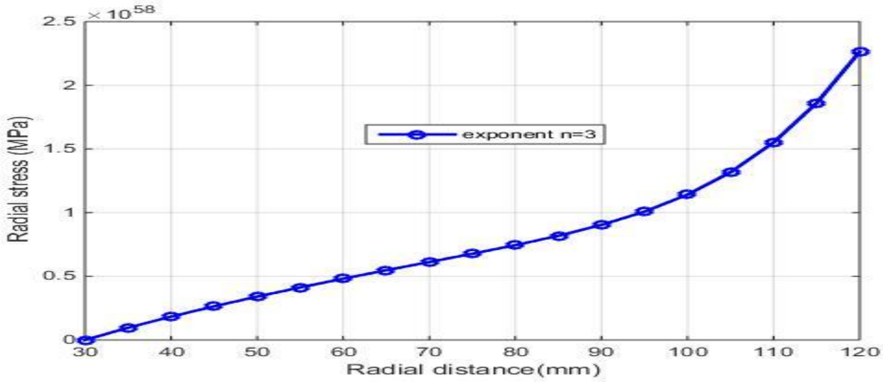

Figure.3. The change of radial stress at various radius with disk at exponent n=3

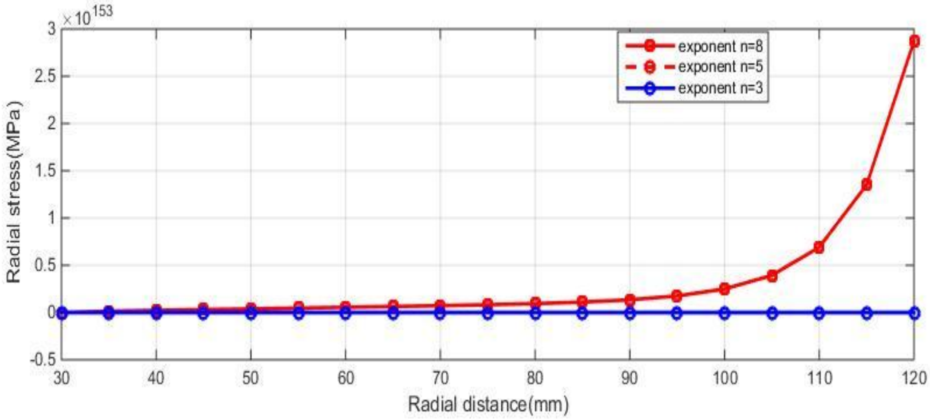

Fig 4 The change of radial stress at various radius with disk at exponent n=8,5,3

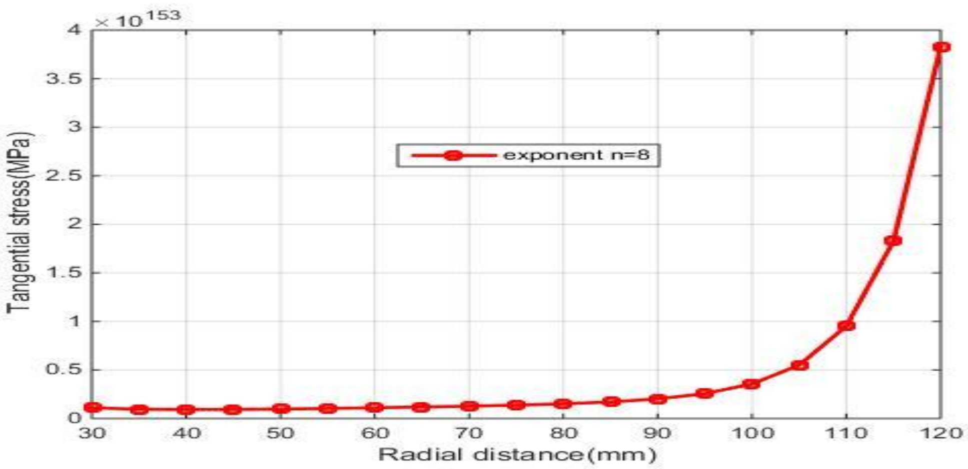

Fig 5. The change of tangential stress at various radius with disk at exponent n=8

