“Energy Transfer and the Importance of Recycling”

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Target Grade/Subject: High School Physics

Lesson Overview
This lesson will take students through the energy transfers that take place during the production of steel. Students will do calculations of energy transfers and compare how much energy recycling steel can save. Energy transformation is an important concept. This lesson will also involve heat, temperature and efficiency. Energy calculations and transformation will be reviewed during this lesson while also informing students about steel production and the importance of recycling.

Sources Consulted

Learning Objectives
Students will be able to:
- Identify the transformation of energy from one form to another.
- Calculate for kinetic energy, heat energy, and efficiency of machines and transportation used in the production of steel.
- Use dimensional analysis to convert given units to proper units.

Michigan High School Physics Standards
P1.1B Evaluate uncertainties or validity of scientific conclusions using an understanding of sources of measurement error, the challenges of controlling variables, accuracy of data analysis, logic of argument, logic of design, and dependence of underlying assumption.
P4.1A Account for and represent energy into and out of systems using energy transfer diagrams
P4.1D Calculate the amount of work done on an object that is moved from one position to another.
P4.2D Explain why all the stored energy in gasoline does not transform to mechanical energy during transportation.
P4.11X Heat, temperature, and efficiency
P4.11B Calculate the final temperature of two liquids (same or different materials) at the same or different temperatures and masses that are combined.

Materials
Pencil and worksheet

Vocabulary
Kinetic Energy- the energy of an object resulting from the objects motion
Flux – A material or chemical used to remove impurities.
Focus Questions
How much energy is saved by recycling steel?

Activity and Assessment
Since this will be a review lesson on the standards of energy transfer and calculations the worksheet will be self-explanatory. This worksheet will have students calculate and identify the work, power, kinetic energy, and thermal energy used during the production and transportation of steel.

After students complete the worksheet with their partners, the class will discuss the importance of recycling, especially the recycling of metals. The teacher should draw a diagram showing all the travel done in producing steel from scratch and the travel done by materials when using recycled materials. Recycling iron saves 75% of the energy used to make iron from scratch and we currently get 2/3 of our steel from recycled iron. Recycling aluminum saves 96% energy but we only receive 1/3 of our aluminum from recycled materials.

Ask students why they think steel is recycled more than aluminum?
**Steel is magnetic and may be retrieved more easily.**
Production of Steel from Raw Materials

Three main materials are used for the production of steel; (i) limestone, (ii) coal, and (iii) iron ore. These materials must travel throughout the Great Lakes before reaching the steel plant in Detroit. This worksheet will have you calculate and identify different energies used during this process.

1A. Coal must be mined from the ground and today the majority of it comes from Wyoming. The coal is put on a train that delivers it to a port in Wisconsin or Minnesota. Trains are very efficient in turning chemical energy stored in diesel fuel in to what form of energy?

1B. Coal is then loaded onto a large cargo ship that will travel 1170 km in 60 hrs to reach Detroit. Cargo ships are very efficient at transporting goods by hauling 7,000 times more cargo than a semi-truck. This cargo ship has a mass of $1.6 \times 10^8$ kg when filled. What is the average kinetic energy of this ship during its trip?

1C. The next ingredient that must be shipped in is the limestone. Limestone is used as a flux (removes impurities) during steel production. The limestone is transported in a ship similar to the one that shipped the coal. However, the limestone is shipped from the largest limestone quarry the world 500 km away in Rogers City, MI. If it takes the ship 17 hours to reach Detroit, what is the ship’s average kinetic energy during the trip?

1D. The last product needed is the iron ore that must be at least 60% iron. All this iron ore has already been mined so 20% iron ore must be turned into 60% iron ore pellets called taconite. To do this primary grinding mills use 5700 HP to crush the rock to the consistency of sand. How much work is done by these mills in one minute? 1 HP = 756 Watts

1E. The crushed iron ore must then travel to the secondary grinding mills to reach the consistency of powder. These grinding mills only use 3200 HP, which is what percentage of the HP used in the primary mills?
1F. The iron powder must now go through a long process of removing the water and impurities while forming into pellets. The pellets are finally heated to 2,300 degrees Fahrenheit from 99° Fahrenheit (F = 9/5 * C + 32°). How much thermal energy is required to heat the 1.35 X 10^5 kg of pellets that are produced everyday at the factory if the pellets have a specific heat capacity of 800 J/kg°C?

2) The iron ore pellets (taconite) must then cool and are shipped to Detroit from the Upper Peninsula of Michigan. Now the materials can be combined to create the steel. The coal is used as a fuel source to melt the iron ore and to add carbon to the ore at the same time. The limestone flux is then added to the liquid iron to remove impurities. The limestone is easily removed because it floats to the top of the liquid iron. Carbon is removed from the liquid iron to make it liquid steel. The liquid steel is finally molded and sold.

2A) What is more dense, the iron or the limestone? Explain.

2B) Which ingredient (taconite, coal, or limestone) do you believe consumes the most overall energy in its manufacturing and shipping? Why?

If you finish the worksheet before the end of the class visit the following website to see diagrams of this process.
http://www.steel.org/~media/Files/AISI/Making%20Steel/Article%20Files/ironore.PDF

**ANSWERS**
1A) Kinetic Energy
1B) 2.3 X 10^9 J
1C) 5.3 X 10^9 J
1D) 2.6 X 10^8 J
1E) 56%
1F) 1.3 X 10^11 J

2A) Iron because the limestone floats
2B) Taconite because it must be processed from a the raw material iron ore