

Wood Canoe Paddle

Another Hard Worker

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PURPOSE OF THE PADDLE – FUNCTION

The wooden canoe paddle encounters a wide range of applications ranging from brisk paddling to pushing a canoe off shore. It is made of a simple design with a few functions in mind. The functional requirements of each component of the wood canoe paddle are as follows:

- Strong handle that can withstand the large forces exerted upon it by the paddler.
- Light shaft that can handle large bending moments.
- Light blade that is tough enough to withstand accidental impact.
- Light blade that is strong enough to handle the large forces exerted upon it.

OBJECTIVES AND CONSTRAINTS

The objectives for the design of a wood canoe paddle are the following:

- Minimize weight
- Maximize strength

The oar must be light so that there will not be any excess weight to weigh the boat down and cause unnecessary drag. In addition, the paddler can become quickly fatigued over time if the weight is not minimized. Furthermore, the paddle must be strong enough to handle the bending moments created by the paddler during the stroke.

Note: The objectives are to be met by all components in the design of the wood canoe paddle and must be met under the following constraints:

NON-NEGOTIABLE CONSTRAINTS

- Material must float in water.
- Must not fracture if accidentally impacted.
- Must be able to support bending load F without deflecting too much.
- Length l specified

- Stiffness S specified

Length and stiffness are constraints that are assumed to be predetermined since they will change according to the feel desired by the paddler.

NEGOTIABLE CONSTRAINTS

- Cost must be reasonable.

OBJECTIVE FUNCTION

The objective function is particularly important when looking at optimizing the design of a structural element. In the design of the paddle we seek to minimize the mass of all the components, the objective function that minimizes mass m is,

$$m = A\rho l$$

where ρ is the density, l is the fixed length, and A is the area. Utilizing the objective function and eliminating the cross-sectional area A the best materials for a light and stiff design are those with large values of the following material index:

$$\text{Shaft: } M = E^{1/2}/\rho$$

$$\text{Blade: } M = E^{1/3}/\rho$$

The best materials to maximize the strength to weight ratio are those with large values of the following material index:

$$\text{Handle and Shaft: } M = \sigma^{2/3}/\rho$$

$$\text{Blade: } M = \sigma^{1/2}/\rho$$

The best materials to maximize the fracture toughness to weight ratio for the blade are those with large values of the following material index:

$$\text{Blade: } C = K^{1/2}/\rho$$

The best materials to minimize cost for all the components are those with large values of the following material index:

$$C = E^{1/2}/C_p$$

COMPARISON TO EXISTING PADDLES

ALUMINUM – PLASTIC BLADE – The aluminum shaft and plastic blade is a fairly strong and cost efficient combination of materials. In addition, the materials are of minimal weight, thus minimizing fatigue. In situations where fracture toughness is needed in the blade; the plastic blade will be at high risk of failing due to the low fracture toughness properties of plastic.

WOOD – The paddle constructed of wood is fairly strong and cost efficient. In addition, it ranks fairly high on the stiffness to weight ratio. The wood paddle is versatile and can be manufactured to fit a wide range of applications.

COMPOSITE SHAFT – The composite shaft provides great strength and stiffness where large bending moments are created. If however, cost is to be minimized, the composite material may not be the best material for the job.

CONCLUSION

Using the material selection charts found in chapter 4 I was able to determine which materials did and did not meet the design criteria defined above. Pulling together the findings from all the charts I find that the most ideal and cost efficient paddle should be made of the following combination:

- Wood handle
- Wood shaft
- Wood blade

If however, cost was not an issue and more strength was needed I think the paddle should be made of the following combination:

- Composite handle
- Composite shaft
- Composite blade

The handle for each of the combinations mentioned above would be greatly improved if they were coated with a rubberized compound to provide grip. In addition, the composite blade could be rimmed with metal to protect the edges so that splintering will not occur.

REFERENCES

1. Michael F. Ashby, Materials Selection in Mechanical Design, Second Edition, 1999

