

**DESIGN AND PROTOTYPE LOADING AND UNLOADING MECHANISM
FOR AUTOMATED GUIDED VEHICLE**

MOHD AIZAT B. MOHD AZIZAN

UNIVERSITY MALAYSIA PAHANG

DESIGN AND PROTOTYPE LOADING AND UNLOADING MECHANISM
FOR AUTOMATED GUIDED VEHICLE

MOHD AIZAT B. MOHD AZIZAN

A report submitted in fulfilment of the requirement
for the award of Degree of
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SUPERVISOR'S DECLARATION

We hereby declare that we have checked this project and in our opinion this project is satisfactory in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering with Automotive.

Signature

Name of Supervisor: En. Wan Sharuzi b. Wan Harun

Position: Lecturer

Date:

Signature

Name of Panel:

Position:

Date:

STUDENT'S DECLARATION

I hereby declare that the work in this thesis is my own except for quotations and summaries which have been duly acknowledged. The thesis has not been accepted for any degree and is not concurrently submitted for award of other degree.

Signature

Name:

ID Number:

Date:

Especially for

My beloved family

And

All my friends

For their support and help

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ABSTRACT

Automated Guided Vehicle or AGV is one of material handling equipment that has been used widely in most manufacturing industry today as it provides more flexibility to the system. The basic concept of the AGV incorporates battery-powered and driverless vehicles with programming capabilities for path selection and positioning. They are equipped to navigate a flexible guide path network that can be easily modified and expanded. This project is focusing on the prototype the loading and unloading mechanism for the AGV, the AGV are needed to specify certain criteria that is lightweight, automatic operated and able to transport the acrylic. This loading and unloading mechanism operated using ballscrew as the movement mechanism and suction cup with vacuum pump as the adhering mechanism. The frame and main material to fabricate this AGV prototype are using the aluminium to minimize weight of the AGV. The application of the AGV in the real world application will help human and reducing cost in repetitive movement transportation activities.

ABSTRAK

Kenderaan panduan automatik adalah salah satu daripada kelengkapan pengendalian barang yang telah digunakan secara meluas di dalam sektor perindustrian kerana ianya menyediakan lebih kemudahan kepada sistem. Konsep asas kenderaan panduan automatik merangkumi bateri, dan kenderaan tanpa pemandu dengan kemampuan perisian untuk pemilihan jalan dan kedudukan. Kenderaan ini dilengkapi untuk mengemudi jalan yang diarahkan dan ianya mudah diubah dan dipanjangkan. Projek ini mengfokuskan di dalam penghasilan mekanisma mengangkut dan memunggah untuk kenderaan panduan automatik, kenderaan panduan automatik ini hendaklah memenuhi beberapa kriteria iaitu, ringan, beroperasi secara automatik dan kebolehan mengangkut akrilik. Mekanisma mengangkut dan memunggah ini beroperasi dengan menggunakan skru bebola sebagai mekanisma pergerakan dan pad sedutan yang dihubungkan dengan pam vakum untuk mekanisma melekap. Rangka dan bahan utama untuk menghasilkan kenderaan panduan automatik ini menggunakan aluminium sebagai bahan untuk mengurangkan berat kenderaan ini. Aplikasi kenderaan panduan automatik ini di dalam kehidupan sebenar boleh membantu manusia dan mengurangkan kos dalam aktiviti penghantaran yang berulang-ulang.

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CHAPTER 1

INTRODUCTION

1.1 Project background

Automated guided vehicles (AGVs) are commonly used in facilities such as manufacturing plants, warehouses, distribution centers and transshipment terminals. AGV can be referred as mobile robots owing to their reprogrammability. The purpose of AGV is to help reduce costs of manufacturing and increase efficiency in a manufacturing system. It also involved the movement of tools, raw material and work in process between station or into the storage. These movements must be safely, accurately, efficiently and without any damage to the materials. It is an important system and in element to integrate manufacturing facilities

In this project to build an AGV to transport the acralyte during laser cutting process, project team have been divided into three different specialize which is, loading and unloading mechanism, AGV control system and mechanical part of AGV. The essential capability of this AGV is ability transfer loads (load and unload) to location through path under computer control by programming.

1.1.1 Loading and unloading mechanism.

The loading and unloading mechanism for this agv includes the vacuum sucking unit for lifting the acralyte by vacuum sucking the acralyte corresponding to a position of working place, a loading mechanism for moving, move the sucking unit which has vacuum sucked the acralyte to the laser cut machine and an unloader for carrying another acralyte.

