

Suppose You Exert A Force Of 180 N Tangential To A 0.280-m-radius 75.0-kg Grindstone (a Solid Disk).

Suppose You Exert A Force Of 180 N Tangential To A 0.280-m-radius 75.0-kg Grindstone (a Solid Disk).

This scenario provides a fascinating insight into the principles of rotational dynamics, torque, and energy transfer. When a force is applied tangentially to a rotating object such as a grindstone, the resulting motion and energy change depend on several factors, including the magnitude of the force, the radius of the object, and its mass and moment of inertia. Understanding these concepts not only helps in solving physics problems but also offers real-world applications, from industrial machinery to recreational activities like using a grindstone or wheel.

In this article, we will analyze the situation in detail, exploring the physics principles involved, calculating key quantities such as torque, angular acceleration, and work done, and discussing the implications of applying such a force to a solid disk with specific parameters.

Understanding the Scenario: Applying a Tangential Force to a Grindstone

Before diving into calculations, it's essential to clarify the physics concepts at play:

- Tangential Force: A force applied along the tangent of a circle at a point on its circumference. It influences the rotational motion of the object.
- Radius of the Disk: The distance from the center to the point where the force is applied.
- Mass of the Disk: The total mass influences the moment of inertia and the disk's resistance to changes in rotational motion.
- Moment of Inertia (I): A measure of an object's resistance to angular acceleration, depending on its shape and mass distribution.

Given data:

- Force, $(F = 180\text{ N})$
- Radius, $(r = 0.280\text{ m})$
- Mass, $(m = 75.0\text{ kg})$

Fundamental Concepts of Rotational Dynamics

To analyze the effect of the applied force, we need to review some fundamental concepts:

1. Torque and Its Calculation

Torque (τ) measures the tendency of a force to cause rotation about an axis. It is calculated as:

$$\tau = r \times F \times \sin{\theta}$$

Since the force is applied tangentially, the angle (θ) between the force vector and the radius vector is 90° , so:

$$\sin{90^\circ} = 1$$

Thus,

$$\tau = r \times F$$

Using the given values:

$$\tau = 0.280 \text{ m} \times 180 \text{ N} = 50.4 \text{ N}\cdot\text{m}$$

This torque causes the grindstone to spin faster or slower depending on the direction and magnitude of the applied force.

2. Moment of Inertia for a Solid Disk

The moment of inertia for a solid disk about its central axis is given by:

$$I = \frac{1}{2} m r^2$$

Calculating:

$$I = \frac{1}{2} \times 75.0 \text{ kg} \times (0.280 \text{ m})^2$$

$$I = 0.5 \times 75.0 \times 0.0784 \approx 2.94, \text{ kg}\cdot\text{m}^2$$

This value quantifies the disk's resistance to angular acceleration.

3. Angular Acceleration

The angular acceleration (α) resulting from the applied torque:

$$\alpha = \frac{\tau}{I}$$

Substituting the known values:

$$\alpha = \frac{50.4, \text{ N}\cdot\text{m}}{2.94, \text{ kg}\cdot\text{m}^2} \approx 17.14, \text{ rad/sec}^2$$

This indicates how quickly the grindstone's rotational speed increases under the applied force.

Calculating the Work Done and Energy Transfer

When a force is applied tangentially over a certain distance, it does work on the object, transferring energy into rotational kinetic energy.

1. Work Done by the Force

Work (W) is calculated as:

$$W = F \times d$$

where (d) is the linear distance traveled along the direction of the force. If the force acts for a time (t) or causes the disk to rotate through an angle (θ), the work can also be expressed as:

$$W = \tau \times \theta$$

Since the question does not specify the duration or the angular displacement, let's assume the force is applied over a linear distance (d) of, say, 1 meter for illustration.

Thus,

$$W = 180 \, \text{N} \times 1 \, \text{m} = 180 \, \text{J}$$

Alternatively, if the force causes the disk to rotate through an angle θ :

$$W = \tau \theta$$

The angular displacement θ in radians for a linear distance d :

$$\theta = \frac{d}{r} = \frac{1 \, \text{m}}{0.280 \, \text{m}} \approx 3.57 \, \text{rad}$$

Hence,

$$W = 50.4 \, \text{N} \cdot \text{m} \times 3.57 \, \text{rad} \approx 180 \, \text{J}$$

which aligns with the earlier calculation.