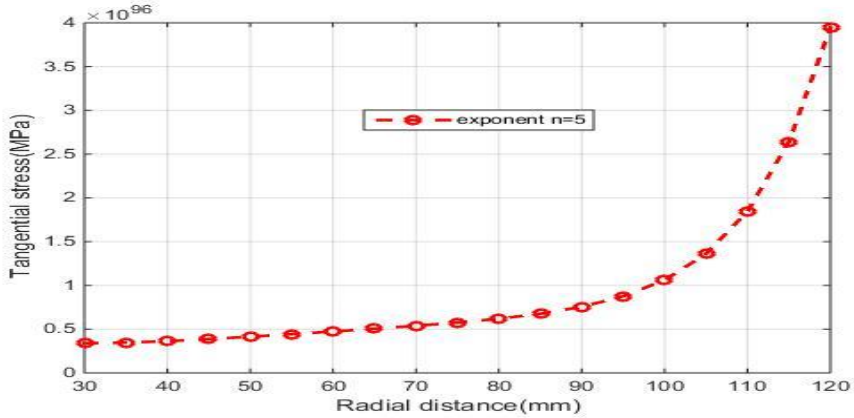

Fig 6. The change of tangential stress at various radius with disk at exponent n=5

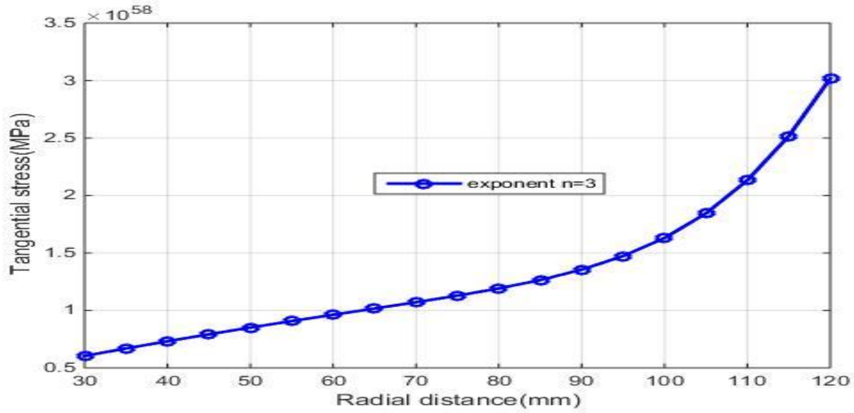

Fig 7. The change of tangential stress at various radius with disk at exponent n=3

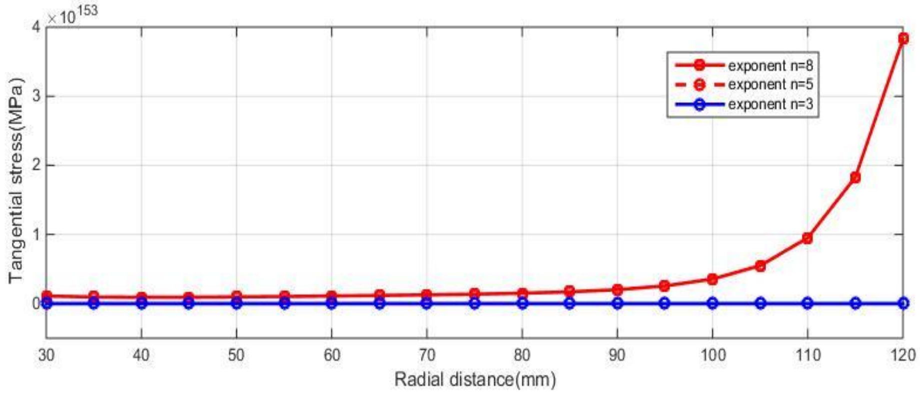

Fig 8. The change of tangential stress at various radius with disk at exponent n=3,5,8