1.2 Project Objectives

The objectives of the project that need to be achieved are:

- 1.2.1 To study basic requirements of loading unloading mechanism for AGV application..
- 1.2.2 To design a loading unloading mechanism for AGV application.
- 1.2.3 To fabricate a loading unloading mechanism for AGV application.
- 1.2.4 To assemble loading unloading mechanism into AGV main body.

1.3 Problem statement

This AGV is designed to avoid the operator from expose with the fume that produce during laser cutting operation , according to material safety data sheet(MSDS) the fume is dangerous to health if it expose directly to the operator besides that there are many practical engineering problems for which we can not obtain exact solutions to get a better result in daily operation. Either in industry,studying or manufacturing field,all need efficient material handling system. Material handling is an integral part of any manufacturing activity.

Given the high costs involved in the equipment and the safety issues, it is imperative to design a good material handling system. The automated guided vehicle system is an important element in the computer integrated manufacturing facility. Automated guided vehicles provide considerable advantages as compared to other material handling equipment. Design concerns involve issues regarding the flow path design and the number of vehicles in the fleet. There are several ways to avoid the problem:-

- 1.3.1 By doing the cutting process remotely outside room.
- 1.3.2 Improve room ventilation system.
- 1.3.3 Anytime during and immediately after cutting there is no operators are allowed to enter the room.
- 1.3.4 Operator must wear PPE during operate the machine

1.4 Scope of project

In order to achieve the project objective, the following scopes are identified:

- 1.4.1 Design AGV cad model using SOLIDWORKS 2006.
- 1.4.2 Analysis the design using ALGOR.
- 1.4.3 Fabricate prototype of AGV
- 1.4.4 Assemble the mechanism into AGV main body
- 1.4.5 Transport acrylic (500x500) 0.85kg weight

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter is discussing on some literature that give information about automated guided vehicle (AGV) and show how this AGV have been fabricated.

2.2 Material handling

There are many solution in material handling process in industry that applied handling system in order to reduce and optimization in time handling. In Material Handling Systems, Designing for Safety and Health book, state that the handling of all types of materials may manifest itself in the individual worker's effort to lift and move material using large industrial crane[1]. Almost every industrial sector has to address material issues, especially workplaces moving material in and products out on a just-in-time schedule. improper handling and storage of materials can result in costly injuries.

Material include many things such as boxes, parts or equipment of steel beams etc. The efficient handling and storage of material in vital to the function of industry. MH provides for the continuous flow of raw material, parts and products throughout the workplace and assure that materials and products are there when they are needed. Handling equipment in modern container terminals is increasingly becoming automated. As the equipment is unmanned and operator intervention is normally not available, efficient scheduling is crucial to

achieve satisfactory performance[1]. If this is done properly, the resulting productivity gains can result in large cost savings for the terminal operators, an important consideration in view of the large financial investment required in terminal equipment.

Material handling does not add value to the product but only cost. Thus the objective of material handling is the efficient movement of goods for the on-time delivery of correct parts in exact quantities to desired locations in order to minimize associated handling costs. Material handling equipment can be classified according to the movement mode: above-floor transportation (e.g., belt conveyors, trucks, etc.), on-floor transportation (e.g., chain conveyors), and overhead transportation (e.g., cranes)[2]. In the following sections, we will review industrial trucks (including automated guided vehicles), conveyors, and industrial robots as the primary mechanized or automated material handling equipment. Material handling is an integral part of any manufacturing activity. The material handling is a variety of advanced technologies are now emerging to expand the capabilities of computer controls into the creation of automated factories[3]. The automatic guided vehicle system is an important element in the computer integrated manufacturing facility.

2.3 Review on automated guided vehicle (AGV)

Automated guided vehicle (AGV) is a driverless vehicle for repetitive movements for transportation. This mobile transport unit is battery powered and typically used in factories and warehouse. The first AGV was developed by Barrett Electronics, U.S.A., in the early 1950s and installed at Mercury Motor Freight in 1954. These towing vehicles received poor acceptance by the manufacturing industry owing to their limited controllers and difficulty in their reprogrammability[4]. The subsequent period of 1960 to 1980, however, was marked by the introduction of a large number of AGVs in Europe, which was further accelerated during the following decade because of better (compact and reliable) onboard computers and electronics. As expected, the automotive

industry such as Volvo, Fiat was the leader in the use of AGVs (more than 50% of over 10,000 installations)[4].

