STRESS ANALYSIS FOR ROBOTIC ARM V2
ANALISA TEGASAN BAGI LENGAN ROBOTIK V2

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ABSTRACT

The design of a robot should be analyzed to ensure the specification and requirement by the user is fullfilled. Therefore, a stress analysis has been done on the robot arm v2 using manual calculation and design software after the robot's fabrication and assembly completion. This paper discusses the results from the stress analysis including safety factor and proposes the measures to improve the future design of robot arm.

INTRODUCTION

A stress analysis needs to be performed to ensure the robotic arm is able to withstand the specified load limit. Eventhough the designer has performed the analysis in the design stage, it has been found that some modifications are required after the robot has been reanalyzed once the assembly process is completed.

The analysis of robotic arm includes a certain safety factor. The requirements are important to be met since the robot is designed to handle the radioactive products and failure during handling will present a danger to personnel and environment.

The robot consists of 5 degree of freedom (DOF) and the design lifting capacity is 2 kg with the safety factor of 2. The material is aluminum grade Al2014 with density of approximately 2.8 x 10^3 kg/m^3. The figure below shows 3 dimensional assembly drawings using Pro-Engineer software.

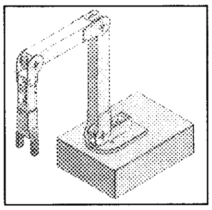

Figure 1: Assembly drawing of robotic arm

RESULTS & DISCUSSION

Basic Static Analysis

There are 2 parameters considered in basic static analysis ; constrain at the base of the robotic arm and load applied to the end of effectors (gripper). In this basic static analysis, the calculated Von Mises Stress by the software is 238 MPa and calculated safety factor is 1.74.

Detailed Static Analysis

Detailed static analysis is the combination of parameters from basic static analysis with the actual moving assembly of robotic arm. This analysis gives better accuracy where the calculated Von Mises Stress is 266 MPa and the calculated safety factor is 1.13.

Complete static analysis

The complete analysis is the combination of both parameters in previous analysis including the consideration of mass gravity acceleration and mass of robotic arm. This analysis provides the calculated Von Mises Stress as 401 MPa and calculated safety factor is 1.03.

METHODOLOGY

Stress Analysis vs Safety Factor

Stress analysis has been performed to ensure the safety factor (N) is within the design limit. The formula that has been used is given below:

$$N = \frac{S_y}{\sigma'}$$

S_y = Yield Strength or Ultimate Strength

σ'_{max} = maximum Von Mises Stress

In this case, the yield strength is Al2014 and the specification provided by Pro-Engineer Software is as shown below:

Density	2.79355e-09 [tonne/mm^3]
Young's Modulus	73084.4 [MPa]
Poisson's Ratio	0.33
Conductivity	192.163 [N/(s °C)]
Specific Heat	9.63753x10^8 [mm^2/(s^2 C)]
Shear Stiffness	27475.3 [MPa]
Ultimate Strength	483 [MPa]
Yield Strength	414 [MPa]

Table 1: Engineering data for Al2014 in Pro Engineer Design Software

By using the software, Maximum Von Mises Stress can be calculated automatically. There are 3 types of analysis which are basic static analysis, detailed static analysis and complete static analysis.

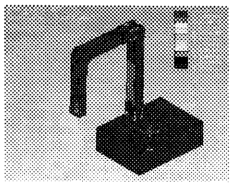

Figure 2: Normal position of robotic arm for basic static analysis

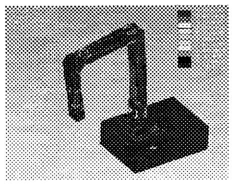

Figure 3: Deformed position of robotic arm for basic static analysis

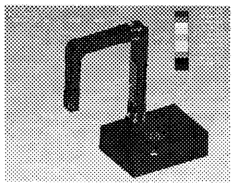

Figure 4: Normal position of robotic arm for detailed static analysis

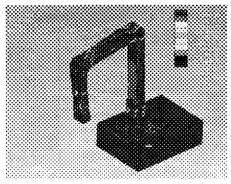

Figure 5: Deformed position of robotic arm for detailed static analysis

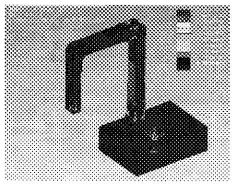

Figure 6: Normal position of robotic arm for complete static analysis

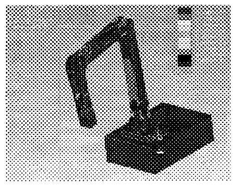

Figure 7: Deformed position of robotic arm for complete static analysis

CONCLUSIONS

The stress analysis that has been performed shows that the safety factor is reduced to 1.00 due to the modification that has been made. Therefore, in order to maintain the safety limit of 2.00, the lifting capacity would need to be reduced to 1 kg. However the same analysis needs to be performed again to verify the exact figure. It is important to analyze the robot's structural integrity after its complete fabrication and assembly to ensure the safety factor is not adversely affected.