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PLC based Remote Guided Vehicle for Filling and Disposal of Toxic Chemical for Unmanned Applications

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***Abstract*—Remote Guided Vehicle designed for performing operations quickly, repeatedly and accurately has a long heritage in the manufacturing industry, operating in relatively static environments and in large numbers. Trends in the oil and gas industry to improve safety and efficiency and reduce environmental impact suggest the use of robotized vehicle. New developments in regions difficult or dangerous for humans to work in could be enabled with maintenance, inspection and repairs carried out by remotely-controlled Automated Guided Vehicle (AGV). Programmable Logic Controller (PLC) is an integral part of any industrial work. Therefore, we have designed and developed a PLC based automated remote guided vehicle for filling and disposal of toxic chemical for unmanned application. This paper discusses aspects of different components used to develop an AGV and controlling its movement and on board utilities. Further, this AGV is interfaced to a 23-point PLC using wireless transmitter and receiver pair. This ensures the wireless communication to suit any such applications where human beings cannot access and control. Automated guided vehicle is used to transport toxic chemicals in areas where humans cannot reach. PLC program is written to control the AGV to follow the predetermined path and then, load the chemical at a point and unload at the other point.**

***Index Terms*— Automated guided vehicle (AGV); PLC (programmable Logic Control); Object Sensor.**

I. INTRODUCTION

Today's existing mobile robots operate in different environments like industries, commercial, military environments. During decision making process these robots has to interact with humans. The working environment is highly unattended and often unknown. Hence, the robots must be able to process a large amount of information, in-order to make planning and navigational decisions immediately. In order to autonomously act, a mobile robot needs to find its way to the target area where the process is to be carried out.

Ref [1, 2].However, the site is very dangerous for humans because of the potential for high radiation exposure. Therefore, there is great need to develop a remote guided vehicle for chemical disposal and chemical leak detection, and emergency response, with the capability of adaptation to a variety of complex hazardous environments, high flexibility and a long control distance.

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Ref [3, 4] Automated Guided Vehicles (AGV) has been applied for the flexible manufacturing system. Many factories were adopted it into assembly line or production line such as automobile, food processing, wood working, and other factories. Since the requirement for movement of materials is generic, the need for an automated guided vehicle system is felt by all segments of industries more so by those whose processes are well structured to take advantage of automation, or those who want to avoid manual handling of hazardous (e.g. radioactive or explosive) materials. The available solution turns out to be very expensive, as in each case they need to be customized to meet exact requirements of the industry. The development of AGV was taken up to generate an indigenous solution that is affordable to the Indian industries going for modernization of their manufacturing processes, and that can be adapted to the exact requirements of an industry without adding substantially to its cost.

Ref [5].In this paper, a PLC based remote guided vehicle for filling and disposal of toxic chemical for unmanned application is designed. The following issues are key consideration.

1. In order to enter chemical contaminated areas to avoid unnecessary causalities, AGV has the tank which will be filled with toxic chemical at filling station and AGV follows the predetermined path and at the chemical Disposal station the chemical will be dumped.
2. The AGV follows the predetermined path which is already stored in the PLC; at the PLC the transmitter sends the commands to AGV to follow the path.
3. The AGV must be equipped with chemical filling tank and level sensor at the tank. Obstacle sensors to detect the obstacles on the path, if any object is detected, then the high signal will be send to the PLC through RF Transmitter which is mounted on the AGV. AGV will not move unless the obstacle is removed.
4. According to the PLC command the AGV will move to chemical disposal station and toxic chemical will be dumped.

II. Related Work

The proposed work involves design of guided vehicle completely and remotely controlled by PLC through wireless communication. Therefore, we have designed and developed a PLC based automated remote guided vehicle for filling and disposal of toxic chemical for unmanned application. This paper discusses aspects of different components used to develop an AGV and controlling its movement and on board utilities. Further, this AGV is interfaced to a 23-point PLC using wireless transmitter and receiver pair. This ensures the wireless communication to suit any such applications where human beings cannot access and control.

Ref [1].The actual requirements of nuclear radiation and chemical leak detection, and emergency response, a new small tele operated robot for nuclear radiation and chemical detection is proposed by Kui Qian et.al.

Ref [4].An industrial robot designed for performing operations quickly, repeatedly and accurately has a long heritage in the manufacturing industry, operating in relatively static environments and in large numbers. Trends in the oil and gas industry to improve safety and efficiency and reduce environmental impact suggest the use of industrial robotics is discussed by Clint Heyer et.al.

Ref [9]. The Yagoda et.al. has described that the effective human robot team configurations and exchanges are needed to ensure optimal task performance for human-robot teams. The exchanges between robots and human operators are mediated through an interface and this interaction has a direct impact on the team configuration associated with a particular task.