There are many benefits by using AGV as a material handling equipment, such as it can reduce product damage because AGV is design to transport the product safely by follow the programmable path, it also is a user friendly because the path and system can be modified or expand easily according to user will. Besides that, AGV also will improve plant logistic by deliver the product upon demand and improve response time, and last but not least, by using AGV aisle traffic will reduce and this will cause an improvement to the plant safety[5].

The AGV system component is, vehicle(AGV), software, batteries/charging unit and integration. AGV can be divided into 3 standard type, forked, tugger/tow and unit load, but AGV can be design according to needs of specific industries and unique material handling challenge.

2.3.1 Forked vehicle.

Forked vehicle is very popular type of AGV because of their versatility and flexibility, it can handle many type of load such as pallet, racks, trays and cart because of that ability forked vehicle are an excellent solution for applications where changes to the facility are expected during the life of the AGV system. These AGVs can easily be reconfigured to handle new and/or additional tasks[6] . This type of vehicle is best when interfacing with a few different type of pick and drop point for example, conveyor, floor and racking stand.



Figure 2.1: Forked vehicle.

2.3.2 Tow vehicle.

Tow AGV is designed to pull wheeled cart and dollies. This vehicle is the most productive form of AGV because it hauls more loads per trip than others AGV types[6]. Many tow types do not operate in reverse and instead operate in either a loop or they have turnaround loops at any end points of the AGV road system. The carts can be loaded automatically or manually. Tow vehicle AGVs are available in several different towing capacities and can even be equipped with an operator station for cases where customers may desire occasional man-aboard operation.



Figure 2.2: Tow AGV

2.3.3 Unit load vehicles

Sometimes these vehicles are also known as a 'top carrier', where the load rests on top of the vehicles. Unit load applications in the Food and Beverage, as well as the Pharmaceutical industry, provide timely and controlled transportation coupled with product identification and tracking of key ingredients necessary for a fully integrated and automated material delivery system[6]. Unit load vehicles are usually divided into two decks: a lift deck design provides an ideal solution for applications where a large number of pickup and deposit stations are utilized. Here the vehicle will drive into a station and either lift the load from that station or deposit the load to that station, and the other deck is a conveyor deck, which is generally used when all load transfers are to or from a stationary conveyor.



Figure 2.3: Unit load vehicle.

2.4 AGV Classification

Modern AGV systems differ from the classic ones. Rather than using fixed paths, many modern AGV are free ranging, which means the path of the vehicle are software programmed and can be change relatively easy when new stations or even flows are added. Modern technology also allows the vehicle to make decisions on its own compare to the past when control was perform by the central controllers. This leads to adaptive, self-learning system of the AGV (Tuan Le-Anh and De Koster). In this section, AGVS classification according to the journal by Peters et al will be described. According to the journal, the automated guided vehicle system can be divided into three basic levels such as below:

1. Guidepath determination
 - a) Static path
 - i. Unidirectional
 - ii. Bidirectional
 - b) Dynamic path
2. Vehicle capacity -
 - a) Single unit load
 - b) Multiple loads
3. Vehicle addressing mechanism
 - a) Direct address
 - b) Indirect address

2.4.1 Guidepath Determination

AGVS guidepaths can be determined in two ways, which are static or dynamic determination. Static guidepath system, it can be further divided into unidirectional and bidirectional systems. In static guidepath, the vehicles use a set of predetermined paths between possible origins and destinations. Variety of guidance mechanisms can be used such as wires embedded in the floor, chemical or optical sensors, dead reckoning and mapping of the paths by using software.

In unidirectional system, the vehicle will only travel in single direction following single predetermined lane. If many vehicles are used, each of them will have its own lane or path and each of the lanes is controlled independently even though the directions are different. This type of system is easier to control as deadlocking and collision problems can be avoided. In bidirectional system, vehicles can travel in forward and backward movement using the same guide path. In order to do so, a turning or turnaround point is specified for the vehicle. Although this type of system can bring improvement in productivity and less vehicle usage, however, the control system is complex since multiple vehicle share the same guidepath and must be able to avoid deadlock' situations.

