MSY 310 Project 2021

Assigned: 3 June 2021
Revised: 17 June 2021. Revisions are highlighted
Due: 23 June 2021, 23h59
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Information about the project

- You will access the project through the Judicator AMS system, ams.up.ac.za . Please ensure that you know how to log in to the system.
- You can now download your unique set of values from AMS.
- Part of the mark will be awarded for correct calculation of the requested values. This will be marked automatically from values which you submit via AMS
- Part of the mark will be awarded for your pictures, calculations and discussion in the submitted report, which you will upload on AMS
- This project will be completed individually. You are welcome to discuss the methods for solving this problem with your classmates. In the end, you must do your own work and complete your own report, based on your own uniquely assigned values.
- This project measures the ECSA Problem Solving Graduate Attribute. It is a requirement that you pass this project in order to be allowed to write the exam.

Problem description

You have been called in as an engineer to help a client with the following problem.

An existing power transmission shaft, as shown in Figure 1, is used in a mining application. At either end of the shaft (points A and D), the shaft is supported by self-aligning journal bearings, which are supported by plummer blocks and securely mounted to the floor of the plant. The shaft is made from EN8 carbon steel.

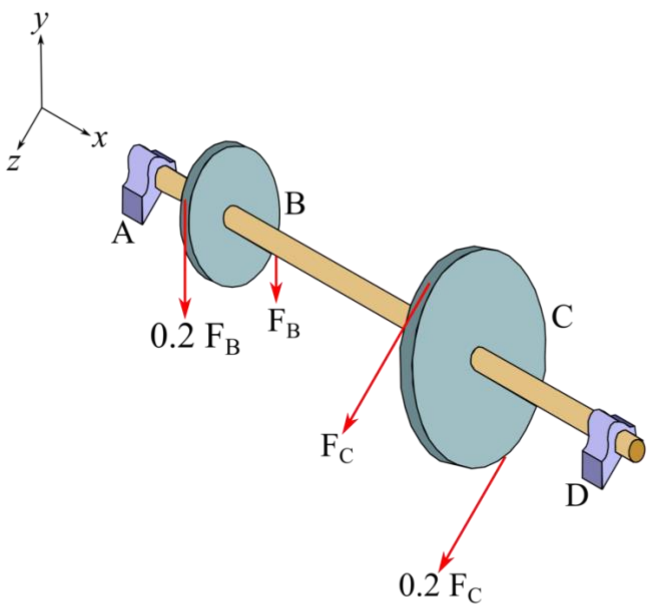

Figure 1: Isometric view of the power transmission shaft. (Note the forces on pulley B have been changed.)

The belt-driven pulley at B powers a lift which transports personnel to the working place. The pulley at B has a diameter of d_B, and the belts for pulley B run vertically (i.e., in the y-direction). A motor which is connected to the belt-driven pulley at C provides power to the shaft. The pulley at C has a diameter of d_C, and the belts for pulley C run horizontally (i.e., in the z-direction). The force on the slack side for each pulley is 0.2 times the force on the tight side.

The shaft is rated for a power of P kW, and runs at a speed of N rpm. The shaft has a diameter d, which you can assume is constant along the whole length (*i.e.*, there are no reductions or increases in diameter at the bearings or the pulleys). You can neglect the weight of the shaft in your calculations.

As shown in Figure 2, the pulley B is a distance a from the bearing A, the pulley C is a distance c from the bearing D, and the distance between the two pulleys is b.

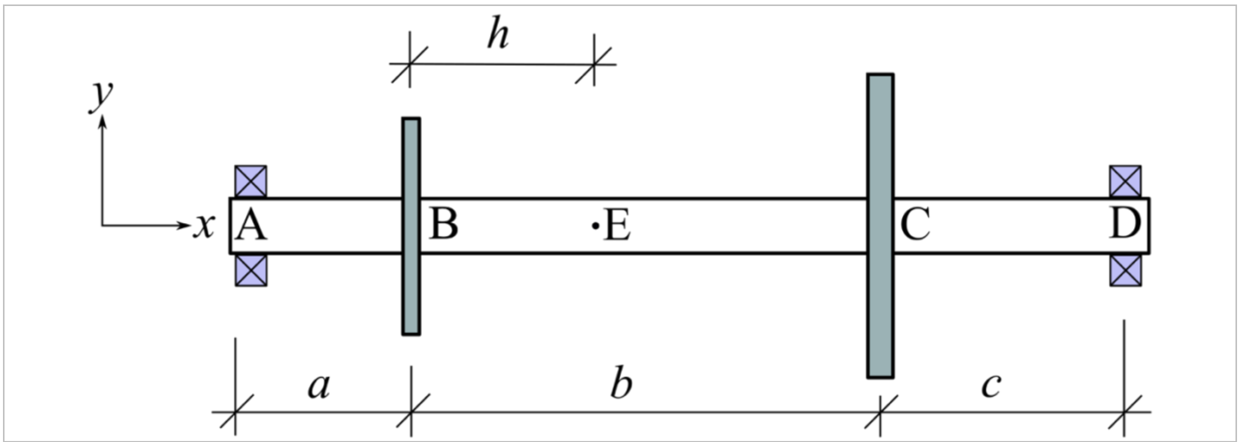

Figure 2: Plan view of the power shaft, showing the location of bearings A and D, pulleys B and C, and the possible location of a new bearing at E.

