Dragon's Fire Breath Effect on an Iron Plate

By: [redacted]

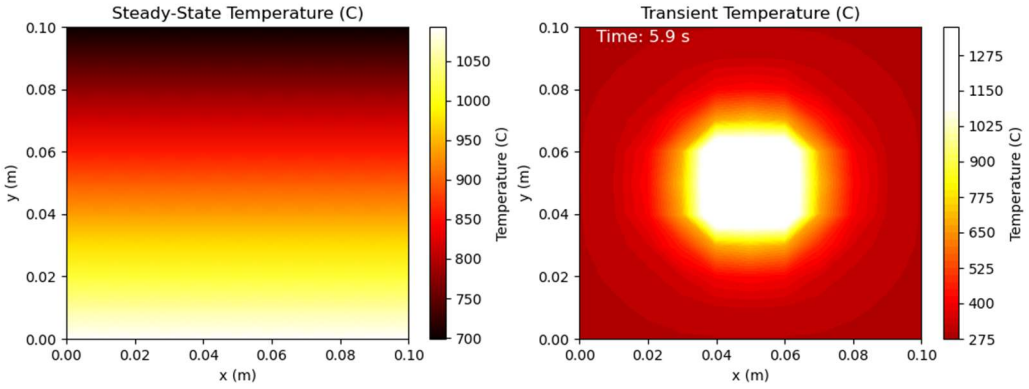
Our group decided to test various metals as armor in a battle against a dragon, specifically the dragon's fire breath hitting the metal plate being used as a shield directly above the knight. I chose iron for the metal I wanted to test. The other metals chosen in the group were 1084 steel, copper, bronze, titanium, and tungsten. We wanted a uniform testing method with the same parameters to ensure we could easily compare results from each metal to see which one held up best against the fire.

Our parameters consist of:

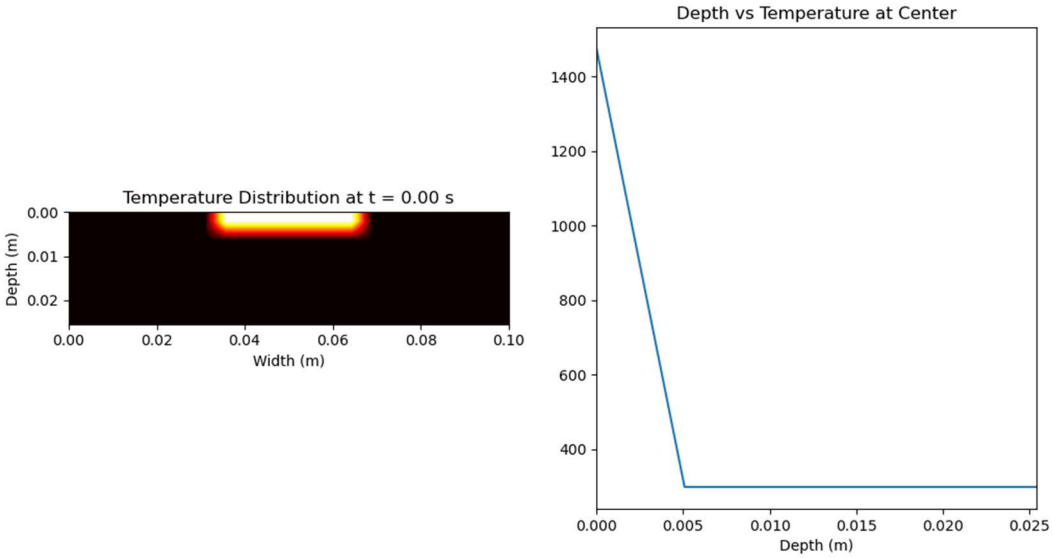
Parameter	**Measurement**
Ambient air temperature	T = 25 °C
Area of the metal plate	0.1m x 0.1m x 0.0254m
Area of the metal getting hit by the fire	$\Delta x = \Delta y = \Delta z = 0.01m$
Dragon	Smaug from *The Hobbit*
Fire Temperature	1093 °C
Fire Velocity	8.75m/s
Fire Properties	Same properties as air
Fire Heat Transfer Coefficient	3.74 W/m^{2}K
Time fire was blown onto metal	6 seconds
Circumstance	Knight is using the metal as their shield to block the dragon's fire from above

We used the heat affected zone above as the mesh size as it did not change the simulation significantly based on the size other than taking longer and running it smoother. The temperature of the fire's velocity was calculated from V_{fire}=$V_{fire+Smaug}$−V_{Smaug} , which was then used with the properties of air to find the heat transfer coefficient.

Steady-State and Transient Simulations



Depth Simulation of the Iron Plate



Analysis and Conclusion

Running the code, it took 471 iterations to complete until the max temperature of 1093 °C for iron. The melting temperature of iron is 1535 °C, so the iron plate was red hot in the center causing the structure of the material to weaken in the middle but not completely fall apart as a structure. As for the rest of shield, the temperature around the edges remained a safe (albeit cold) temperature around approximately 275 K (1.85 °C). If the knight's skin was in direct contact with the metal, his skin would definitely burn, but he would not be burnt to ash if the shield effectively covered him.

Testing

Real life testing is limited because there is no dragon nor dragon's fire breath to test on each metal, but using fire that is assumed to have the same properties as the dragon's breath we can find a close approximation according to descriptions of Smaug. The fire could be aimed directly at the center of each metal that is of the same dimensions as ours at the same velocity as ours. After 6 seconds of direct contact of the fire, we could note our observations of each metal and compare it to our simulations.

Errors

Our simulations only considered convection as the heat transfer occurring affecting a very small section of the plate which also had a small dimension compared to the reality of how large a shield would be in this situation. We considered the fire to have the same properties of air, but another gas could have worked better such as napalm. The surface temperature of the block began at 1093 °C

in our simulation, which would have been unrealistic. Overall, we understood how our errors affected the code and our results, but we were still confident that titanium would have been the best metal to use according to its density, low thermal conductivity, melting point, and toughness.

Sources

Peter Jackson's Film *The Hobbit*

www.matweb.com