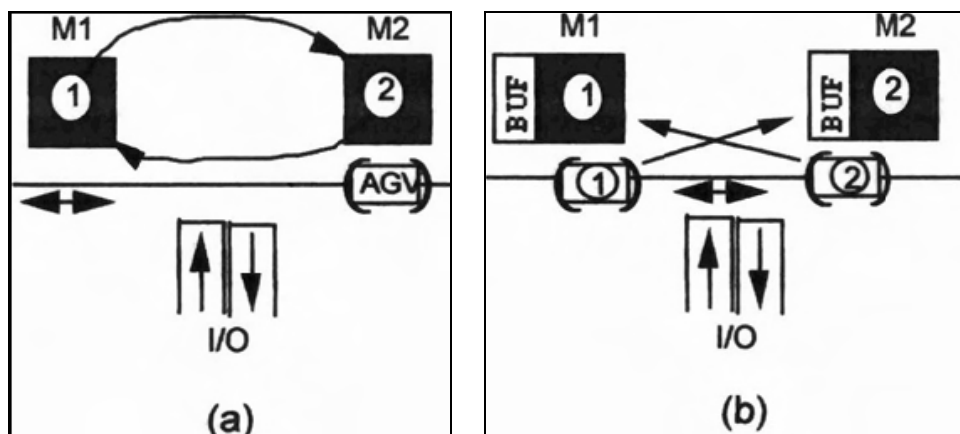


Figure 2.4: Deadlock Situations in Manufacturing Systems: (a) Part Routing Deadlock;(b) AGV Deadlock (Peters *et al*)

Dynamic guide path system use fully autonomous vehicles, which are capable of determining its path through obstacle detection and avoidance systems. In this system, the vehicle is given the destination, a location that the vehicle knows through coordinate system. The vehicle then determines its path from its current position to the desired position through its internal navigation scheme (Peters *et al*).

2.4.2 Vehicle Capacity

In automated guided vehicle system, the vehicle can be classified based on its load capacity, which is either single load or multiple load vehicles. System that use single load vehicle is known as single load system and if multiple load vehicles are used, it is known as the multiple load system. In a single load system, an empty vehicle will be assigned for a task for example taking a load and deliver it. From its current position; it will then travel to a station to pick up the load and then travel to the desired position to drop off the load. During performing its task, it is not interrupted with another assignment and will only move in path to pick up and drop off the load. In multiple load system, the task of the vehicle is more complicated where the vehicle may be interrupted while

performing its task. It may stop to another station to pick up another load. In this type of system, the planning and scheduling functions of the controller might be difficult as the plan and schedule must integrate the new tasks into previously assigned tasks (Peters *et al*)

2.4.3 Vehicle Addressing Mechanism

Vehicle addressing system in AGVS can be grouped into two, which are direct or indirect address system. In direct address system, any vehicle is allowed to visit any stations available in the same system. This system is much alike the taxi service. The planning function for this system routes vehicle from its current location to its destination considering the current status of the system. In other words the routes are not determined in advanced. Vehicles must be assigned to tasks since vehicles are not restricted to serve any particular station. The planning function might be complicated since the location of the vehicle is not known initially but only changes upon system changes.

In indirect address system, vehicles will stop at stations in a fixed sequence, which is more likely a bus service. The routes are predetermined as part of the system design, not one of the controller planning function. Compare to direct address system, the dispatching in this system is straightforward. As the route of the vehicle is predetermined, it will pick up and drop off loads when it reach each stations in its route (Peters *et al*).

2.5 AGV Applications

According to Groover (2001), Automated Guided Vehicles are widely used for variety of applications. Such applications can be grouped into five categories such as following:

1. **Driverless train operations.** This type of applications usually involves transferring of large quantities of loads over large distances.

2. **Storage1 distribution systems.** For this type of applications, unit load carriers and pallet trucks are used. In this application, materials in unit loads are moved from or to specific locations. The system usually involve interface with other automated handling or storage system, for example the automated storage/retrieve system (ASRS). In such interface, the vehicle will pick up or drop off unit loads from receiving dock to the ASRS, which then placed them in storage. After that, upon request, the ASRS will of the floor, applying a narrow photo sensitive chemical strip on the surface of the floor, applying a narrow photo reflective tape on the surface of the floor and embedded wire just below the surface of the floor. In the technique that **uses** wire embedded in the floor, wires that have varying frequencies are used. AGV will then select a path at a control point according to the assigned frequency. AGV using this type of system usually equipped with sensor underneath the vehicle, usually a small antennae consisting of magnetic coils. With presence of current that flows, a magnetic field surrounds the buried wire. The closer the buried wire to the antennae, the stronger the field will be.

The other three type of fixed AGV path is also known as the optical guide path technique. For these types of AGV paths, AGV will move by focusing on the **beam** of light reflected **from** the paints strip or reflective tape. It follows the path by measuring the reflected light. These methods require a sensor mounted under the vehicle, which able to detect the presence of the surface mounted path. Of course, the purpose of the sensor is to keep the AGV correctly over the guide path (Frog Navigation System, 2004).

