HEAT TRANSFER

DUNGEONS AND DRAGONS COIN CASTING
BACKGROUND

THE SILVER COINS	MAE 3233	[redacted]
RACE (MATERIAL)	CLASS & LEVEL	PLAYER NAME

DENSITY	VOLUME	Cp	k	DIAMETER	THICKNESS
10.49	0.8675	234	419	23.50	2
g/cm^3	cm^3	J/kg-K	W/m-K	mm	mm

POURING TEMP	FINAL TEMP
975	400
℃	℃

+1	INSPIRATION
+3	PROFICY BONUS
16	P. WISDOM (PERCEPTION)

○	+3	Strength
○	-2	Dexterity
○	+0	Constitution
○	+1	Intelligence
●	+3	Wisdom
○	+2	Charisma

SAVING THROWS

●	+1	100% pure materials
○		- Graphite
○		- Platinum
○		- Gold
○		- Silver
○		- Copper
○		
●	+2	No air pockets or pores
○		
●	+3	Coins are cast as perfectly cylindrical blanks
○		
○		
○		
●	+4	Fully enclosed mold
○		
●	+5	Static material properties
○		- Thermal conductivity
○		- Specific heat

ASSUMPTIONS

SILVER	MOLD CAST	11.045 MIN
ARMOR	INITIATIVE	SPEED

TOTAL: 662.7 Seconds

TIME TO COOL

f'(x) = [f(x+h)-f(x)]/h

FINITE DIFFERENCE METHOD

Q*cond,cyl= -kA (dT)/dr
Q/t = kA((T1-T2)/l)
where Q/t is the rate of heat transfer, k is the thermal conductivity of the material, A is the cross-sectional area, T1-T2 is the temperature difference, and l is the thickness.

2D CONDUCTION CALCULATIONS

The simulation does not take into account the outside air or any human factors. Individuals casting might use a different starting temperature or different mold size.

FLAWS (SOURCES OF ERROR)

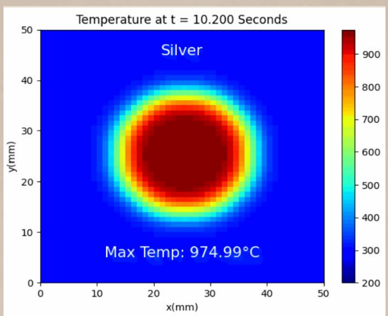
GRAPHITE MOLD VALUES

INITIAL TEMP: 202.44 ℃

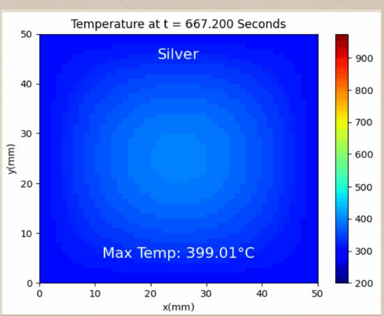
k: 24.0 W/m-K

Cp: 707.7 J/kg-K

EQUIPMENT (THE MOLD)



(IMMEDIATELY AFTER POUR)



AT 399.01 ℃

The simulation shows even cooling around the entirety of the coin.

The simulation does not take into account:

- Convection
- The openings at the top of the mold
- Pores in the graphite

The simulation uses a starting temperature of 202.44 ℃ for the graphite mold and a starting temperature of 975 ℃ for the molten silver.

The silver reached a temperature of 400 ℃ at 662.7 sec.

FEATURES & TRAITS (OF THE SIM)

HEAT TRANSFER

DUNGEONS AND DRAGONS COIN CASTING
BACKGROUND

THE SILVER COINS
RACE

MAE 3233
CLASS & LEVEL

[redacted]
PLAYER NAME

CHARACTER APPEARANCE

🐉 Introducing Dragoncrest Mint - Where Tradition Meets Mastery! 🐉

💰Embark on a journey through the mystic realms of Baldur's Gate with Dragoncrest Mint, your gateway to exquisite coinage! Our newly opened mint combines ancient craftsmanship with modern precision, offering you coins of unparalleled quality and beauty.