Ref [5]. Khatib et.al. a unique real-time obstacle avoidance approach for manipulators and mobile robots based on the "artificial potential field" concept. In this approach, collision avoidance, traditionally considered a high level planning problem can be effectively distributed between different levels of control, allowing real-time robot operations in a complex environment.

Ref [10]. The Hoa G. Nguyen et.al, described the web based survey to establish law enforcement robotics needs for applications that extend beyond explosive ordnance disposal.

III. Materials Used

Following materials are used to fulfil the work:

- AGV chassis with Dimension 16 cm Length x 12cm Width x 1.5cm Diameter for Motors Fixing
- PLC with VersaPro 2. 02 version
- DC motors with 12 V and 6 amps.
- Castor wheel

- Motor drive circuit /motor speed control circuit
- Object sensor
- RF transmitter and Receiver

IV. Constructional Details

A. Automated Guided Vehicle (AGV)

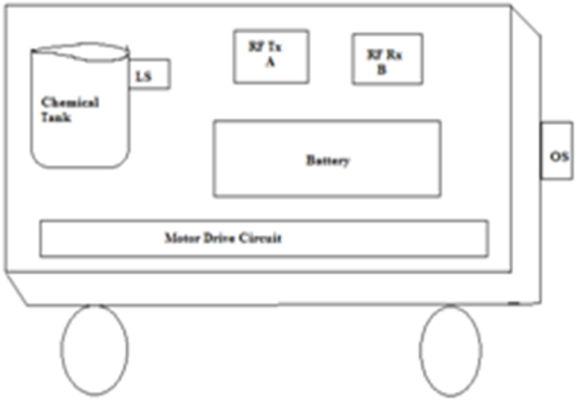

Figure1. Constructional details

Ref [6].A thorough interaction between the AGV and PLC is achieved by two pairs of RF transmitter and receiver .One pair that is RF TX A is placed on AGV and RF Rx A is placed at the PLC side. Another pair of RF TX B is placed at PLC side and RF Rx B is placed on the AGV. Fig 1 describes the constructional details of the automated guided vehicle. It consists of a chemical tank, a level sensor, an RF transmitter and a receiver with on board 12V battery. Level sensor is fixed at the tank .When the level reaches the nozzle of the chemical reservoir, the level sensor informs the PLC to take action to close the chemical filling valve. The motor drive circuit is used to control the vehicle speed. Here we are using two separate motor drive circuit for two wheels. The AGV consists of two back side wheel and one front side castor wheel to ensure a total freedom of 360 degree rotation. The dc motor is used to drive the two back side wheels. We are using 12V dc geared motor with 60 rpm. Radio frequency transmitter and receiver used in this AGV to send and receive the command from PLC to AGV and from AGV to PLC. If any object sensed on the path, the signal or command will be sent by RF TX A to RF Rx A. The path pattern command which is stored in PLC program is sent through RF TX B to RF Rx B. According to that pattern the AGV will move.

B. Arrangement at PLC side

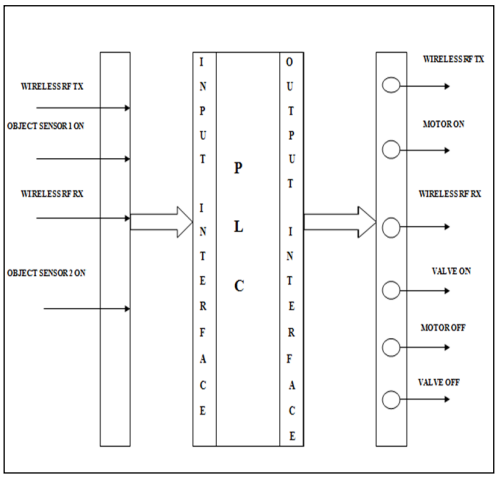

Figure.2. Block Diagram of PLC

The details of construction at PLC side are shown Fig 2. The PLC used is 23 Point GE-Fanuc with VersaPro installed on a window operating PC. A transmitter and receiver pair (Tx B and RF Rx A) is interfaced to PLC to receive the command transmitted from RF Tx A of AGV and also, to send control commands from the PLC program to AGV sent by RF Tx B.