2.6 Position Technique

In this section, detail description about these technologies will be included as this project will involve one of these navigation technologies.. According to Borenstein et *al*, the positioning techniques in AGV can categorized into two groups and the two groups can be M e r divided into following seven categories:

- I. Relative position measurements (also known as dead-reckoning)
 1. Odometry
 2. Inertial navigation
11. Absolute position measurements (reference-based systems)
 1. Magnetic compasses
 2. Active beacons
 3. Global positioning systems
 4. Landmark navigation
 5. Map based positioning

2.6.1 Odometry

Odometry is the most widely used navigation method for AGV positioning as it provides good short-term accuracy, inexpensive, and allows very high sampling rates. Odometry is used to estimate (not determine) the position of an AGV relative to a starting location. It uses of data from the rotation of wheels or tracks to estimate change in position over time. This method is often very sensitive to error. Specifically, orientation errors will cause large lateral position errors, which increase proportionally with the distance traveled by the AGV. The necessary motion information is often obtained by measuring wheel revolutions. Devices called wheel encoders are coupled to a robot's drive wheels and act like digital odometers.

Odometry is based on the assumption that wheel revolutions can be translated into linear displacement relative to the floor using data utilized from incremental wheel encoders such as stated above. However, when there is case such as slippage on a slippery floor, encoders generally provides a good estimate of displacements for the right and left wheels, respectively. Details on odometry calculations will be described in Differential Drive System section as this method will be used in this project.

As described earlier, odometry is sensitive to error. Such errors are in form inaccuracies in the translation of wheel encoder readings into linear motion. Cause of such errors can be grouped into two categories, which are: (1) systematic errors and (2) non-systematic errors. Systematic errors usually occurs because of factors such as unequal wheel diameters, average of both wheel diameters differs from nominal diameter, misalignment of wheels, uncertainty about the effective wheelbase (due to non-point wheel contact with the floor), limited encoder resolution and limited encoder sampling rate. Non-systematic errors are usually happen due to travel of the AGV over uneven floors, travel over unexpected objects on the floor, wheel-slippage due to slippery floors, over-acceleration, fast turning (skidding), external forces(interaction with external bodies), internal forces (e.g., castor wheels) and non-point wheel contact with the floor (Borenstein and Feng, 1996).

2.6.2 Internal Navigation

Inertial navigation does not measure the rotation of wheels or shafts like in odometry but rather tracks the accelerations that the AGV has undergone, which then converts such information into positional displacement. This method uses gyroscopes and accelerometers as sensors to measure rate of rotation and acceleration, respectively. Measurements are integrated once (or twice, for accelerometers) to yield position. Inertial navigation systems have the advantage as they don't need external references. However, inertial sensor data drift with time because of the need to integrate rate data to yield position; any small constant error increases without bound after integration. Inertial sensors are thus

mostly unsuitable for accurate positioning over an extended period of time (Dixon and Henlich, 1997).

2.6.3 Magnetic Compass

Magnetic compasses allow the navigation of the AGV using the advantage of the magnetic field of the earth to find its orientation information. This can be very useful if coupled with the dead reckoning⁴ technique of odometry to cut down on the orientation errors that may be accumulating with time. This type of method is expensive compared to other orientation measuring devices such as the gyroscopes and it provides excellent companion measurement for odometry. However, this type of sensing method is sensitive to metallic structures and the earth magnetic fields tend to distort in such environment (Borenstein et al, 1996).

2.6.4 Active Beacon

Active beacon navigation systems are the most common navigation aids on commercial mobile robot or AGV systems. Active beacons can be detected reliably and provide accurate positioning information with minimal processing. As a result, this approach allows high sampling rates and yields high reliability, but it does also incur high cost in installation and maintenance. However, accurate mounting of beacons is required for accurate positioning of the vehicle. For most AGV, laser, sonar and radio (or microwave) is common media for navigational beacons. Because of this, most methods are "line-of-sight" dependant which means that there must be no obstructions between the AGV and the beacons. Beacon types include radar reflectors, radio beacons, sound signals, and visual **beacons** (Dixon and Henlich, 1997).

2.6.5 Global Positioning System (GPS)

The Global Positioning System (GPS) is a revolutionary technology for outdoor navigation. It is not based on dead reckoning, because they work by receiving radio signals from (external to the AGV) satellites orbiting the Earth. The system comprises 24 satellites (including three spares) which transmit encoded RF signals. Using advanced trilateration methods, ground-based receivers can compute their position by measuring the travel time of the satellites RF signals, which include information about the satellites temporary location. Knowing the exact distance from the ground receiver to three satellites theoretically allows for calculation of receiver latitude, longitude, and altitude of the AGV. Global positioning systems are low in cost but cannot be used inside buildings, especially office factories with large amount of steel-reinforced concrete. The reception of radio signals also can be interrupted by cellular phones or any features that obstruct the receiving of the signals (Dixon, 1997).

