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Modelling and Analysis of Automated Guided Vehicle System (AGVS)

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Abstract-The Automated Guided Vehicle (AGV) is a mobile Robot used in industrial applications to move materials around a manufacturing facility or a warehouse. An AGV can also be called a laser guided vehicle (LGV) or self-guided vehicle (SGV). In Germany the technology is also called Fahrerlose Transport system (FTS).

AGV's are extensively adopted in Flexible Manufacturing System (FMS), AGV's Navigate on Their own with the help of various guiding mechanisms; broadly these mechanisms are classified as wired & wireless guidance mechanisms. In this project we mainly concentrate on wireless guidance mechanism which makes use if guide tape (colored in this case) for navigation. Basically this type of AGV's act as a line follower robot which follows the guide tape which is imprinted on the shop floor. The guide tape is sensed by the onboard sensors which are present on the AGV; the sensor used for this purpose is an optical sensor which uses Infrared LED's.

AGV's can be controlled by one centralized or onboard computer which i present in the AGV; in this project we use of an Onboard microcontroller which acts as a machine control unit (MCU) to control & coordinate all the parameters of an AGV.

Index Term—Automated Guided Vehicle

1. INTRODUCTION

Automated guided vehicles (AGV's) help to reduce costs of manufacturing and increase efficiency in a manufacturing system.

1.1. Problem Statement

"One of the Major Challenges in Industries is the Internal Logistics; the problem arises when the right product doesn't reach right destination at right time, in order to overcome these we make use of advance material handling technologies such as AGV's".

Flexibility, agility, and dependability are critical in business survival in 21st century. Stock holders and customers demand value; companies must offer more for less or risk losing market share. Product models come & go as the consumer preference change in a single season. In retail operation change may happen even faster.

Due to the advancements in the science, technology & Process in Today's Business, the only real constant is change. In face of unrelenting change how the factories distribution centres get the right product at the right place at right time. In growing numbers they meet the challenge with internal plant logistics system based on advance material handling technology. These systems offer flexibility, agility & dependability to help manage the pace of change.

1.2 scope of the thesis and literature review

An AGV is Mechatronic system. Designing a mechatronic system for mechanical engineers is a challenge, as it requires a synergistic approach which involves multiple disciplines such as Mechanical, Electronics & Computer Science.

Modern day industries are looking for a Flexible Manufacturing System (FMS), which boost their production & profit margin. AGV's are extensively used in FMS.

Future mechanical engineers have to work with such a mechatronic systems, as more & more companies are looking for these kinds of technologies in meeting the internal logistics problems. This thesis helpful in designing such a mechatronic systems & improve upon knowledge base.

2. THE FUNCTIONAL REQUIREMENTS FOR THIS PROJECT

- *Primary Function*: - An AGV used in Flexible Manufacturing System (FMS) to carry the Load from one point to another autonomously along the guide tape.
- *The Mechanical Structure*: - An AGV with a Fork Lifter (double power Screw Mechanism), unit load carrier and A Multi Wheel equipped with belt drive Vehicle System, Bumpers & Gearbox Coupled to Motors.

- *Power Transmission*: - Gear Drive Transmission.
- *Driving System*: - Electrical Actuators (High Torque Geared DC motor) were adopted.
- *Sensory System*: - Non Contact Type Optical Sensors for Positioning, Path Tracking, & Obstacle Detection. Contact Type Sensors for Fork Lift Positioning & Obstacle Detection.
- *Control System*:- Onboard Machine Control Unit (Microcontroller is used as MCU)

Other features such as Dynamic LCD Display, Buzzer, Warning Lights etc was used to add more Features into the AGV

2.1 Functional Design Phase

2.1.1 Data taken for the numerical calculations of the power screw

Data Given:

- Diameter (D_1) =10 mm
- Pitch (p) =2
- Load to be lifted (w) =100N
- Co-efficient of friction (μ) =0.173
- Angle of thread (θ) =60deg

2.1.2 Results obtained for the numerical calculations of the power screw:

a) **Torque required to raise the load:**

Formula to find the torque to raise the load is given by

$T=w*D_m/2*(\mu+\tan\alpha/1- \mu*\tan\alpha)$ N-mm ------(1)

Where,

D_m=Mean diameter

A=Lead angle or helix angle.