🌟 Be among the first to own a piece of Baldur's Gate history – visit Dragoncrest Mint today and experience the magic for yourself! Hurry, and claim your share of the treasure before it's gone!

CHARACTER BACKSTORY

Coins have been made using various methods throughout history, from hand-minting in medieval times to casting in colonial America and Britain. Traditional methods involved striking metal blanks with dies, while casting involved pouring molten metal into molds, often made with special casting sand or graphite molds. Modern casting techniques use graphite molds, where molten metal is poured and allowed to solidify before removal.

The Dungeons and Dragons Player's Handbook mentions four types of coins used in the game but doesn't detail their manufacturing process. Given the fantasy setting, it's assumed some magical element is involved. To simulate coin casting, the project utilizes double-sided pure graphite molds. Each coin varies in size and metal type, with a consistent weight for all types. Analysis focuses on platinum, gold, silver, and copper coins, assuming they are shaped like typical American coins.

Analyzing the casting of a silver coin in Dungeons and Dragons involves calculating its volume and dimensions based on its weight and density. By using the volume formula for a cylinder and known height, the diameter of a silver coin with a 2mm thickness is determined to be 23.50 mm.

Preparation for casting with graphite molds includes ensuring they're stored in dry areas, preheating them to prevent damage, and drying them thoroughly if exposed to moisture. Mold temperature should reach approximately 400 degrees Fahrenheit before casting.

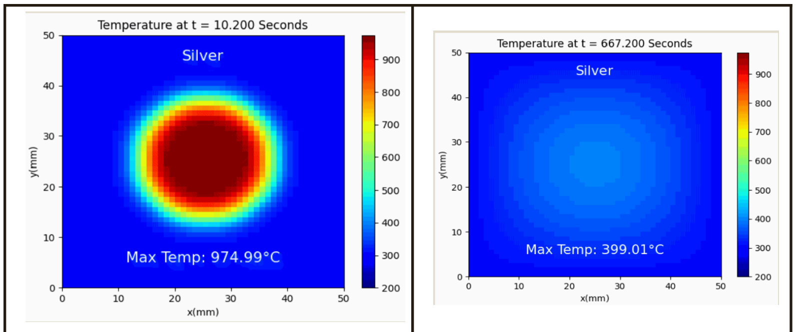
Assumptions for the simulation include perfectly pure materials and no air pockets in the graphite mold. Access to real-world forging equipment and materials was limited, so comparisons rely on existing casting practices observed through videos and forums.

Some factors that can affect these results are the environment around the real world. My simulation looks at the relationship and heat transfer between the mold and the metal being cast and does not take consideration of outside air or the pores in the mold. Using assumptions of pure silver and pure graphite, treating the coin as a perfect cylinder as opposed to including design like a coin would actually have, assuming we know the exact temperature the metal is heated to prior to pouring (usually when casting metal is simply melted and often starts higher than technical melting point to ensure all the metal is liquid).

Mesh size in simulations is critical for balancing accuracy with computational resources. A coarser mesh may suffice for simple shapes, but finer meshes offer better resolution at the cost of increased computational burden. Finding the optimal mesh size requires considering accuracy needs, available resources, and system complexity.

ADDITIONAL INFORMATION (REPORT OVERVIEW)

One way to cast coins is using graphite molds to pour molten metal into to cure. The graphite permanent mold casting process begins with clamping two graphite blocks together. Molten metal of the maker's choosing is then poured into a sprue or pouring basin at the top of the mold. Once the metal has solidified, the graphite molds are separated and the castings are removed.