2.6.7 Landmark Navigation

Landmark navigation is a navigation method that uses landmarks as the reference based for the AGV to determine its position. Landmarks are distinct features that the AGV can recognize from its sensory input. Landmarks can be a geometric shapes (e.g., rectangles, lines, circles), and they may include additional information (e.g., in the form of bar-codes). In general, landmarks have a fixed and known position, relative to which a robot can localize itself. These landmarks are usually easy to be identified the AGV; for example, there must be sufficient contrast relative to the background. Before an AGV can use landmarks for navigation, the characteristics of the landmarks must be known and stored in the vehicle memory. The main task in localization is then to recognize the landmarks reliably and to calculate the vehicle position relative to the position of the landmarks that are preprogrammed in the vehicle memory (Elorenstein et al, 1996).

2.6.8 Map Based Positioning

Map-based positioning, also known as "map matching," is a technique in which the robot uses its sensors to create a map of its local environment. This local map is then compared to a global map pre-stored in the AGV memory. If a match is found, then the robot can compute its actual position and orientation in the environment. The pre-stored map can be in form of CAD model of the environment, or it can be constructed from previous sensor data. Map-based positioning is advantageous because it uses the naturally occurring structure of typical indoor environments to derive position information without modifying the environment. Also, with some of the algorithms being developed, map-based positioning allows a robot to learn a new environment and to improve positioning accuracy through exploration. Disadvantages of map-based positioning are the strict requirements for accuracy of the sensor map, and the requirement that there be enough stationary, easily distinguishable features that can be used for matching. Because of the challenging requirements currently most work in map-based positioning is limited to laboratory settings and to relatively simple environments (Borenstein et al, 1996).

CHAPTER 3

METHODOLOGY

3.1 Introduction.

This chapter is focused on the methodology process which is the sets of methods to fabricate and the design that been used. The design that been implement are need to specify certain criteria to achieve project objectives. The information in the literature review is interpreted to select the suitable design for the AGV. The design need to be specified in CAD software model. The steps that involve in fabricating and programmed the model are stated.

3.2 Flow chart

To achieve the objectives of this project, a methodology has been constructed (see figure 3.1). The methodology flow chart is purposed to give guidelines and directions to successfully accomplish the main goal of this project. The following is the summary methodology flow chart.

