Name: _____ Date: _____

The Spinning Balls That Steered a Steam Engine

Circle group

Early steam engines had a problem. Their speed did not stay the same. If the fire got hotter, the engine sped up. If the work got harder, the engine slowed down. A factory needs steady motion. It could not keep a worker beside the engine all day to turn a valve. Engineers wanted an engine that could control itself.

James Watt used a smart answer on his engines. It is called a centrifugal governor. A shaft stands up straight, and the engine turns it. Two heavy metal balls hang from arms near the top. When the shaft spins slowly, the balls hang close to it. When it spins fast, the balls swing out and up. A spinning thing tends to fly away from its center.

Rods link the balls to a throttle valve. The valve controls how much steam goes to the engine. When the balls rise, the rods close the valve a little. Less steam comes in, so the engine slows down. If the engine slows too much, the balls sink. The rods open the valve, and more steam rushes in.

No person has to tell the governor what to do. The engine's own speed is the message. Engineers call this feedback. Thermostats and cruise control use the same idea.

Questions

1. What problem did early steam engines have?

_____

_____

2. What do the two balls do when the shaft spins faster?

_____

_____

3. What does the throttle valve control?

_____

_____

4. What happens to the valve when the balls rise?

_____

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5. Why does the governor need no person to run it?

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_____

6. Why are thermostats said to use the same idea?

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_____

Words to know

centrifugal: describes the tendency to fly outward from a center
throttle: a valve that controls how much fuel or steam flows
feedback: using the result of a process to adjust that same process
shaft: a long rod that turns to carry power

Talk together (every group has these)

1. Find one fact that every group read. How did your sheet say it?
2. What did your sheet tell you that you think another group's did not? Ask them.
3. What is one question about this topic that none of the sheets answered?

Name: _____ Date: _____

The Spinning Balls That Steered a Steam Engine

Triangle group

Early steam engines suffered from a stubborn weakness, which was that their speed refused to stay constant. If the fire burned hotter, or if the machinery the engine was driving suddenly became easier to turn, the engine would race ahead. If the load grew heavier, it would slow down. A factory that depended on steady motion could not rely on a worker standing beside the engine all day, adjusting a valve by hand. Engineers wanted an engine capable of regulating itself.

An ingenious answer was the centrifugal governor, which James Watt used on his engines in the late eighteenth century. Picture a vertical shaft that is turned by the engine, with two heavy metal balls hanging from arms attached near the top. When the shaft spins slowly, the balls hang fairly close to it. When it spins faster, they swing outward and upward, because a spinning object tends to fly away from its center.

What matters is what the balls are connected to. A set of linked rods joins their arms to a throttle valve, the gate that controls how much steam reaches the engine. As the balls rise, the rods partly close the valve. Less steam flows in, and the engine slows down. If the engine slows too much, the balls sink, the rods open the valve again, and more steam rushes in.

The governor never needs a person to tell it what to do. The engine's own speed is the message, and the response pushes that speed back toward a steady value. Engineers call this feedback, and the same idea appears in thermostats and cruise control.

Questions

1. What problem did early steam engines have?

_____

_____

2. What happens to the two balls when the shaft spins faster?

_____

_____

3. What does the throttle valve control?

_____

_____

4. What happens to the valve when the balls rise?

_____

_____

5. Why does the governor need no person to operate it?

_____

_____

6. Why is a thermostat described as using the same basic idea?

_____

_____

Words to know

centrifugal: describes the tendency to fly outward from a center
throttle: a valve that controls how much fuel or steam flows
feedback: using the result of a process to adjust that same process
shaft: a long rod that turns to carry power

Talk together (every group has these)

1. Find one fact that every group read. How did your sheet say it?
2. What did your sheet tell you that you think another group's did not? Ask them.
3. What is one question about this topic that none of the sheets answered?

Name: _____ Date: _____

The Spinning Balls That Steered a Steam Engine

Square group

Early steam engines suffered from a stubborn and costly weakness, which was that their speed refused to remain constant. If the fire burned hotter, or if the machinery the engine was driving suddenly became easier to turn, the engine would race ahead of itself. If the load grew heavier, the engine would labor and slow down. A factory that depended on perfectly steady motion could not afford to keep a worker standing beside the engine all day, adjusting a valve by hand. Engineers therefore searched for an engine capable of regulating itself without human assistance.

An ingenious answer was the centrifugal governor, which James Watt used on his engines in the late eighteenth century. Picture a vertical shaft that is turned by the engine, with two heavy metal balls hanging from arms attached near the top of it. When the shaft spins slowly, the balls hang fairly close to it. When it spins faster, they swing outward and upward, because a spinning object tends to fly away from its center.

What makes the device remarkable is what the balls are connected to. A set of linked rods joins their arms to a throttle valve, the gate that determines how much steam is admitted to the engine. As the balls rise, the rods partly close the valve, so less steam flows in and the engine gradually slows. Should it slow too much, the balls sink, the rods open the valve again, and more steam rushes in to restore the pace.

The governor never needs a person to instruct it. The engine's own speed is the message, and the response pushes that speed back toward a steady value. Engineers call this principle feedback, and the same basic idea appears in thermostats, cruise control, and countless other modern machines.

Questions

1. What stubborn weakness did early steam engines have?

_____

_____

2. What happens to the two balls when the shaft spins faster?

_____

_____

3. What does the throttle valve determine?

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_____

4. What do the linked rods do as the balls rise?

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5. Why does the governor operate without a person instructing it?

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_____

6. Why is a thermostat described as using the same basic idea?

_____

_____

Words to know

centrifugal: describes the tendency to fly outward from a center
throttle: a valve that controls how much fuel or steam flows
feedback: using the result of a process to adjust that same process
shaft: a long rod that turns to carry power

Talk together (every group has these)

1. Find one fact that every group read. How did your sheet say it?
2. What did your sheet tell you that you think another group's did not? Ask them.
3. What is one question about this topic that none of the sheets answered?

For the teacher: The Spinning Balls That Steered a Steam Engine

Each student sheet carries a shape, not a level. The same topic and facts, written three ways.

Circle: The Spinning Balls That Steered a Steam Engine

Easier · 211 words · Flesch-Kincaid grade 2.7

1. Their speed changed when the fire or the work changed.
2. They swing out and up.
3. How much steam goes to the engine.
4. The rods close it a little, so less steam comes in.
5. The engine's own speed moves the balls, and the balls change the steam.
6. They also use the result to push it back to a steady value.

Triangle: The Spinning Balls That Steered a Steam Engine

This passage · 268 words · Flesch-Kincaid grade 7

1. Their speed changed when the fire or the load changed.
2. They swing outward and upward.
3. How much steam reaches the engine.
4. The linked rods partly close it, so less steam flows in.
5. The engine's own speed moves the balls, and the balls adjust the steam.
6. It also uses a measurement of the result to push the result back toward a steady value.

Square: The Spinning Balls That Steered a Steam Engine

Harder · 296 words · Flesch-Kincaid grade 8.7

1. Their speed refused to stay constant when the fire or the load changed.
2. They swing outward and upward.
3. How much steam is admitted to the engine.
4. They partly close the valve, so less steam flows in.
5. The engine's own speed moves the balls, and the balls adjust the steam supply.
6. It also uses the measured result to push that result back toward a steady value.