2. Rotational Kinetic Energy Gained

The work done translates into the rotational kinetic energy (KE_{rot}) of the grindstone:

$$KE_{\text{rot}} = \frac{1}{2} I \omega^2$$

where ω is the angular velocity after the force is applied. If the work done equals the increase in rotational energy:

$$W = KE_{\text{rot}}$$

$$180 \, \text{J} = \frac{1}{2} \times 2.94 \, \text{kg} \cdot \text{m}^2 \times \omega^2$$

$$\omega^2 = \frac{2 \times 180}{2.94} \approx 122.45$$

$$\omega \approx \sqrt{122.45} \approx 11.07 \text{ rad/sec}$$

This is the angular velocity gained by the grindstone after the force application.

Real-World Applications and Implications

Understanding the dynamics of applying tangential forces to rotating disks has significant real-world relevance:

- **Industrial Machinery:** Many machines, such as grinders, turbines, and centrifuges, rely on precise control of torque and rotational energy. Engineers must calculate the required forces and torque to achieve desired speeds efficiently and safely.
- **Mechanical Design:** Knowledge of moment of inertia and torque is critical in designing rotating systems to withstand operational stresses and to optimize energy transfer.
- **Sports and Recreation:** Activities like cycling or using a wheel involve similar principles, where force application affects rotational speed and energy expenditure.

Additional Considerations and Safety

While applying forces to rotating disks, safety is paramount. High torque and angular accelerations can lead to rapid spinning, which might cause mechanical failure or injury if not properly managed. Engineers must ensure:

- Proper material selection to withstand stresses.
- Adequate safety shields and guards.
- Precise control mechanisms to regulate force application.

Furthermore, real-world situations often involve frictional forces, air resistance, and other dissipative effects that reduce the efficiency of energy transfer. These factors should be considered when designing systems or performing calculations for practical applications.

Conclusion

Applying a tangential force of 180 N to a grindstone with a radius of 0.280 meters and mass of 75.0 kg results in a torque of approximately 50.4 N·m. This torque causes an angular acceleration of about 17.14 rad/sec², leading to a significant increase in the grindstone's rotational speed, with an estimated angular velocity of around 11.07 rad/sec after the force is applied over a linear distance of 1 meter. The work done by the force is approximately 180 joules, translating into the rotational kinetic energy acquired by the disk.

This analysis underscores fundamental principles of physics that govern rotational motion, energy transfer, and mechanical design. Whether in industrial applications or everyday activities, understanding these concepts is crucial for efficient, safe, and effective use of rotational systems.

Keywords: rotational dynamics, torque, moment of inertia, angular acceleration, work done, rotational energy, grindstone, tangential force, physics problem, engineering applications

Frequently Asked Questions

How do you calculate the work done by the 180 N tangential force on the grindstone?

Work done (W) is calculated by multiplying the force (F) by the displacement in the direction of the force. If the force is applied over a certain angular displacement (θ), the work is $W = F r \theta$, where r is the radius. For example, if the force causes the grindstone to rotate through an angle θ in radians, then the work done is $W = 180 \text{ N} \cdot 0.280 \text{ m} \cdot \theta$.

What is the torque exerted by the 180 N force on the grindstone?

The torque (τ) is calculated using $\tau = r F$, where r is the radius and F is the force. Substituting the given values, $\tau = 0.280 \text{ m} \cdot 180 \text{ N} = 50.4 \text{ N}\cdot\text{m}$.

How can we find the angular acceleration of the grindstone given the applied force?

Angular acceleration (α) is found using Newton's second law for rotation: $\tau = I \alpha$, where I is the moment of inertia. For a solid disk, $I = (1/2) m r^2$. Plugging in the values, $I = 0.5 \cdot 75.0 \text{ kg} \cdot (0.280 \text{ m})^2 = 2.94 \text{ kg}\cdot\text{m}^2$. Then, $\alpha = \tau / I = 50.4 \text{ N}\cdot\text{m} / 2.94 \text{ kg}\cdot\text{m}^2 \approx 17.14 \text{ rad/s}^2$.