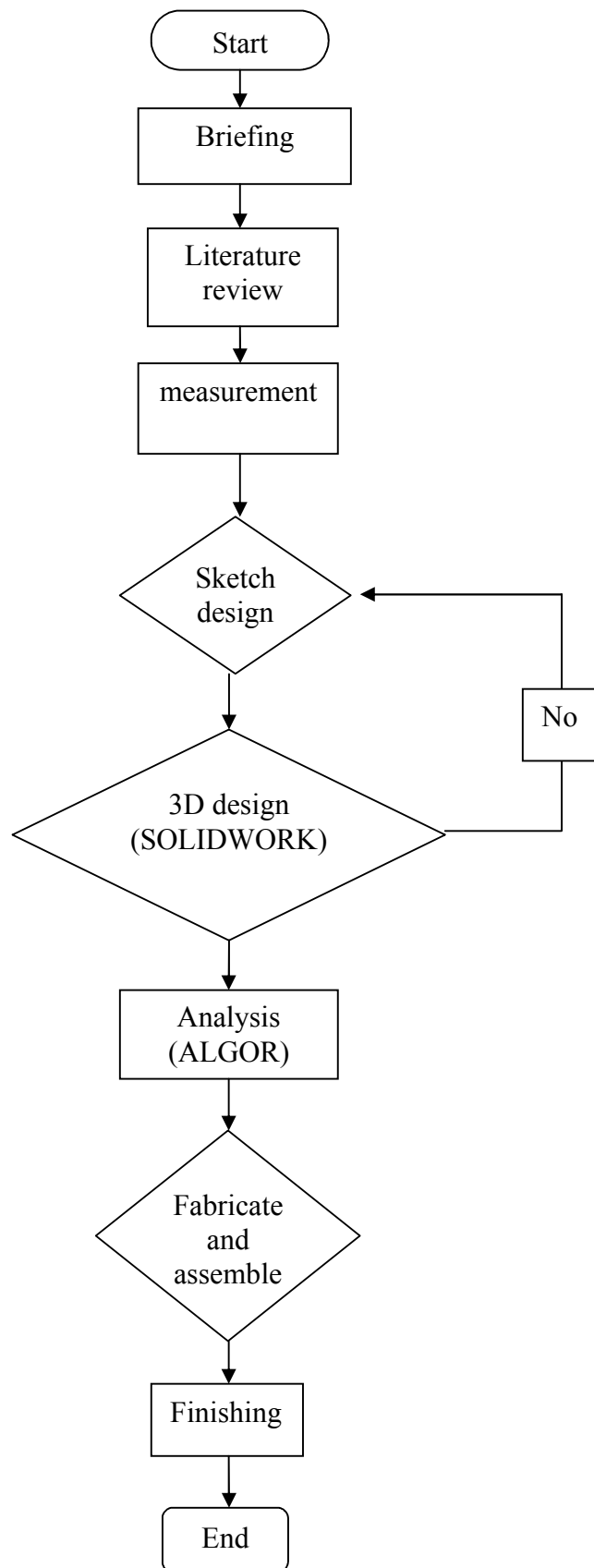


Figure 3.1: Project Methodology

3.3 Material selection

3.3.1 Aluminium

Aluminium is a silvery white and ductile member of the boron group of chemical elements. It has the symbol Al, its atomic number is 13. This material is too reactive chemically to occur in nature as a free metal. Instead, it is found combined in over 270 different minerals. The chief source of aluminium is bauxite ore.

Aluminium have been chosen as the main material to this AGV because its ability to resist corrosion (due to the phenomenon of passivation) and its low density. Structural components made from aluminium and its alloys are vital to the aerospace industry and very important in other areas of transportation and building. Its reactive nature makes it useful as a catalyst or additive in chemical mixtures, including being used in ammonium nitrate explosives to enhance blast power.

Aluminium is a soft, durable, lightweight, malleable metal with appearance ranging from silvery to dull grey, depending on the surface roughness. Aluminium is nonmagnetic and nonsparking. It is also insoluble in alcohol, though it can be soluble in water in certain forms. The yield strength of pure aluminium is 7–11 MPa, while aluminium alloys have yield strengths ranging from 200 MPa to 600 MPa. Aluminium has about one-third the density and stiffness of steel. It is ductile, and easily machined, cast, and extruded.

3.4 Drawing

3.4.1 Drawing Consideration

The drawing of the AGV must achieve all of the objectives desired. So the drawings must be as complete as possible and can be fabricated perfectly without any errors on the middle of the fabrication process. This is to keep track of time and not to be late of schedule.

The consideration for the drawing is for it firstly to be movable, In sketching, the measurement of the laser cutting machine must been taken to get the suitable size for the AGV. This is to make sure the loading and unloading mechanism can lift and move the load to the cutting process table.

3.4.2 Drawing Method

In this project, the software that will be used to draw the model is SolidWorks 2006. The SolidWorks software is a mechanical design automation as a computer added software (CAD). This software is chose as it is possible for designers to sketch their ideas of the design, experiment with features and dimensions and produced models and detailed drawings. SolidWorks enables us to draw the models much more quickly and precise. SolidWorks designs are defined by 3D design and are based on components. To draw the design of the quenching tank it must have some steps that must be followed. It includes:

- i) **Sketches** : Create the sketches, dimensioning , where to apply the objectives needed and so on.
- ii) **Features** : Select the appropriate features, determine the best features to be applied and so on.
- iii) **Assemblies**: Select the components to be mate, what types of mate to applied in the drawing and so on.