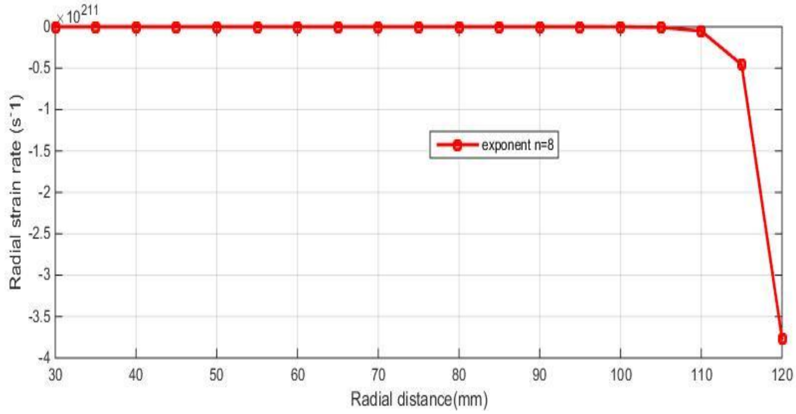

Fig 9. The change of radial strain at various radius with disk at exponent n=8

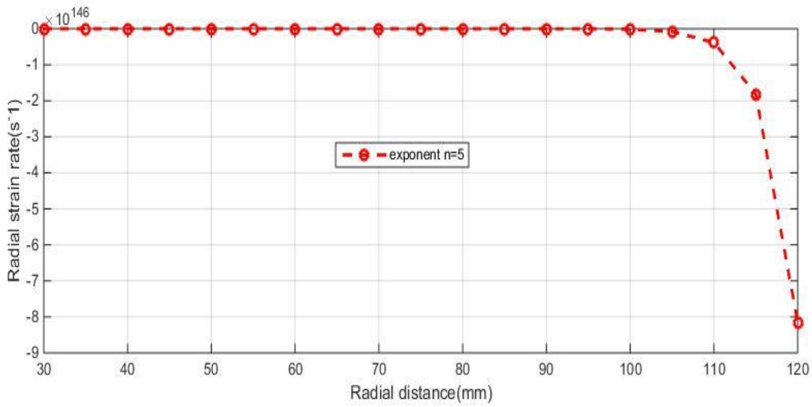

Fig 10. The change of radial strain at various radius with disk at exponent n=5

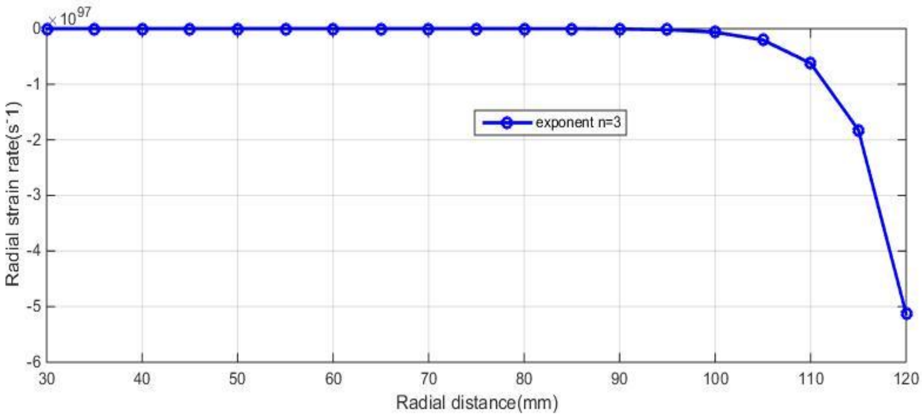

Fig 11 The change of radial strain at various radius with disk at exponent n=3

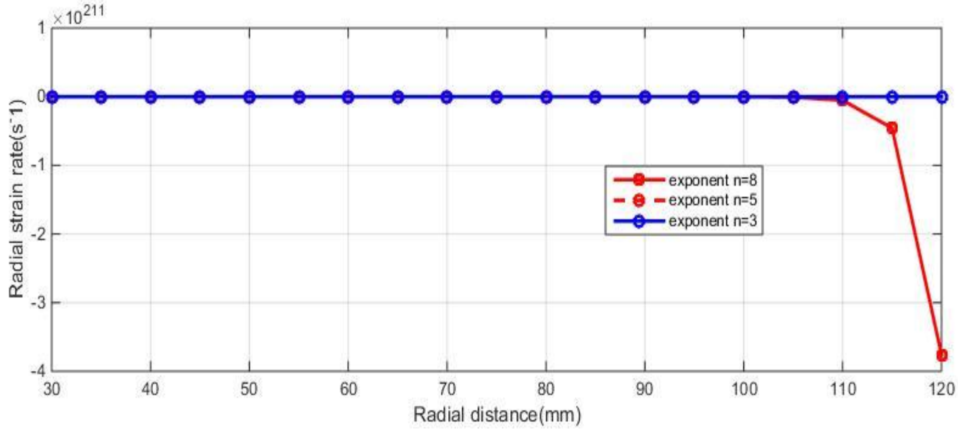

Fig 12 The change of radial strain at various radius with disk at exponent n=3,5,8

