68K Turbine Blade Handling

Interim Design

Team 14

Patrick Filan
Clint Kainec
John Kemp

Outline

- Background Information
- Problem
- Designs
  - Overview
  - Analysis

Advisors

Industry

Ashtok Patel

Industrial Engineer
Environmental Health & Safety
Manager at **TECT Power**
CSP, CHMM

Faculty

Dr. Patrick Hollis

Associate Professor &
Undergraduate Coordinator
Department of Mechanical
Engineering

Dr. Kamal Amin

Professor
Department of Mechanical
Engineering

TECT Power: Thomasville, GA

- A turbine part manufacturing facility
- Currently process a variety of turbine blades
  - Machining, finishing, testing
- Operates both single-axis manual mills and multi-axis automated mills

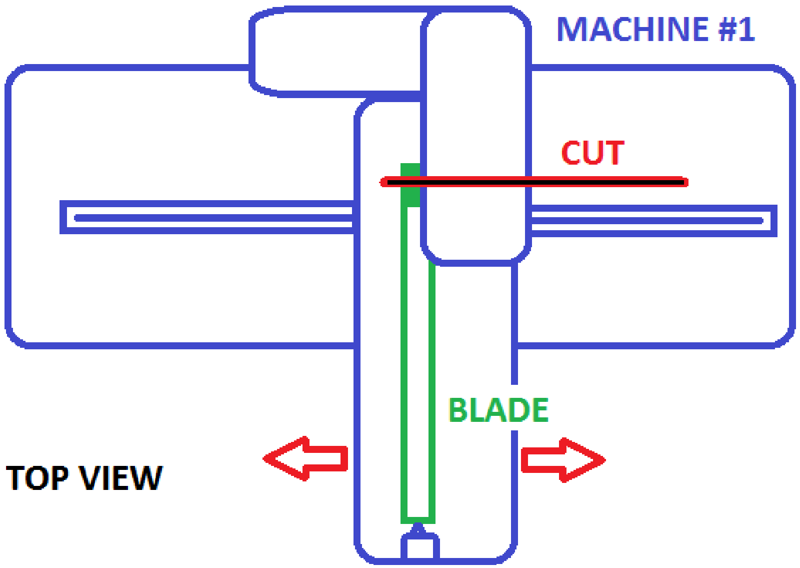
The 68K Blade

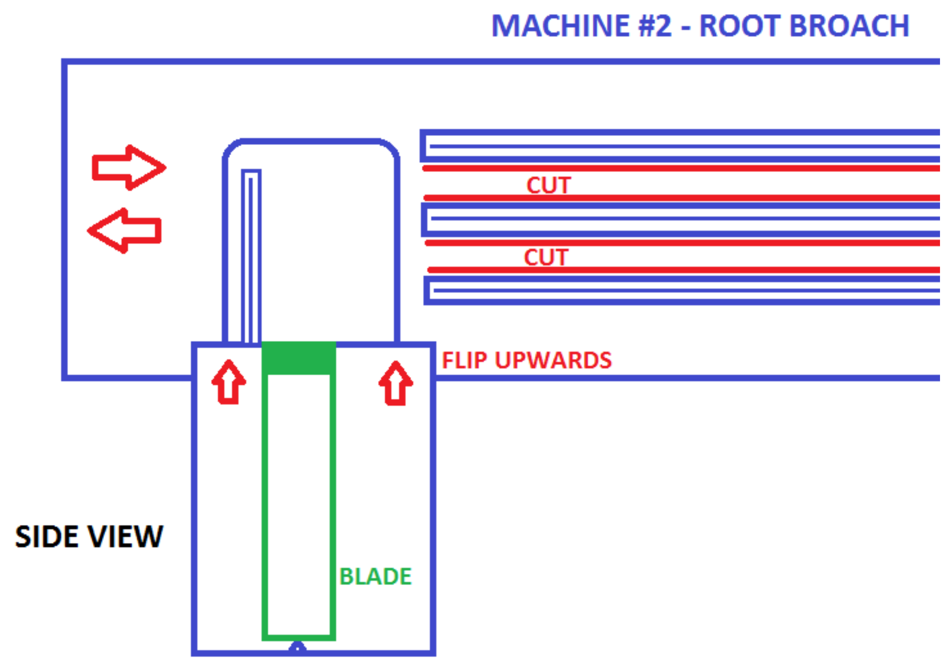
- 45 lb
- 3ft x 1ft
- Titanium aluminide
- Received as a raw forging
  - Only basic geometry
- Geometry
  - Root
  - Tip
  - Twist
  - Midspan