WKT;

$D_m=D_1-p/2$

$=10-2/2$

$=9$ mm

$\tan\alpha=p/\pi*D_m$

$=2/ \pi*9$

$\alpha=4.046$

Now substituting all the values in eqn(1), we get

$T=100*9/2*(0.173+\tan4.406/1-0.173*\tan4.406)$

=450*(0.25/0.986)

T =114.1 N-mm

b) Tangential force acting on the mean radius

F=w (μ-tanα/1+ μ*tanα) N
=100(0.173-0.077/1+0.173*0.077)
=100(0.096/1.013)
=9.477 N

c) Stress in power screw

σ_c=w/A_c

A_c=π/4*D_2^2

D_2=8 mm whereD_2= 2D_m-D_1

A_c=π/4*8^2

A_c=50.26 mm^2

σ_c=100/50.26

σ_c=2.00 N/mm^2

d) To find Torsional shear stress

WKT τ=16*T/π*D_2^3

=16*114.1/ π*8^3

=1.135 N/mm^2

2.1.3 Fork Stress Distribution Analysis using software "ANSYS"

Fork lift model designed using CATIA

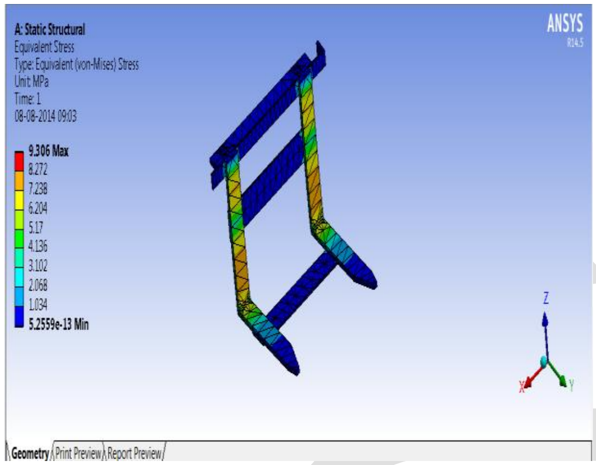


Fig. von-mises(equivalent) stress at load 50N

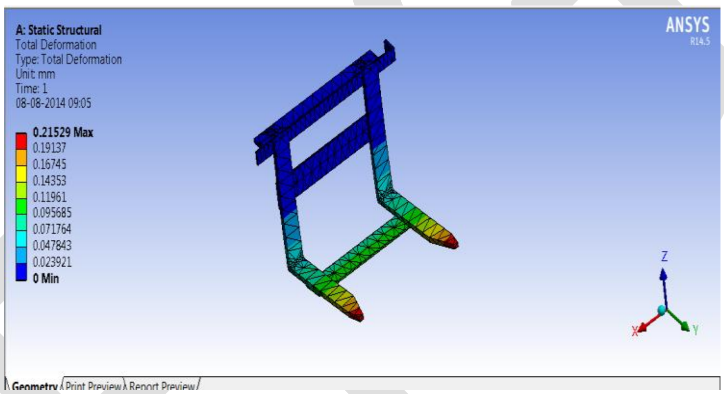
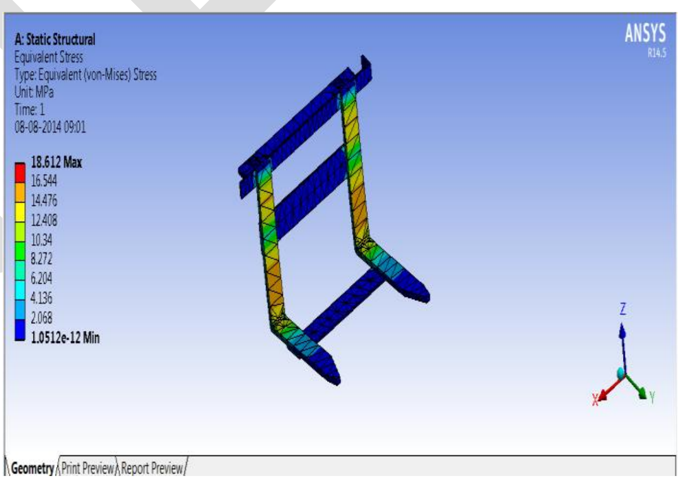
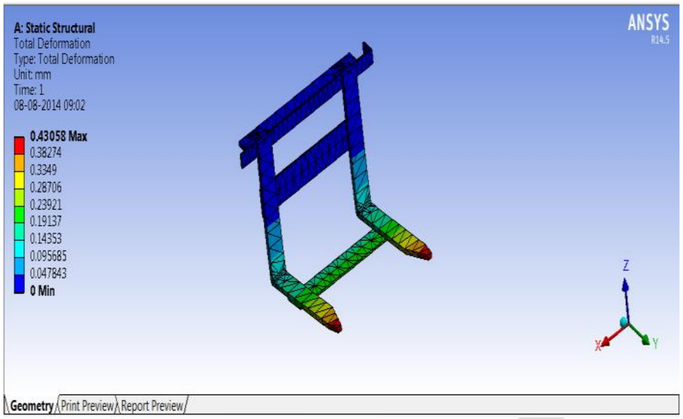