(IMMEDIATELY AFTER POUR)	AT 399.01 ℃

According to the 5e Player's Handbook, fifty coins weigh a pound. The handbook does not indicate a different weight for any different type of coin so it's safe to assume the coins vary in size but not weight. Thus, a single coin of any type weighs 0.02 pounds or 9.1 grams. Assuming the coins are made of pure metal and not an alloy of some kind, we can use the density to calculate the volume of each type of coin. While there are many potential shapes used for these fantasy coins, for the sake of this project we will be assuming the coins are shaped like a typical American coin, short cylinders with thicknesses a consistent 2 mm. The four main types of coins used in Dungeons and Dragons are platinum, gold, silver, and copper, and these are the materials we will be using for our analysis.

For this project, I focused on analyzing the casting of a silver coin in Dungeons and Dragons. Since we know from the D&D Player's Handbook that each individual coin weighs 9.1 grams, we can use Silver's density of 10.49 g/cm^3 to calculate the volume of the coin and the specific dimensions of the cylinder. Thus, the volume of a silver coin in D&D is 0.8675 cm. The volume of a cylinder can be calculated using $V = \pi r^2 h$ and we have a selected height of 2 mm and a known volume. From this information we can determine the diameter of a silver coin in D&D with a thickness of 2mm is 23.50 mm.

Casting using graphite molds requires some level of preparation. Firstly, it's important to ensure the molds are stored indoors in dry areas, otherwise the mold needs to be thoroughly dried before coming in contact with any molten metal. The water in the pores of the graphite will turn to steam when in contact and can become dangerous to the operator and detrimental to the mold. Also, the molds must be preheated to prevent damage to the interior surface or cracking in some cases. The mold should be preheated to approximately 400 degrees fahrenheit.

While molds in the real world are hardly ever 100 percent pure graphite and the metal used for casting the coins will not likely be 100 percent pure either, we are assuming the materials are perfectly pure and there are no air pockets/pores in the graphite for the sake of calculations and simulation.

Sadly we did not have easy access to a real forge and a double sided graphite mold or pure gold, silver, or platinum to accurately compare the simulation with actually casting coins. While we likely could have gotten our hands on some usable copper, there were still roadblocks in casting our own coins. So, for the comparison we will have to rely on others' casting practices.

To compare the simulation to the real world, I consulted various videos and forums relating to casting as a hobby and career. The size and shape of the mold will affect how long it is kept there and there are also factors up to the caster's preference. Some let the cast cool longer than others but typically, the cast only needs to cool below red-hot and can be removed so the mold can be used again. This typically takes between 5 and 30 minutes depending on the size and shape of the mold. In the simulation it shows that the silver took about 11 minutes to cool which aligns with what would be expected in the real world.

Some factors that can affect these results are the environment around the real world. My simulation looks at the relationship and heat transfer between the mold and the metal being cast and does not take consideration of outside air or the pores in the mold. Using assumptions of pure silver and pure graphite, treating the coin as a perfect cylinder as opposed to including design like a coin would actually have, assuming we know the exact temperature the metal is heated to prior to pouring (usually when casting metal is simply melted and often starts higher than technical melting point to ensure all the metal is liquid).

The mesh size refers to the density of the grid used to discretize the domain being simulated. A finer mesh means more grid points, allowing for better resolution of temperature gradients and spatial variations within the domain. This finer resolution can capture small-scale features and phenomena more accurately, leading to a more precise simulation.

However, using a finer mesh comes with a computational cost. More grid points require more memory and computational power, which can increase simulation time and resource usage significantly. Additionally, using an excessively fine mesh may introduce numerical errors or instability, particularly if the simulation involves complex geometries or transient phenomena.

On the other hand, using a coarser mesh reduces the computational burden but may oversimplify the model, leading to loss of detail and accuracy. Important features or gradients may be smoothed out or entirely missed, resulting in less accurate results.

Finding the optimal mesh size involves balancing these trade-offs. It often requires iterative refinement, where the mesh size is adjusted based on the specific requirements of the simulation, such as the desired level of accuracy, available computational resources, and the complexity of the system being modeled. Because the shape is so simple for my simulation, there is not as much detail needed to get an accurate representation of the heat transfer problem. A coarser mesh works well enough to display the results.

Citations:

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