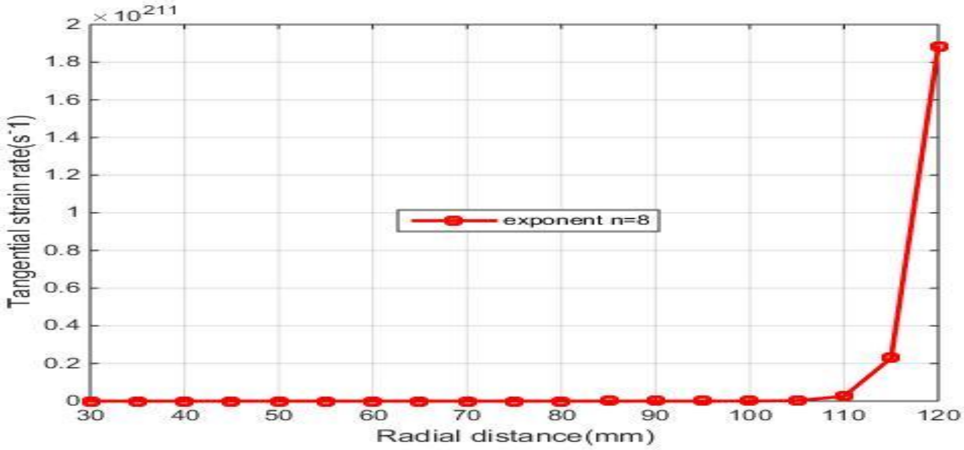

Fig 13 The change of tangential strain at various radius with disk at exponent n=8

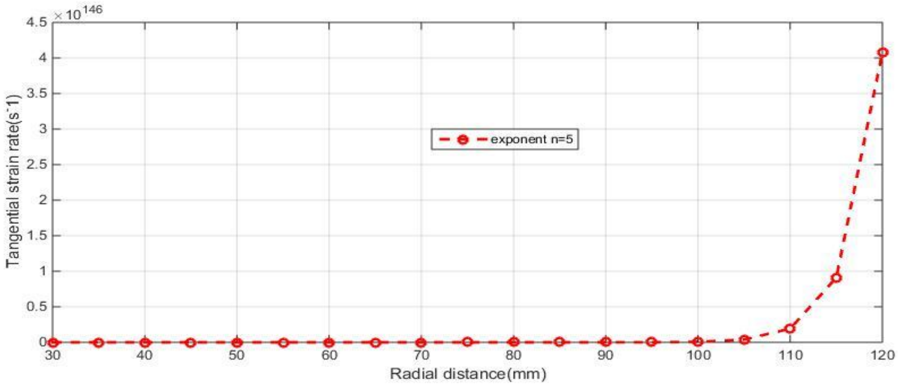

Fig 14 The change of tangential strain at various radius with disk at exponent n=5