What is the moment of inertia for the grindstone, and how does it affect its rotational motion?

The moment of inertia for a solid disk is $I = (1/2) m r^2$. With the given values, $I = 2.94 \text{ kg}\cdot\text{m}^2$. A larger I

means the grindstone resists changes in its rotational motion more, requiring more torque to accelerate or decelerate.

If the force is applied tangentially and causes the grindstone to rotate through a certain angle, how much work is done in that rotation?

The work done is $W = \tau \theta = (r F) \theta$. For example, if the grindstone rotates through 1 radian under the applied force, then $W = 50.4 \text{ N}\cdot\text{m} \cdot 1 \text{ rad} = 50.4 \text{ Joules}$.

Additional Resources

Introduction to Torque and Mechanical Work in Grindstones

When considering the application of forces to rotating machinery, such as a grindstone, understanding the fundamental physics involved—especially torque, work, and rotational dynamics—is essential. In this article, we delve into an illustrative scenario where a force of 180 N is exerted tangentially on a grindstone with a radius of 0.280 meters and a mass of 75.0 kg, which is a solid disk. Through a comprehensive analysis, we will explore the implications of this force on the grindstone's motion, energy transfer, and mechanical performance, providing insights valuable to engineers, physics enthusiasts, and machinery operators alike.

Understanding the Basic Concepts: Force, Torque, and Rotational Motion

Force and Its Application on Rotating Disks

Force is a vector quantity that causes an object to accelerate in the direction of the applied force. When a force is applied tangentially to a rotating object like a grindstone, it not only influences the linear motion at the point of contact but also affects the rotational motion of the entire disk.

In this context, the tangential force of 180 N acts at the surface of the grindstone, which, due to its tangential orientation, directly affects the disk's angular acceleration and rotational energy.

Torque: The Rotational Equivalent of Force

Torque (τ) quantifies the tendency of a force to rotate an object around an axis. It depends on:

- The magnitude of the applied force (F)
- The distance from the axis of rotation to the point where the force is applied (r)

- The angle between the force vector and the lever arm (which, in this case, is tangential, so the angle is 90°)

Mathematically, torque is expressed as:

$$\tau = r \times F \times \sin \theta$$

Since the force is applied tangentially ($\theta = 90^\circ$), ($\sin \theta = 1$), simplifying the calculation.

Calculating the Torque Exerted on the Grindstone

Parameters and Assumptions

- Force, ($F = 180\text{ N}$)
- Radius of grindstone, ($r = 0.280\text{ m}$)
- Force applied tangentially, so ($\theta = 90^\circ$)
- The grindstone is a solid disk with mass ($m = 75.0\text{ kg}$)

Torque Calculation

Given the parameters, the torque exerted by the force is:

$$\boxed{\tau = r \times F = 0.280\text{ m} \times 180\text{ N} = 50.4\text{ Nm}}$$

This torque represents the rotational influence of the applied force—a measure of how effectively the force can spin or accelerate the grindstone.

Analyzing the Rotational Dynamics of the Grindstone

Moment of Inertia of a Solid Disk

The moment of inertia (I) of a solid disk about its central axis is given by:

$$I = \frac{1}{2} m r^2$$

Calculating I :

$$I = \frac{1}{2} \times 75.0 \, \text{kg} \times (0.280 \, \text{m})^2$$

$$I = 0.5 \times 75.0 \, \text{kg} \times 0.0784 \, \text{m}^2$$

$$I = 37.5 \times 0.0784 \, \text{kg} \cdot \text{m}^2$$

$$I \approx 2.94 \, \text{kg} \cdot \text{m}^2$$

This value indicates the resistance of the grindstone to changes in its rotational velocity.

Calculating Angular Acceleration

If the force is applied steadily, the torque causes the grindstone to accelerate angularly according to:

$$\alpha = \frac{\tau}{I}$$

Substituting values:

$$\alpha = \frac{50.4 \, \text{Nm}}{2.94 \, \text{kg} \cdot \text{m}^2} \approx 17.14 \, \text{rad/sec}^2$$

This significant angular acceleration suggests that the force can rapidly increase the rotational speed of the grindstone, assuming no other resistive forces like friction or air resistance.

