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Mechanical Engineering

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From: Team 19F03- Hip Exoskeleton A

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Subject: ERs and TPs revamp memo.

1 INTRODUCTION

In the development of the Exoskeleton device whose stability and strength are key, much emphasis is given to the material used which happens to be instrumental both the engineering as well as the customer requirements. On one hand it is imperative that the selection of the material follows due procedure to ensure that it has necessary engineering properties that manifest strength durability and is free from harmful chemical properties. As a customer requirement the material ought to achieve comfort ability and aesthetics. The exoskeleton device is designed to aid a patient with coordination and walking problems affecting their limbs the noninvasive exoskeleton therefore reinforces their body structure and hence helping them to be able to walk and move. In that case therefore several requirements are important paramount to full fill in order to make the device useful to the user. Being a structure that supports the weight of the rest of the body, the materials used in its construction ought to meet certain thresholds to ensure stability and strength that is resistant to buckling or any other form of failure. Besides strength and the structural integrity, the material ought to meet certain safety standards to ensure that the user is not at risk exposed to health hazards emanating from the chemical properties such as corrosion carcinogen or other form of radiation. Besides, its nature dictates whether it is prone to rust or not and therefore making it subject to scrutiny. Other physical properties for consideration about the nature of the material include; its workability and cost which in turn affects the overall cost of the entire device upon production. With the above factors, several materials were available for considerations which were subjected to a selection criterion through a decision matrix which took into consideration the aforementioned factors. Steel and Thermoplastic were adopted for various components as it befits.

2 Customer Requirements

The customer requirements of the project are in line with the overall objectives of the project. The fundamental aim is to provide mobility to physically challenged persons and therefore the designed exoskeleton ought to fulfill both functionality and strength requirements. Weight and strength are the basic requirements for the exoskeleton which form part of the priority list. In this regard the material selection determines these key characteristics. Materials with such properties include thermoplastic (ABS) and stainless steel. Such are subject to further scrutiny in the criterion of the material selection. Other customer requirements are cost comfort size flexibility safety availability of spare parts and durability. Again, the rest also do rely on the material selected for use in the making of the components. High cost of material affects the overall cost of the device. The same case applies to the durability and the availability of spare parts.

3 Engineering Requirements

The key engineering requirements that the project sought to fulfill include durability, strength safety functionality and chemical properties of the material used. The strength threshold ensured is one that guarantees the stability of the exoskeleton. The exoskeleton is a framework that is meant to offer reinforcement and support to the individual using it. Top on priority on the strength properties is achieving high strength and not compromising on the low weight which is desirable for the structure.

3.1 ER 1: Weight

3.1.1 ER 1: The weight [0.75Kg to 2Kg]

The weight and strength of the design are fundamentally important and therefore this single deliverable forms the basic engineering requirement of the project. It therefore ranks highest on the scale among other basic important requirements. The tolerances are determined from available lightweight materials possible.

3.1.2 ER 1: material density ranging from 1.2g/cm3 to 7.8g/cm3]

The weight of the device may be predetermined at the design stage by analyzing the densities of lightweight materials which may be potentially used for the project. Therefore, the tolerances allowed for this particular deliverable is between 1.2g/cm3 to 7.8g/cm3 which are the densities for thermoplastic (ABS) and steel respectively which may be used for the project.

3.2 ER 2: Strength

3.2.1 ER 2: the shear modulus of 3 GPa

Thermoplastic is one of the materials with a high shear modulus whether existing as a composite material or in pure form. This was used as a yardstick for the perquisite strength of the material which may be considered safe for support of the human weight without failure.

3.2.2 ER #2: Shear modulus tolerance of +/- 4 Gpa

For most materials used for structural elements the shear modulus happens to fall between the given ranges steel happens to have the highest shear modulus of the materials under consideration for the project

3.3 ER 3: Cost under $2,250

3.3.1 ER 3: Cost under $2,250 - Target = $2,250

With consultations the cost was increased to $2,250 which is believed to be an ideal based on research on the cost by the team.

3.3.2 ER #3: Cost under $2,250 - Tolerance = $250

This project was estimated at a maximum of $2250 with a slight allowance as indicated above.