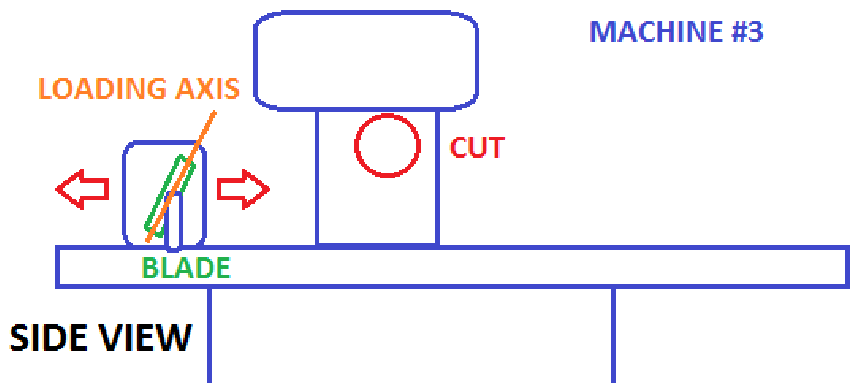
The Problem

- Manual lifting of the 68K turbine blade
  - Risk of injury
  - Straining workers
  - Difficult for new workers
  - Needs to be eliminated
- The blade moves through several machines
  - Each machine unique
    - Obstructions
    - Placement
    - Orientation

Blade Orientations







Machines 1-3 perform root operations on the blade

Project Focus

- **Safety**
  - Ergonomics
  - Part-friendly
- Modify current cart
- Orientation and 3D position of the blade
  - Machine-friendly
    - Loading and unloading
  - Time efficiency
  - Cost effectiveness

Existing Apparatus

Previous Team

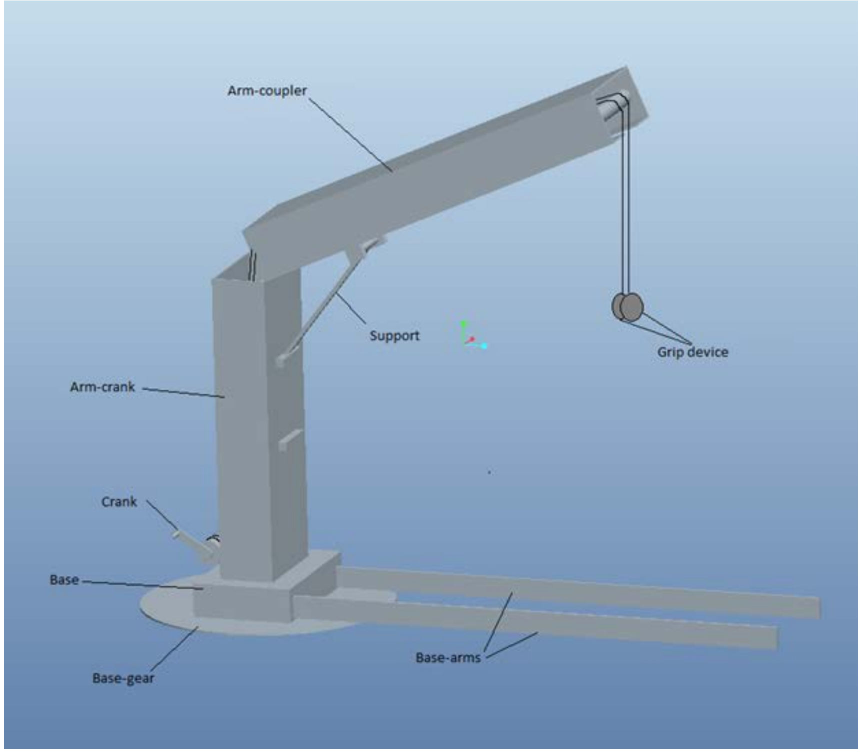
- Cart design
- Transport from storage to machine 1
- Orientated horizontally
- Many machines

Modifications Necessary

- Cart stability - struts
- Removing shelves
  - Adding storage
- Attaching new apparatus
  - Crane
  - Grips
- Housing for apparatus parts
  - Electrical system – If applicable
  - Battery – If applicable

Design: Pulley System Crane

- Mechanical advantage
- Pulley system
- Arm-coupler angle
- Rotation about the vertical axis via base-gear
- Individual control of each grip with crank



Design Analysis: Crane

- Factor of safety: 3
  - Standard safety for static objects
- Pulleys needed:
  - Manual (10lbf applied): 13
  - Motorized (0.5-1hp): 2-4
- Conflicting Criteria
  - Needs to be quick (requires low M.A.)
  - Applied force by user less than 10lbf (requires high M.A.)