V. WORKING METHODOLOGY

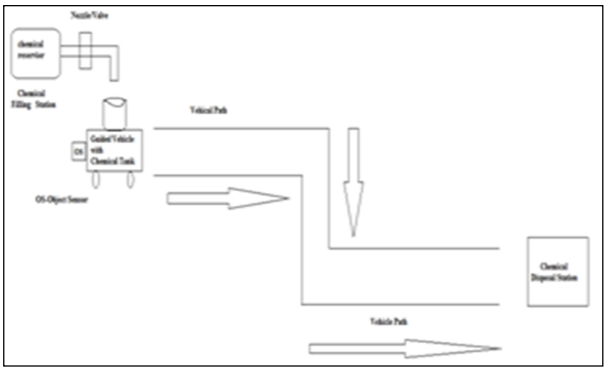

Figure.3. Line Diagram

Fig 3 shows the complete line diagram of the work. At filling station, nozzle or valve fitted to a chemical reservoir is automatically opened when the guided vehicle is at filling station. This is achieved through an obstacle sensor placed at the filling station. The guided vehicle automatically moves with the filled hazardous chemical tank according to the stored path. The path shown in Fig 3 is implemented by PLC program. The path which we have implemented here consists of two 90^0 turns to achieve first left turn and then a right turn. In each such turn, one of the motor moves with rated speed and the other with half speed. The path can be defined by controlling the motor to suit a given application. Once the AGV reaches the disposal point, another obstacle sensor instructs the PLC. The PLC stops the AGV and opens a valve fitted to the bottom of the chemical tank to dispose the hazardous chemical. During the path if any obstacle is detected, PLC stops the vehicle and the vehicle will not move until unless that obstacle is removed.

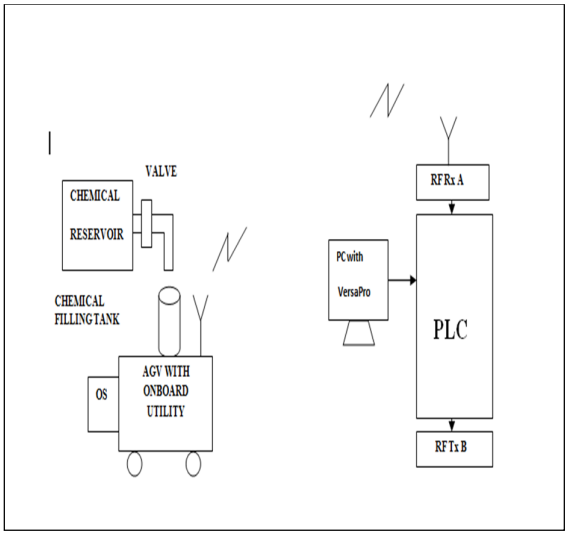

Figure.4. Block diagram of AGV System

Fig 4 shows complete block diagram an AGV system. Here we are mainly representing a wireless communication between AGV and the PLC.

VI. Flowchart For An AGV System

The PLC is programmed to provide system operation in a manner illustrated, in simplified form, in the flowchart of Fig 5. The whole software process can be described as follows.