4 Testing Procedures (TPs)

The three main engineering requirements that were specific and measurable were the material weight and strength the cost of the project and the functionality which includes the degree of freedom of the movable parts allowing mobility of the parts.

4.1 Testing Procedure 1: Strength test

4.1.1 Testing Procedure 1: Tensile strength test

The tensile strength is tested through subjecting the pieces to forces acting away from each other. This may be conducted though a simple test involving scales and forces applied axially on the materials pulling apart. This is a procedure of a tensile strength machine in a laboratory where readings at failure are taken to calculate the tensile strength. However, there are already provided values for the tensile strengths of each of the materials which may be used at the design stage.

4.1.2 Testing Procedure 1:

As mentioned above the following resources are required in this case for the procedure: Tensile strength testing machine. The materials are fitted appropriately in the section meant for specimens in the lab Proper tightening then follows before switching on the machine. The ultimate pressure used is read after failure of the specimen hence verifying the actual tensile strength for each of the materials used.

4.1.3 Testing Procedure 1: Schedule

Procedure	Start date	Finish Date
Tensile strength test	02/01/2020	02/08/2020

4.2 Testing Procedure 2: Material weight test

4.1.4 Testing Procedure 2: weight test

The proper description befitting the desired material for use is a high strength light weight material and therefore is not enough to have a high strength material alone. The weight of the material is measured by weighing it on a scale and comparing it with the rest if materials in consideration.

4.1.5 Testing Procedure 2: bill of materials

Using a scale each of the material is placed and the aim is getting the measurement of the each of them individually. The results are compared against each other to obtain the lightest of the materials paired with high strength and an optimum balance is achieved. This procedure can be done alongside that of the tensile strength.

4.1.6 Testing Procedure 2: Schedule

Procedure	Start date	Finish Date
Material weight test	02/07/2020	02/30/2020

4.2 Testing Procedure 3: material cost analysis

4.2.1 Testing Procedure 3: cost test

The cost of the project is paramount as the cost is transferred to the customer. The aim is obtaining the most effective device at a pocket friendly budget. In that case therefore careful selection of the materials will also involve consideration of the prices and therefore a variety of retailers both online and physical are considered.

4.2.2 Testing Procedure 3: bill of materials

A bill of materials is prepared in consideration of the most affordable retailers which can provide the various components without compromising on the quality needed. This is done through vetting of the available commodities on all available platforms.

4.2.3 Testing Procedure 3: Schedule

Procedure	Start date	Finish Date
Material cost analysis	02/07/2020	02/14/2020

4.3 MATERIAL *ANALYSIS*

Various alloys and materials have proven to be favorable for use when it comes to biomedical devices for both invasive and non-invasive uses. A material analysis is key and a decision matrix based on key factors of the project is necessary to fine tune on the best material of use for this particular project.

Engineering Requirement	Titanium Allow(T6-4AL-V)	Steel	Chromium	Aluminum silicon (ALSi)	Colbat chromium (COCr)	Thermoplastic
Strength	3	5	3	2	3	4
Weight	5	2	4	3	3	4
Cost	2	4	3	3	4	3
Workability	4	4	3	4	3	3
Corrosion	3	5	3	3	3	4
Durability	4	4	3	3	2	5
AGG/Score	**21**	**24**	**19**	**18**	**18**	**23**

Table 1: Material decision Matrix

While Thermoplastic is among the best materials in terms of weight to strength ratio other factors come into play for the project including cost and aesthetics. Thermoplastic (ABS) has a density of 1.2g/cm^3 while steel has a density of 7.8g/cm^3 making it heavier. Steel scores higher on other factors as in the decision matrix. Top on the list were the thermoplastic and the steel. The three were therefore used interchangeably for all the components capitalizing on the strengths of each depending on their availability. Availability of the components and parts fitting measurement adjustments was higher as the varieties were more. This was the case while adjusting the nuts and bolt sizes to accommodate the changes effected. The thermoplastic forms the majority of the frame due its nature of neutrality as well as strength. The availability of parts was much higher and at a lower cost.