Work Done by the Force and Energy Transfer

Work and Power in Rotational Systems

When a force acts tangentially over a certain distance, it does work on the system. The work done (W) is given by:

$$W = F \times d$$

However, since the force causes rotation, it's often more insightful to consider the work in terms of angular displacement (θ), via:

$$W = \tau \times \theta$$

where θ is the angle in radians through which the grindstone rotates.

Relationship Between Work and Rotational Kinetic Energy

The work done by the force is converted into the rotational kinetic energy of the grindstone:

$$KE_{\text{rot}} = \frac{1}{2} I \omega^2$$

where ω is the angular velocity after the work is applied.

Suppose the force is applied over a certain distance d ; then, the angular displacement is:

$$\theta = \frac{d}{r}$$

If, for instance, the point of application moves through a linear distance d , then:

$$W = \tau \times \frac{d}{r} = F \times d$$

This demonstrates the fundamental link between linear work and rotational work.

Practical Implications and Real-World Considerations

Estimating the Increase in Rotational Speed

Assuming the force is applied steadily over a distance (d) , the increase in rotational energy can be estimated. For example, if the force acts over 1 meter:

$$W = F \times d = 180 \, \text{N} \times 1 \, \text{m} = 180 \, \text{J}$$

This energy transfer translates into an increase in the grindstone's rotational kinetic energy:

$$\Delta KE_{\text{rot}} = 180 \, \text{J}$$

Corresponding change in angular velocity:

$$\frac{1}{2} I \omega^2 = 180 \, \text{J} \rightarrow \omega = \sqrt{\frac{2 \times 180}{I}} = \sqrt{\frac{360}{2.94}} \approx \sqrt{122.45} \approx 11.07 \, \text{rad/sec}$$

This analysis highlights how applying a 180 N force tangentially can significantly spin up the grindstone.

Limitations and Real-World Factors

While the calculations provide valuable insights, practical scenarios involve additional considerations:

- Friction: Both at the axle and between the grindstone surface and the material being ground.
- Air Resistance: Slight but generally negligible at low speeds.
- Force Application: In real operations, forces may fluctuate, and the point of application might shift.
- Structural Integrity: The grindstone and supporting structures must withstand the applied torque without deforming or failing.

Conclusion: The Power of a Single Force in Rotational Mechanics

Applying a 180 N tangential force on a 0.280-m-radius, 75.0-kg solid disk grindstone generates a

torque of approximately 50.4 Nm, capable of producing significant angular acceleration and kinetic energy transfer. This scenario exemplifies fundamental principles of physics—how force, torque, and energy interplay in rotational systems—and underscores the importance of precise calculations in designing and operating machinery.

Understanding these dynamics not only helps optimize performance but also ensures safety and efficiency in industrial applications. Whether you're an engineer fine-tuning a grinding setup or a physics enthusiast exploring rotational motion, appreciating the impact of forces like these deepens your grasp of the intricate mechanics that power everyday tools and machines.

Key Takeaways:

- The torque exerted by a tangential force depends on the force magnitude and radius.
- The moment of inertia determines how easily an object accelerates rotationally.
- Applied work converts into rotational kinetic energy, influencing the system's speed.
- Real-world factors such as friction affect actual performance and energy transfer.

By mastering these concepts, one can effectively analyze and optimize the operation of rotating machinery, harnessing the fundamental physics principles that drive mechanical innovation.

[Suppose You Exert A Force Of 180 N Tangential To A 0.280 M Radius 75.0 Kg Grindstone A Solid Disk](#)

Suppose You Exert A Force Of 180 N Tangential To A 0.280 M Radius 75.0 Kg Grindstone A Solid Disk

Related Articles

- [Please Help Me With This Chem Question, Ill Mark You Brainiest If Its Right. Theres Multiple Answers](#)
- [One Sunday, A 44-minute Call Cost \\$2.54. On Another Sunday, A 10-minute Call Cost \\$0.84. Assume That](#)
- [Parallel Lines R And S Are Cut By Two Transversals, Parallel Lines T And U.Lines R And S Are Crossed](#)

[Back to Home](#)