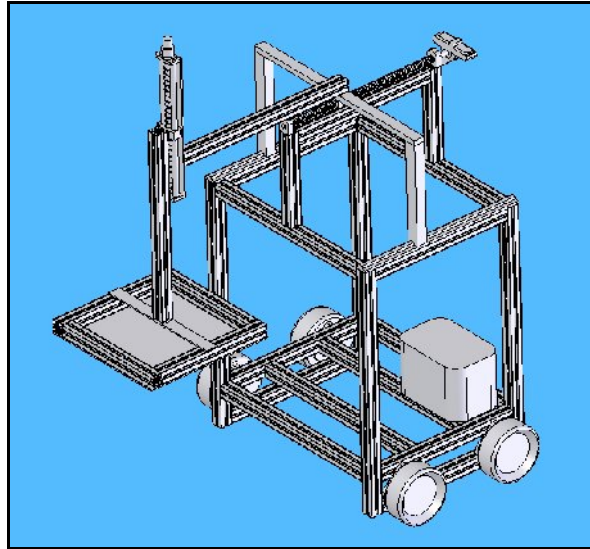


Figure 3.2: AGV design isometric view

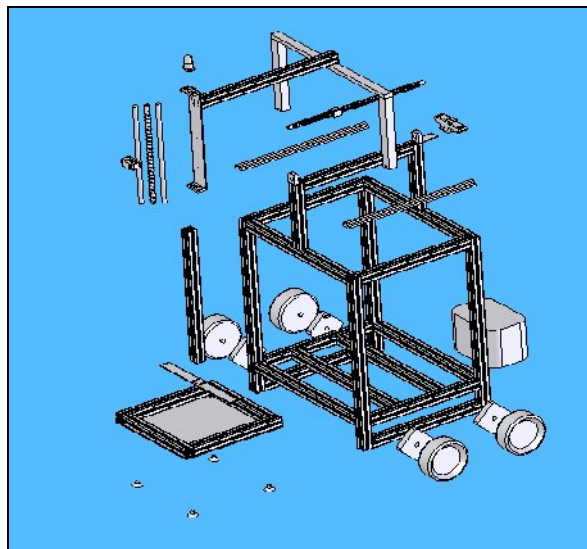


Figure 3.3: AGV design explode view

3.5 Analysis.

The analyses of this AGV strength have been done using ALGOR. ALGOR software is a general-purpose multiphysics finite element analysis software package developed by ALGOR. After finish the analysis using this software, we can know if the aluminum profile which is used to carry the load is strong enough or not.

3.6 Fabrication Process

To assemble the parts of this AGV, we must be sure and know the method of fabricating the parts, because the part that is to be assembled has different dimensions and usage. There are two mechanisms in loading and unloading which is, movement mechanism and lift mechanism.

The movement mechanism that is used in this project is using ballscrews to move the acrylic for two axis movement, x-axis and y-axis. The ballscrews is assembled with the DC motor using coupling to give the movement.

The suitable lift mechanism is important to the AGV. The methods that have used to lift the acrylic in this AGV are, using the suction cup and this mechanism is powered by diaphragm pump to give the negative pressure to stick the acrylic.



Figure 3.4 : Ballscrew for y-axis movement



Figure 3.5 : Ballscrew for x-axis movement

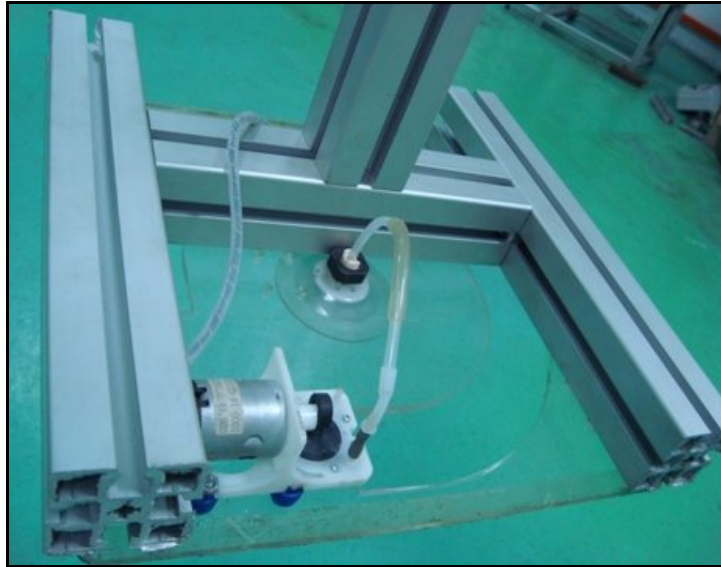


Figure 3.6 : Suction cup with diaphragm pump



Figure 3.7 : DC motor 1 assembled with ballscrew



Figure 3.8 : DC motor2 assembled with ballscrew

3.7 Expected outcome

The expected outcome after complete this project is, this AGV able to:

- Max loading: 5kg of 500mmx500mm
- Max loading unloading height : 950mm
- Max loading unloading distance: 700mm

3.8 Conclusion

The whole procedures in this chapter are important to build the AGV. Starting with design concept, analysis and fabrication process. The design concept is to set the AGV mechanism in the movement mechanism and lift mechanism. With all the design concept, it's go to the next level that is analysis based on the design concept. The analysis is to get the result whether the design is capable to lift the acrylic or not. After completing the analysis, fabrication process can be take place.