Construction Site Energy: *Mechanical*

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Grinders and Gears – Making Sense of Mechanical Energy Sources

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The Science Behind the Energy

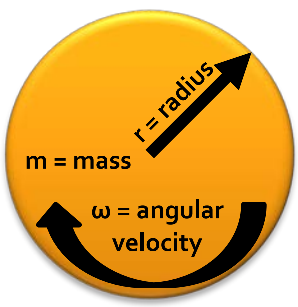
Mechanical energy comes from the operation of machinery. Mechanical energy can be from rotation, vibration or motion of the components in tools and equipment [1]. In today's construction industry, when working with metals or woods, a standard practice is to use grinders or saws to cut and finish materials. Grinders or saws utilize a motor (electric or internal combustion) to rotate a blade or wheel to produce rotational energy. Rotational energy is also Kinetic Energy, or the energy associated with motion of an object. More energy develops the faster a wheel or blade spins. The energy is then utilized to make cuts in materials. However, when improper cutting techniques or defective materials are used, excess energy can cause kickback from the equipment. Kickback is when a blade or wheel gets caught and is suddenly forced out of the material.

Kinetic energy depends on two major components: speed and mass. The general formula of kinetic energy is:

$$KE = \frac{1}{2}mv^2$$

In the case of a grinder, the kinetic energy is rotational and the formula is:

$$KE = \frac{1}{4}mr^2\omega^2$$



where:
m is the mass in pounds
r is the radius in inches or feet
ω is the angular velocity unit, a speed unit, in angle per time. (i.e. RPM)

This formula shows that kinetic energy will increase when:
The mass of the disc increases.
The size of the disc increases.
The speed of the disc increases.

Now let's see to what extent kinetic energy is involved in grinder kickback.

IN THIS ISSUE

The Science Behind the Energy

By breaking down the science of rotational energy, angular momentum, and other terms fine gentlemen like Sir Isaac Newton loved to study, we explain how mechanical energy is created and where it is going if things go wrong.

Where Does the Energy Go?

Mechanical energy is often driven by objects that are fast, heavy, and sharp. What happens when all that energy no longer acts the way you intended it to?

Why Does This Matter to Me?

So, what? That's the question we are often trying to answer. It is likely that almost every worker injured once thought, "It will never happen to me!" Learn how you can make that the case.

One of the most simple and powerful principles of physics is that in an isolated system, energy is conserved over time. Energy can neither be created nor destroyed; rather, it transforms from one form to another. This principle is observable in most of our daily routines. A common example would be a car and its conversion of multiple energy sources.

A car tank filled up with gas becomes an "isolated system" where the energy is actually locked inside the gas in chemical form. When the gas flows into the engine, it burns with oxygen in the air. The **chemical energy** in the gas is converted first into **heat energy**: the burning fuel makes hot expanding gas, which pushes the pistons in the engine cylinders. In this way, the heat is converted into **mechanical energy**. The pistons turn the crankshaft, gears, and driveshaft and—eventually—the car's wheels. As the wheels turn, they move the vehicle along the road, giving it **kinetic energy**.

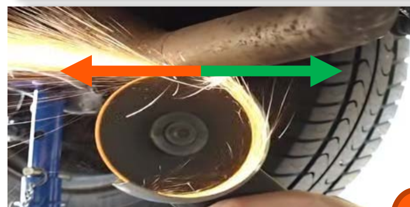
Therefore, this principle applies to the moving disc in the grinder. As long as the grinder is working and the disc is spinning, the energy is under kinetic form. However, as soon as the disc stops instantly, then the speed is equal to zero. At that point, $KE = \frac{1}{4}mr^2\omega^2 = 0$, which means that energy is no longer under kinetic form. Yet, energy cannot be destroyed. In conclusion, when the disc is stopped instantly, the exact amount of energy that use to spin the disc is released! This is a result of the conservation of energy and Newton's third law of motion that states, for every action, there is an equal and opposite reaction.

As a tennis ball bounces back when it hits a wall, the kinetic energy released will spread in all the grinder and push the grinder in the opposite direction of the movement of the disc. This is the kickback.

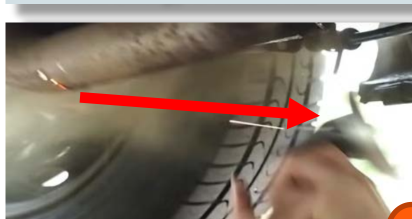
Where Does the Energy Go?

As mentioned in the previous section, conservation of energy changes the kinetic energy of the spinning wheel into a kickback force. There are two common components in the operation of a grinder that translate to injury. First, grinders are small and meant to be easily transported so they can be used anywhere. This means they are very light and do not have permanent fixtures making them stationary. Second, when in use, grinders are typically held by the base of the tool to avoid being cut by the wheel. When kickback occurs the force pushes the blade end of the unfixed tool away from the material.

Disc is spinning
Rotational Kinetic Energy
1



Disc stops spinning
Force applied by the disc in the pipe
Reaction of the pipe
Kinetic Energy is conserved
2



Disc is ejected: Kickback
Movement of the kickback
Translational Kinetic Energy
3

A low grip on the equipment provides little to no resistance against the force and the force can push the grinder towards the user. At this point, the grinding wheel is most likely still spinning, it can be hot from use, and are typically rough. If allowed to come into contact with skin, the grinding wheel can cause deep cuts, burns, and heavy abrasions. Most grinders on the market today do not have auto-kill features. The absence of an auto-kill device means the grinder will only stop when enough friction is produced to stop the wheel.

Fast Facts

#9 – Machinery and Machine Guarding (Top 10 OSHA Violations FY2015) [2]

5,400 – Average number of yearly grinder injuries [3]

Why Does This Matter to Me?

Imagine pedaling a bicycle as fast as you can for a short sprint. At a high estimate, your legs are moving at 110 rpm. How bad would a bike crash at full speed hurt? In comparison, average grinders spin at 4,000-7,000 rpm. Now consider, how bad would grinder contact with your body at full speed hurt?

Injuries resulting from the use of angle grinders are numerous. While kickback is the most common cause of injury, a secondary cause stems from incorrect or worn discs that increase the likelihood of excessive vibration and disc shattering. The most common sites injured are the head and face. The high speed disc of angle grinders does not respect your clothes or body and the injuries produced can be disfiguring (facial scars), permanently disabling (amputated fingers), or even fatal [3]. Fortunately, OSHA reports only one death caused by angle grinders from 2000-2012 [2].

Prevention, knowledge, and awareness are the best tools to avoid these types of mechanical hazards. Follow OSHA guidelines for Hand and Portable Powered Tools and Other Hand-Held Equipment (Section 1910.243) [2]. Lastly, here are some basic measures to take to keep yourself safe on the job site: stay focused on your task; never remove a hand guard; avoid loose clothing; wear safety glasses; use tools with built in kill-switches; operate at the appropriate RPM in accordance with the owner's manual; and do not force the tool.

Be safe! The goal is to leave the job site in better shape than you arrived in the morning!

References

[1] Dr. Matthew Hallowell Hazard Identification Tool
[2] OSHA website (https://www.osha.gov/)
[3] Bio-Med Central Website (https://www.biomedcentral.com/)