$$\sigma_f = FS * \sigma_a$$

$$M.A. = \frac{F_o}{F_i}$$

$$M.A. = \frac{v_i}{v_o}$$

$$M.A. = n \ \ (ideally)$$

$$n_{pulley} = n - 1$$

Design Conclusion: Crane

- Need motor driven system
  - Reduces mechanical system requirements
  - Increases speed of system
  - Solves both problems
    - Speed
    - Strength
  - Alleviates all manual stress (carpal tunnel)
- Motor requirements
  - 0.5-1hp
  - Variable speed
    - Requested

Design: Support Strut

- Must support moment of the arm and external forces
- Must not:
  - Fail
  - Buckle
  - Deflect

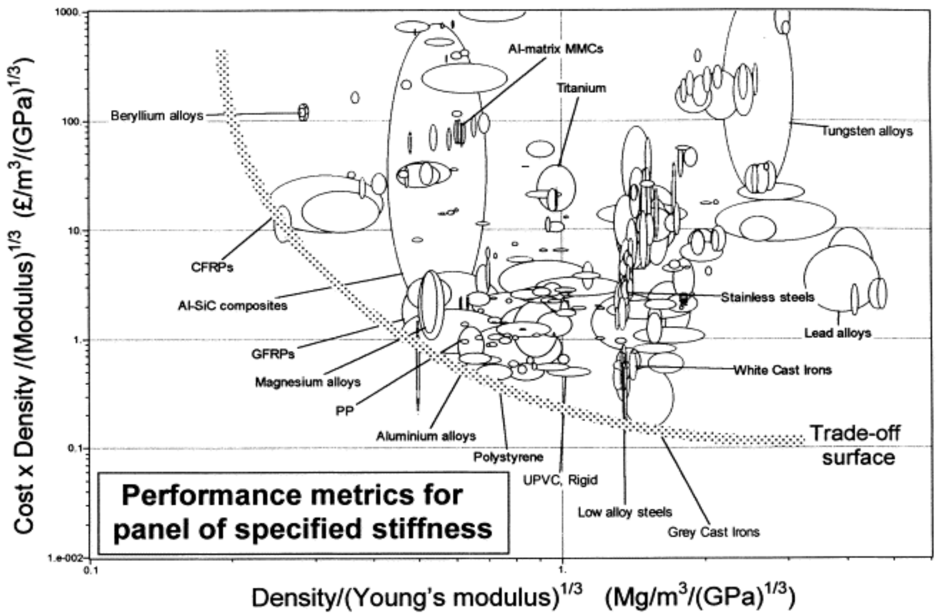
Analysis: Support Strut

$$m_{buck} > \frac{144\left[C_{cx}w_c - (w_p + w_w)z_x\right]L^2}{t^3 n^2 \pi^2}\left(\frac{\rho}{E}\right)$$

$$m_{bend} > \frac{12\left[C_{cx}w_c - (w_p + w_w)z_x\right]}{C_2 t^2 \Delta\theta}\left(\frac{\rho}{E}\right)$$

$$m_{fail} > \frac{6\left[C_{cx}w_c - (w_p + w_w)z_x\right]L}{t}\left(\frac{\rho}{\sigma^*}\right)$$

- Two material indices – 1 trade off surface



Cost analysis: Support Strut

- Best materials
  - CFRP
  - Aluminum alloys
  - Poly styrene
  - Grey cast irons
- Conclusion: Grey cast iron
  - Cheap
  - Shape can be adjusted
    - May increase durability
    - Lower weight

Nominalized cost comparison

Material	C_{buck} ($)	C_{bend} ($)	C_{fail} ($)	C_T ($)
CFRP	1.12	36.08	.01	36.08
Al Alloys	0.11	3.50	0.001	3.50
Polystyrene	1.05	33.85	0.03	33.85
Grey Cast Irons	0.05	1.59	.001	**1.59**

Design: Dynamic Gripping System

- Uses vacuum-packed sand
  - Forms a solid impression
- Pros
  - Soft
  - Durable
  - Can grip edges
- Cons
  - Experimental
    - Weight rating may vary
  - Electronics
  - Expensive

Subsitutional Design: Suction Grips

- Rated up to 100lbs for under $100
- Pros
  - Inexpensive
  - Easily accessible
- Cons
  - Surface geometry
  - Oil – Slip
  - Can only attach to flat plane

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Questions?