Due to a redesign of the plant, the shaft is being re-rated, and will now transmit a higher power at the same speed. The new power rating is $P_{new} = 1.5P$.

Two feasible design options exist:

A. A new bearing E can be added to the shaft. You can assume that this bearing will be carefully installed, with no misalignment, and that this bearing will be the same as the bearings at A and D. The shaft diameter, and all other fixtures will remain the same size. The location of the bearing E, indicated by h in Figure 2, needs to be determined.
B. Alternatively, no additional support will be added, but the shaft diameter d will be increased. This will require re-fitting of the pulleys and journal bearings.

The design must satisfy the following requirements:

- The maximum normal stress in the shaft may not exceed σ_{allow}
- The maximum shear stress in the shaft may not exceed τ_{allow}
- In order to maintain belt tightness, the maximum deflection of the shaft at the pulleys may not exceed δ_{allow}
- In order to prevent damage to the rollers, the maximum angle of the shaft at any of the journal bearings may not exceed θ_{allow}

You are required to make an engineering recommendation to the client, supported by calculations: **Which design option should be chosen, and for what reason?**

Limitations of scope

- You are not required to design the bearings or the pulleys.
- You may select any integer shaft diameter, you do not need to consider availability of stock.
- The allowable stresses which you have been given already include a safety factor below the endurance limit, thus you do not need to include a safety factor or complete a fatigue design

Deliverables

You will submit a report, in which you clearly lay out your solution and final recommendation, showing all your logical steps and decision-making processes. Be sure to consider all implications of each of these design choices. You should also discuss (but not attempt to quantify) the cost implications of each choice.

You should use the systematic problem-solving method outlined on page 4, following the steps of Conceptualise, Categorise, Analyse and Reflect. You will probably need to iterate on your solution, so I will expect you to use some computational tool (e.g., Jupyter, Excel) to do the repetitive calculations. Your report should show the equations you are implementing, the decisions that you are making, the values you are inputting, and your results.

You will receive a unique variable set via the Judicator AMS system. The following variables will be provided to you:

Variable	Symbol	Units
Power	P	[kW]
Speed	N	[rpm]
Shaft diameter	d	[mm]
Diameter of pulley B	d_B	[mm]
Diameter of pulley C	d_C	[mm]
Distance from A to B	a	[m]
Distance from B to C	b	[m]
Distance from C to D	c	[m]
Allowable normal stress	σ_{allow}	[MPa]
Allowable shear stress	τ_{allow}	[MPa]
Allowable shaft deflection	δ_{allow}	[mm]
Allowable shaft angle at the journal bearings	θ_{allow}	[°]

Errors in supplied values:

Several of you received a unique value set in which $d > d_B$, which is of course not physically feasible. Please check the values you received, and if this is true for your design, then please modify your given values as follows:

$$d_{new} = d - 2$$
$$d_{B_{new}} = d_{new} + 20$$

You will submit some key calculated values as well as your report via the AMS system. Your report may be typed or handwritten and scanned, or some combination of these.

ECSA Graduate Attribute 1: Problem Solving

This is an exit level module for ECSA Graduate Attribute 1: Problem Solving. The learning outcome, associated assessment criteria and range statement come from the ECSA definition of the Graduate Attribute.

Learning outcome: Demonstrate competence to identify, assess, formulate and solve convergent and divergent engineering problems creatively and innovatively.

Associated Assessment Criteria: The candidate applies in a number of varied instances, a systematic problem solving method including:

1. Analyses and defines the problem, identifies the criteria for an acceptable solution;
2. Identifies necessary information and applicable engineering and other knowledge and skills;
3. Generates and formulates possible approaches to solution of problem;
4. Models and analyses possible solution(s);
5. Evaluates possible solutions and selects best solution;
6. Formulates and presents the solution in an appropriate form.

Range Statement: Problems require identification and analysis. Some cases occur in unfamiliar contexts. Problems are both concrete and abstract and may involve uncertainty. Solutions are based on theory and evidence, together with judgement where necessary.
The ECSA Graduate Attribute for Problem Solving will be assessed in the Project. These problems will be assessed with a rubric based on the ECSA problem solving requirement.
The rubric categories are shown in the following table.

In MSY 310 we use a **systematic problem-solving method** which aligns with the ECSA assessment criteria. Your project will be assessed against these categories.

Conceptualise

- *Sketch the problem, showing relevant geometry, dimensions, support and loadings*
- *Sketch e.g.: FBD or stress element as applicable*
- *Identify Boundary conditions and other support conditions*

Categorise

- *Identify problem type, solution strategy, relevant criteria and analyses*
- *Write the governing equations*
- *Identify unknowns*
- *Make necessary assumptions*
- *Identify material properties*

Analyse

- *Solve the governing equations*
- *Solve for unknowns or formulate problem to allow solution*
- *Clearly outline steps so that it is easy to review / check*

Reflect

- *Evaluate possible solutions and select best solution (if necessary). Justify and explain choice*
- *Examine answer – does it make sense? Are units correct?*
- *Compare with reference solution*