Proceedings of Mechanical Engineering Research Day 2016, pp. 58-59, March 2016

Structural design and analysis of autonomous guided vehicle (AGV) for parts supply

Mohd Suffian Ab Razak[1,*], Khairul Hazwan Mohd Rasit[1], Nur Rashid Mat Nuri[1], M.Z.A Rashid[2]

[1)] Faculty of Engineering Technology, Universiti Teknikal Malaysia Melaka,
Hang Tuah Jaya, 76100 Durian Tunggal, Melaka, Malaysia
[2)] Faculty of Electrical Engineering, Universiti Teknikal Malaysia Melaka,
Hang Tuah Jaya, 76100 Durian Tunggal, Melaka, Malaysia

[*]Corresponding e-mail: suffian@utem.edu.my

Keywords: Automated guided vehicle; topology optimization; SolidThinking Inspire

ABSTRACT – The world economic growth rapidly and becomes very competitive. AGV is introduced to support the supply system, however the initial investment is very high and it cannot convince a certain company to invest such amount of money for the system. In this project, the focus research is more on a low cost, lightweight AGV development. Lightweight design leads to less energy consume to carry its body. The purpose of this study is design an AGV that to be used in parts supply using polyboxes. The structural strength analyses are performed through computer aided engineering (CAE) simulation.

1. INTRODUCTION

The main concept of an autonomous guided vehicle (AGV) grasps all transport systems which are capable of functioning without driver assistance. When its first introduced to industry, the AGV was in competition with driver operated material handling system such as pallet carts, fork lifts and tow tractors. However, since microcontroller technology has evolved, the capabilities and types of AGV system improved from time to time [1]. Nowadays AGV is now in direct competition with other forms of industrial transportation such as roller conveyors, belt conveyors and chain conveyors.
The objective of this project is to design and optimize economic lightweight AGV through structural strength analysis by CAE simulation

2. RESEARCH METHODOLOGY

2.1 *Material properties of AGV structure*

Steel ASTM 500 is being used in this project due to low cost and light. The material properties will influence the accuracy of virtual result when compared to physical prototyping [2].

Table 1 Material properties of AGV frame (ASTM 500).

Properties	Data
Modulus of Elasticity, E	14.0 E+03 MPa
Poisson Ratio, Nu	0.3
Tensile Strength	7.861E-09 t/mm^3
Yield Strength	315 MPa

2.2 *Create design space*

Figure 1 shows the design space of the AGV is basically a space where the material layout is allowed. This space is where the topology optimization process takes place.

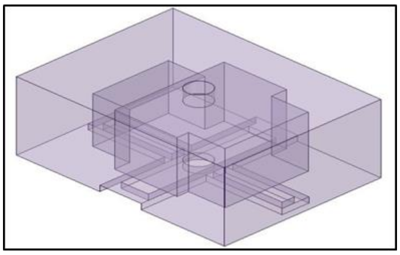

Figure 1 The AGV design space.

2.3 *Topology optimization*

The SolidThinking Inspire is an easy to use CAE software which runs the selected design space based on boundary conditions and generates optimized design (Figure 2).

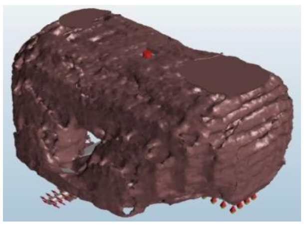

Figure 2 The optimized design space.

2.4 *New structurally efficient conceptual design.*

The model is then imported to Computer Aided Design (CAD) hybrid modelling software, SpaceClaim, in order to interpret the design based on the load path and design new conceptual model using the previous optimization result which is saved in STL file (Figure 3).

2.5 *Result interpretation*

The design is then runs through several design iterations in order to further reduce structure mass while retaining the Von Mises Stress below target 8.0 MPa. It is also important to ensure the design is feasible to manufacture. After the structural frame is optimized by the SolidThinking software, a new model, as in Figure 4, is designed based on the previous optimization load path result.

Figure 3 AGV design with load path iteration.

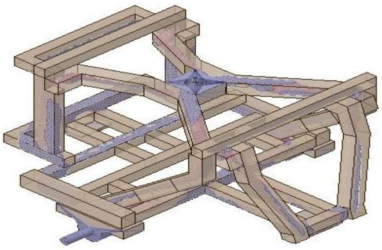

Figure 4 Final design iteration.

3. RESULTS AND DISCUSSION

Based on the results, the mass of the AGV structure, as in Figure 5, shows weight reduction after seven design iteration.

