**Objectives**
To gain experience with a wide variety of materials processing and fabrication techniques through the construction of an aesthetically pleasing and functional metal chess set.

**Design**

**Design Constraints**
- King's height ~ 9 cm with ~ 4 - 5 cm base.
- Aesthetically pleasing, stable, and of comfortable weight.
- Pieces proportionate in height and form.

**Piece Design**
Pieces were chosen to be sand-cast using a single metal (such as aluminum) to ensure a uniform weight on both sides and would later be surface treated in order to obtain the necessary difference in coloration.

**Board Design**
Individual tiles were to be machined, polished, and colored from stock material. In order to lighten the overall weight of the board and the materials cost of the project, these tiles (chosen to be brass), would be cast on an aluminum base. Aluminum was chosen was for its relatively low weight and cost, as well as high stiffness.

**Materials Selection**

**Materials Constraints**
- Castable metal readily available as sheet stock (for board).
- Of "comfortable" weight.
- Fracture and dent resistant product.
- Surface finishing options.

**Materials Options**
Castable metals were ranked based on material properties.

**Materials Choice**
Ultimately a Copper-Zinc alloy was selected for the project. The particular alloy consisted of ~ 58% Cu and 39% Zn, with other trace impurities. The alloy is extremely hard and cold in color when cast (it is commonly used in Hollywood as a substitute for gold on screen), however the alloy can be somewhat difficult to cast as it is particularly sensitive to turbulent flow.

**Materials Characterization**

**Microstructure**
Samples were cast from both the as-received ingots and the cast material, and the microstructures were compared. The ingot displayed a much higher concentration of alpha phase, suggesting that the cooling conditions under which they were formed differed from our casting process. Additionally, many more inclusions believed to be voids were present in the cast samples.

**SEM Analysis**
Samples from both the as-received ingots and cast metal were taken for SEM analysis. The ingot overall composition was within 0.5% of the manufacturer specifications, and consisted primarily of alpha and beta phase material.

**Methods and Construction**

**Investment Casting**
A ceramic powder is mixed into a slush with ethanol and poured over a wax version of the object to be cast. After solidifying, the wax material is removed through heat treatment and molten metal is poured into the cavity.

**Investment casting**
One of the two major methods of casting, sand casting allows for a greater level of surface detail to be captured, and as a result was chosen for this project.

**Machining Operations**
The board was constructed primarily through the use of tooling, consisting of a CNC mill, lathe, and water jet. The construction was a multi-step process involving careful computer design and technical execution of the design to machine numerous pieces with high precision (to ensure an appropriate fit when the end product was assembled).

**Surface Treatments**
White pieces were electroplated using a proprietary method at the Xtalic corporation. The process involves controlled deposition of nickel and tungsten atoms through the use of alternating current to fine tune the nanocrystalline surface structure of the product.

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