Fig. total deformation at load 50N

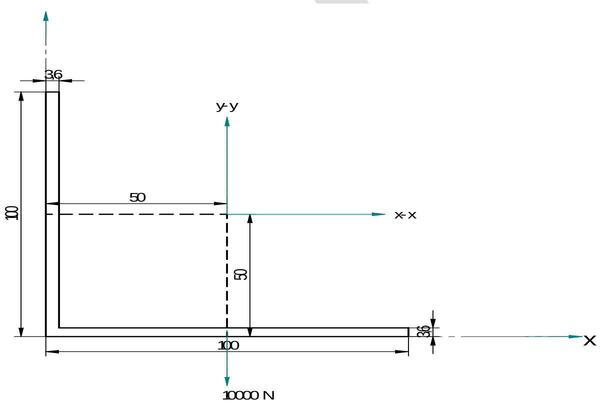


Von-mises stresses at load of 100N



Total deformation at load of 100N

Fork Analysis using Bending stress analytically



Bending moment (M)= Force * Perpendicular distance= (100*100)*(50) = 5*10^5 N-mm

Maximum deflection(Y) = h/2=100/2=50 mm

To find Moment of Inertia (I):

A_1=96.4*3.6=347.04 mm^2

A_2=100*3.6=360 mm^2

Moment of Inertial along X-X axis

y_1=50 mm $\qquad$ y_2=1.8 mm

$$y^1 = \frac{A1*y1+A2*y2}{(A1+A2)} = \frac{347.04*50+360*1.8}{(347.04+360)} = 25.45 \text{ mm}$$

$$Ixx_1 = \frac{b1*d1^3}{12} + A_1*h1^2 = \frac{3.6*96.4^3}{12} + 347*24.45^2 = 4.76*10^5 \text{ mm}^4 \qquad \text{where } h1=(y_1-y^1)$$

$Ixx_2 = \frac{b2*d2^3}{12} + A_2*h2^2 = \frac{100*3.6^3}{12} + 360*(-23.65)^2 = 2.02*10^5\ mm^4$ where $h2 = (y_2 - y^1)$

$Ixx = Ixx_1 + Ixx_2 = 4.76*10^5 + 2.02*10^5 = 6.78*10^5\ mm^4$

Moment of Inertial along Y-Y axis

$x_1 = 1.8$ mm $x_2 = 50$ mm

$x^1 = \frac{A1*x1 + A2*x2}{(A1+A2)} = \frac{347*1.8 + 360*50}{(347+360)} = 26.34$ mm

$Iyy_1 = \frac{b1*d1^3}{12} + A_1*h1^2 = \frac{96.4*3.6^3}{12} + 347*(-24.54)^2 = 2.09*10^5\ mm^4$ where $h1 = (x_1 - x^1)$

$Iyy_2 = \frac{b2*d2^3}{12} + A_2*h2^2 = \frac{3.6*100^3}{12} + 360*(23.66)^2 = 5.01*10^5\ mm^4$ where $h2 = (x_2 - x^1)$

$Iyy = Iyy_1 + Iyy_2 = 2.09*10^5 + 5.01*10^5 = 7.1*10^5\ mm^4$

$I = Ixx + Iyy = 6.78*10^5 + 7.1*10^5 = 13.88*10^5\ mm^4$

$I = 13.88*10^5\ mm^4$

$$\sigma = \frac{M*y}{I}$$

$$\sigma = \frac{5*10^5*50}{13.88*10^5}$$

$\sigma = 18.01\ N/mm^2$

Since the both analytical stress and Von Miss's stress in FEA are less than the yield stress of Aluminium (i.e. Y_s of Al is 20 MPa), the Design is safe.

3. CONCLUSION

AGV's is a proven technology; a lot of research is undertaken in this field as there is more scope for improvements. AGV's of modern day are so intelligent that they can recharge their batteries on their own by docking into recharge station.

This project has given me a great exposure in designing such a mechatronics system. Prior to this project venture I didn't had any experience in designing such a system. I approached this project with "learning by doing" mode. So I had learnt a great deal of things right from detailed engineering design to final design.

ACKNOWLEDGMENT

This project was a great learning experience for me & I cherish this throughout my life. I would like to thank all the people who helped me directly or indirectly in making this project successful. I thank my parents & friends for their moral support. I thank the God for hearing my prayers & I seek his blessings for all my future endeavours.

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