EDUCATIONAL MODULE ON SUSTAINABLE ADDITIVE MANUFACTURING (AM)

Homework

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# Part I: Homework Assignment

1. Briefly discuss the following concepts. Include at least one reference (website, textbook, journal articles, etc.) in your response:
   1. Sustainability Engineering
   2. Advanced Manufacturing
   3. Additive Manufacturing
2. List and define the three pillars of sustainability. Provide three metrics that can be used to measure the performance of each of the three pillars (nine metrics total).
3. Identify three key limitations of additive manufacturing and discuss how these can be addressed by future research. Include at least three references (website, textbook, journal articles, etc.) in your response.
4. Find three new additive manufacturing applications that have been developed in the last year. Include your references (website, textbook, journal articles, etc.) in your response.
5. A prototype of a keychain with a circular cross-section is to be fabricated using stereolithography. The radius of the outside dimension is 40 mm and the inside radius is 30 mm (ring thickness of 10 mm). The thickness (z-direction height) of the keychain is 10 mm and the layer thickness is 0.20 mm. The laser beam spot size is 0.5 mm. Assume beam is moved across surface at a velocity of 3000 mm/min. Compute an estimate for the time required to build the part, if 5 seconds are lost for each layer to lower the platform that holds the part. Neglect the time for post curing.
6. A company wants to produce 1000 toy connector blocks by using fused deposition modeling (FDM). The toy connector block design is shown in Figure 1. The major cost drivers to fabricate the blocks are materials and energy use. Engineers know that build time is a major factor to reduce energy use. Thus, they developed a process model to estimate build time (Tbuild), where V is the volume of the part, SA is the surface area, and C1, C2, C3, and C4 are model constants, as shown in Eq. 1.

(1)

The values for C1, C2, C3, and C4 are 2.8625x10-4, 9.6791x10-1, 2.4636x10-6, and 12.5292, respectively. The FDM machine has a rated power (PFDM) of 10 kW. Assume that the company buys electricity at the rate of 10 cents/kWh in completing the analysis below.

* 1. Calculate the total process energy. Determine the energy and material costs of manufacturing 1,000 toy blocks from ABS, which has a density of 1.07 g/cm3 and costs $100/kg.
  2. Calculate the post processing energy cost involved if the block design has a shape complexity value of 2. The post processing machine rated power (Ppost) is 1 kW. Assume the parts are washed in batches of 10. The base washing time (tbase) is 30 seconds, the base area (Abase) is 2 cm2, and K1, K2 and K3 are 1, 1, and 0, respectively.

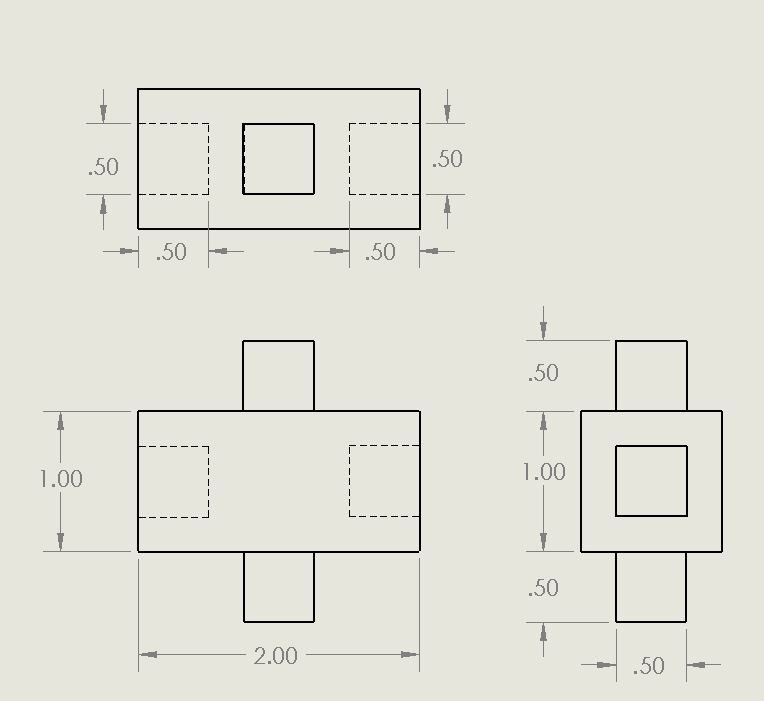


Figure : Toy Connector Block Design

# Part II: In-class Discussion

In the next class period, we will be learning about recent and future trends in additive manufacturing. As a part of the class, we will discuss emerging developments based on information you find. Complete the following tasks:

1. Choose an AM process technology (FDM, SLM, SLS, or any other)
2. Research the technology background and future paths
3. Create a short PowerPoint presentation with four slides, including:
   1. Title slide: Technology Name (Process Type), Your Name, Class Name, Date
   2. Technology background: Describe the operation of the process
   3. Potential breakthrough development: Describe one key development that will transform the process in industry. How will this contribute to sustainability?
   4. References: Provide a formatted list of references you used