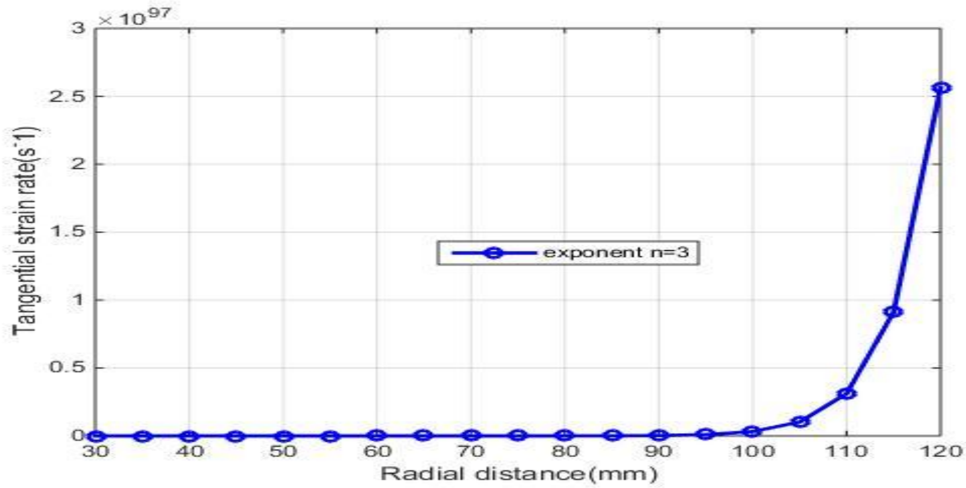

Fig 15 The change of tangential strain at various radius with disk at exponent n=3

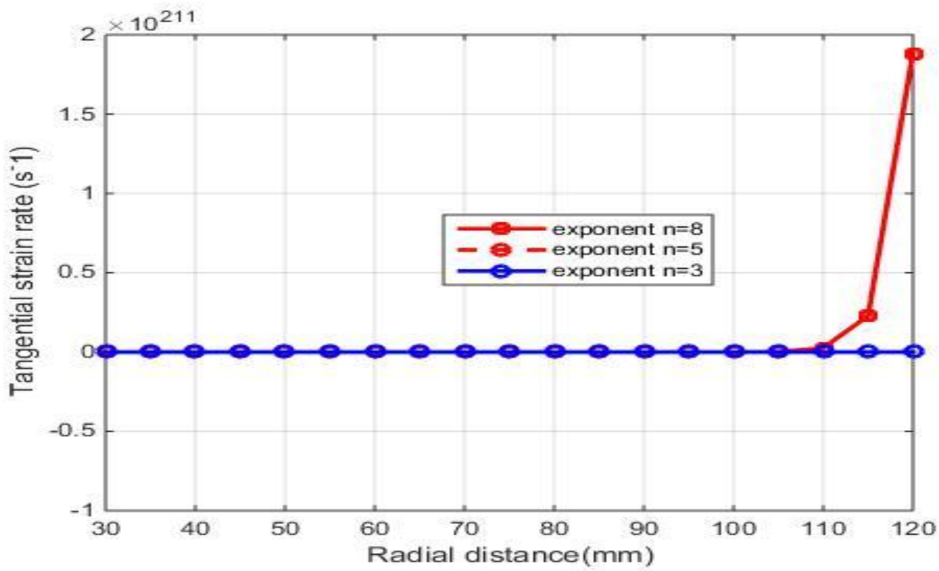

Fig 16 The change in tangential strain at various radius with disk at exponent n=3,5,8

In this given figure 1,2,3 the radial stress along radius at n=8,5,3 respectively there observed that radial stress rate increased as we move from inner radii to outer radii. In figure 4, radial stress along radius at exponent n=8,5,3 we observed that increases the value of exponent radial stress rate decreases.

In this given figure 5,6,7 the tangential stress along radius at n=8,5,3 respectively there observed that tangential stress increased as we move from inner radii to outer radii. In figure 8, tangential stress along radius at exponent n=8,5,3 in fig 8 observed that tangential stress rate decreases with increased the value of exponent.

In this given figure 9,10,11 the radial strain along radius at n=8,5,3 respectively there observed that radial strain rate decreases as we moves inner radii to outer radii. In figure 12, radial strain rate along radius at exponent n=8,5,3 in fig 12 observed that radial strain rate decreased with increases the value of exponent.

In this given figure 13, 14, 15 the tangential strain along radius at n=8,5,3 respectively there observed that tangential strain rate increases from inner radii to outer radii. In figure 16, tangential strain rate along radius at exponent n=8, 5, 3 it is observed increasing the value of exponent the tangential strain rate decreases.

V. CONCLUSIONS

We concluded that with increases the value of exponent in moving composite disk having volume 20%, angular speed 16000rpm at inner radii 30mm and outer radii 120mm the stress also strain rates decreases with increases the value of exponent n=3,5,8. So in order to reduce distortion take the value of exponent n=8.

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