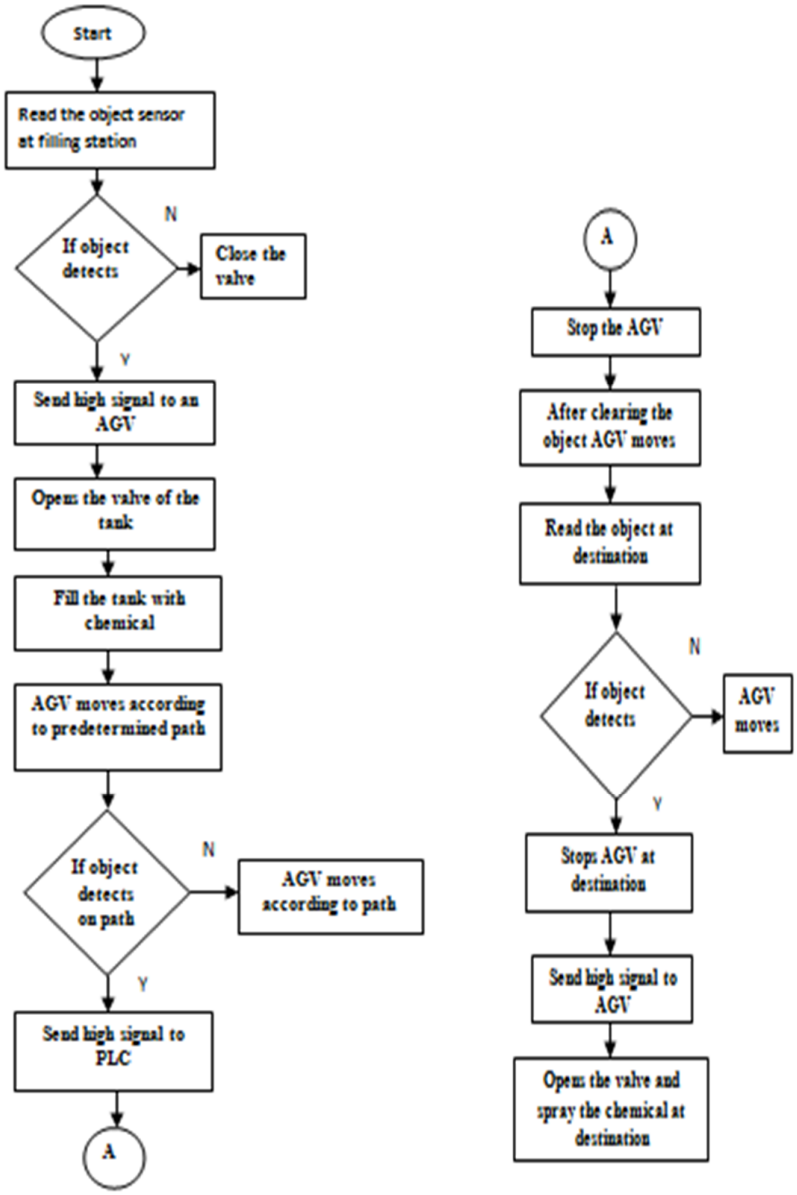

Figure.5. Flowchart for an AGV

A. Controller program for Object Sensor and valve

Object sensor fitted on the AGV detects the object at filling station if object detects then opens the valve if not then AGV follows the path.

B. Controller program for RF TX and Rx

RF transmitter receiver pair is used to send and receive the command from PLC to AGV or from AGV to PLC.

VII. Ladder Diagram

The movement and the different actions on the AGV are controlled by the resident PLC. This is achieved by the logics implemented in PLC program. Fig 6 shows the ladder diagram implemented for the complete work. VersaPro 2.02 version software is used.

VIII. Conclusion

This paper discusses an automated guided vehicle for toxic chemical disposal for unmanned application and describes the overall structure, control system and human - robot interaction design. In numerous modern applications PLC controlled AGVs are used and as a part of the majority of such applications wired correspondence is utilized. In this venture, the remote controlling is accomplished and the AGV used is intended for hazardous chemical transfer. The same method of design and controlling can be used with some modifications to suit any other application.

Future Scope

Ref [7].The movement and utility control on the AGV can be used for multiple applications. The remote vehicle can be used to replay real time video, audio, detection data and other sensor readings while the operator stays at a safe distance. In applications such as high nuclear radioactive and strong chemically contaminated areas, the robot detects the radiation level and recycles radioactive sources, in addition to producing an emergency response to toxic, hazardous, flammable, explosive or dangerous objects using a small manipulator.

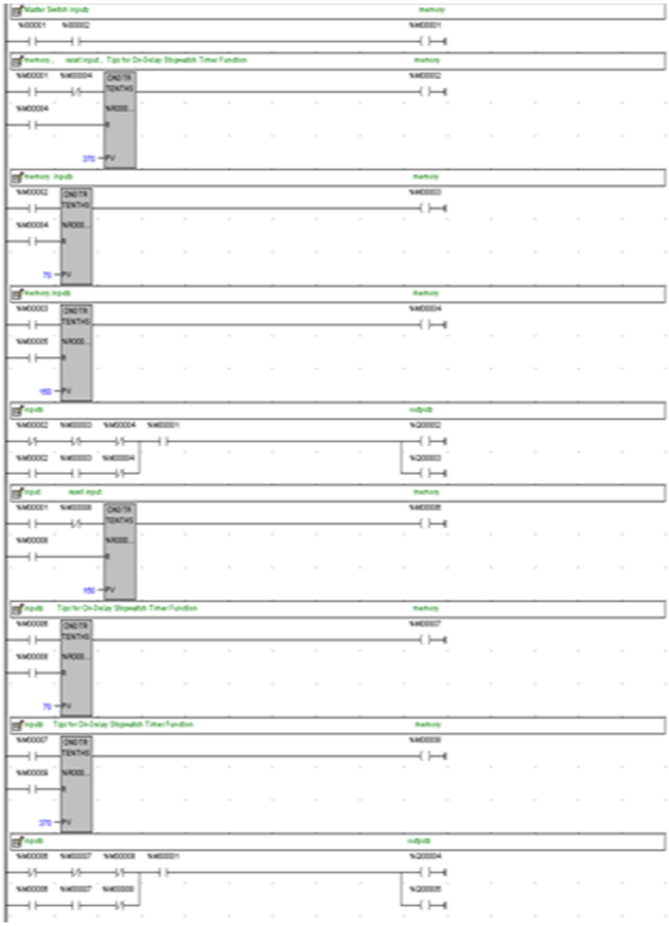

Figure.6. Ladder Program for the AGV

Some of the other applications are:

- Detection of radioactive radiation levels
- Detection of chemical leakage in the industry
- Welding and such works at an intricate place where human cannot access
- Detection and inactivation/diffusion of bombs and other ammunitions

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