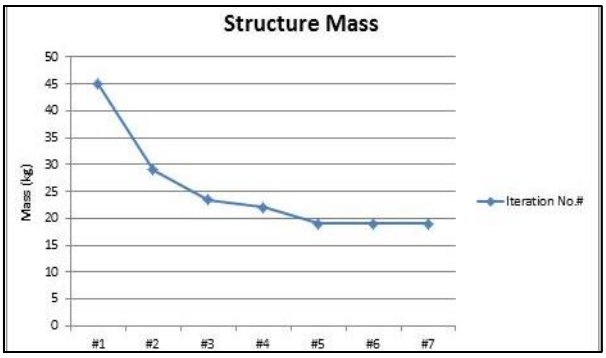

Figure 5 The AGV structure mass distributions.

The initial weight of 45 kg AGV structure mass is a massive value to move the AGV from stationary position. Therefore, the reduction of the mass after optimization phase helps the AGV to be more effective and the efficiency increase. The final mass obtained is 19 kg, which is total 58% total mass reduction from the original design. This result is based on solid structure, since the SolidThinking Inspire is only allows solid meshing instead of shell meshing. The actual product which is using hollow square would weigh only 20% ~ 25% of the mass based on cross section area calculation.

During the structural strength analysis of AGV structure, the maximum Von Mises Stress were obtained from each optimization results to determine the maximum stress level as shown in Figure 6.

From Figure 7, the Von Mises Stress distribution is not uniform through each stage of design iteration. The optimum value of the Von Mises Stress is at 4.50 MPa, which is at design iteration #6, not exceeding the limitation value of 8MPa. As the result is far below the yield strength of 315 MPa, the design is safe to carry loads of 200kg based on its total tractive effort calculation and feasible to manufacture.

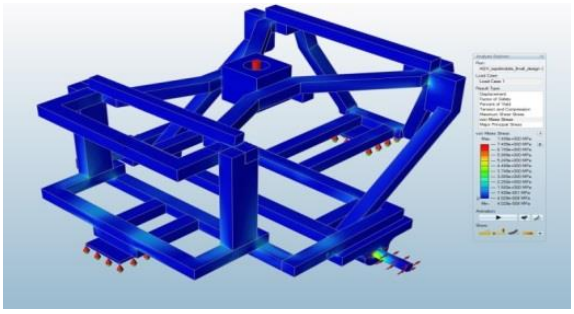

Figure 6 Von Mises stress analysis of AGV structure.

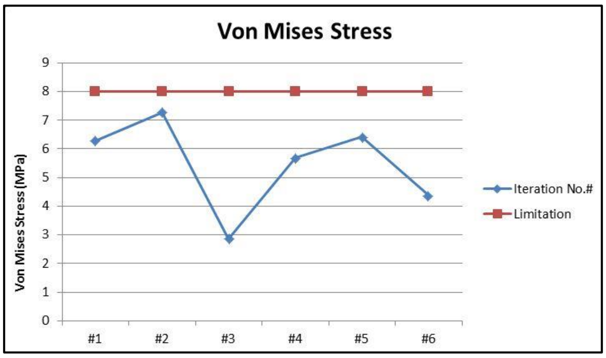

Figure 7 Von Mises Stress distribution.

4. CONCLUSION

The new concept structure was intended to replace the present bulky and heavy AGV structure with the same amount of ability to carry loads. By utilizing analyses and advanced techniques relative to material, and design, a unique, non-traditional structure which is 58% lighter frame from the original design space is successfully designed. The frame is 100% ASTM 500 steel and the overall complex structure was reduced to simpler design and meets the design requirement. In spite of current limitation of SolidThinking Inspire is for solid meshing only, the topology optimization result generated is suitable for CAE driven conceptual design.

ACKNOWLEDGEMENTS

The author would like to express appreciation to Creative Innovation Technology Management Research Group, Institute of Technology Management and Entrepreneurship (COSSMET) and Universiti Teknikal Malaysia Melaka for funding this project under PJP/2014/FTK(19C)/S01348

REFERENCES

[1] J.L. Jones, A.M. Flynn and B.A. Seiger, *Mobile Robots: Inspiration to Implementation*, AK Peters, Ltd, 1998.

[2] M.Z. Hassan, M.R. Razali and M.S. Halid, "Design and Development of Amphibious Hybrid Vehicle Body Structure," *International Journal of Science and Research (IJSR),* vol. 2, no. 5, pp. 220-223, 2013.