

Realization of flying shear for laboratory experiments

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Abstract – In industry automatic lines, it is all about shorter production time. It would be the best for some automatic lines, to do cutting or drilling on moving parts without stopping. This type of machine is commonly called “machine on the fly”. This paper presents realization of one type of machine known as a parallel “flying shear” for laboratory experiments. Main components of the system are PLC controller, AC servo drive and variable frequency drive. It would be used for testing of different algorithms and for educational purposes.

Keywords – flying shear; PLC; variable frequency drive; servo drive.

I. INTRODUCTION

The flying shear is a common industrial application for cutting a product into smaller lengths, without stopping the line, this means that the main production process is not interrupted, and so machine's productivity is maximized. The cutting tool is typically mounted on a carriage that moves either parallel to the product flow or at an angle across the product flow. The flying shear drive accelerates the carriage to synchronize with the line speed. While they are synchronized the cut is done. After that the carriage decelerates and returns to start position ready to cut again. There are also many other similar applications where a carriage must be synchronized at line speed. The most of these applications can also be accommodated using the flying shear application software.

A couple of examples are:

A machine extrudes plastic pipes that must be supplied to the customer in pre-cut lengths. The extrusion process requires the extruder to run at a continuous speed to maintain the quality of the product. The pipe is uniform along its length and provided the length is within a set tolerance then the pipe is fit for sale. The flying shear is used to cut the product cyclically.

Linear flying shears are used in a variety of applications ranging from cutting material on the fly, filling bottles as they are moving on a conveyor, to forming soft material in a mold while being transferred along the process. This particular overview describes the flying shear (cutting) application, but can be used for any process that requires speed matching to a given axis. Linear flying shear applications can be used to solve both random in-feed and constant feed applications. This application controls the linear axis of the saw to ensure

accurate cutting as well as a digital output for providing control of the cutting mechanism [1]–[5].

II. PARALLEL FLYING SHEAR

With parallel flying shears, the carriage travels in the same direction as the material. In the example shown below a shear is used to cut through a material, while the carriage and the material are synchronized. The shear would then be raised and would return to the start position ready to repeat the cycle. The parallel mode is best suited to applications where the tool operates instantaneously across the whole material width at the same time, such as a punch tool or a shear.

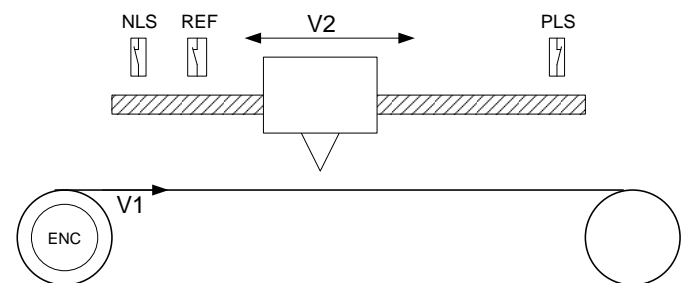


Fig. 1. Flying shear concept

Components shown in Fig. 1. above are:

- NLS – negative limit switch
- PLS – positive limit switch
- REF – reference switch
- V_1 – conveyor speed
- V_2 – carriage speed
- ENC – master encoder

III. ALGORITHM

Algorithm for flying shear application can be divided into three steps [6].

1. Homing
2. Synchronization
3. Specific operation (cutting, printing, gluing...)
4. Back to start position

Homing is process wherein the system is seeking for reference point or home. Homing can be done in many different ways, using the reference switch, using limits switches, with encoder, or with some mechanical barrier. When the system is referenced, next step in the algorithm can start.

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Synchronization is process wherein linear axis with carriage is pretending to synchronize its moving with conveyor. When the speed of the carriage becomes equal to speed of conveyor, these two axes are synchronized. During synchronized moving some specific operation can be done. After specific operation is done carriage on linear axis go back to start position and wait for next move.

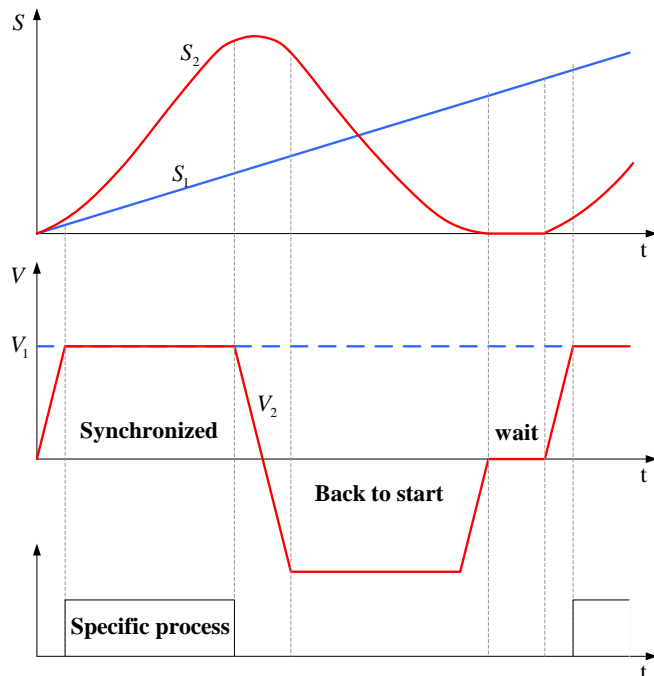


Fig. 2. Timing sequence

There are two different types of work regime of linear axis. It can be: continuous and discontinues. When carriage goes back to a start position also called wait position it is discontinues regime, and when there is no time for back to wait position it is continuous regime.

IV. COMPONENTS OF THE SYSTEM

The main components of the system are presented on Fig. 3:

- Programmable logic controller
- Servo drive
- Variable frequency drive
- Servo motor
- Master encoder
- Induction motor

A. Programmable logic controller

Programmable logic controller (PLC) used for this application is Schneider Electric Modicon M238. This controller offers high performance at low cost with efficient embedded features dedicated to simple axis motion control

(high speed counting up to 100kHz, high speed pulse train and pulse width outputs). Embedded CANopen master allows easy and adaptable architectures for development flexibility. There are two serial lines for HMI connection or peripherals devices [7].

B. Servo AC drive

Motion servo drive used for this application is Schneider Electric Lexium32M. This motion servo drive enables different work regimes: speed, position, torque and electronic gear. For a use of this application, servo is working in electronic gear regime. Electronic gear regime represents the operation in which two independent axes can be synchronized. The work way is based on getting impulses from the master encoder directly into a pulse train input (PTI) on motion servo drive. The basic thing which should be set is ratio between impulses from encoders. The purpose is to get good ratio between the speeds [8].

C. Variable frequency drives

Variable frequency drive (VFD) used for this application is Schneider Electric Altivar 312. This frequency drive represents standard industrial converter. He has CANopen port, so the wiring is minimized. All commands and reference of speed are being setup throw CANopen communication [9].

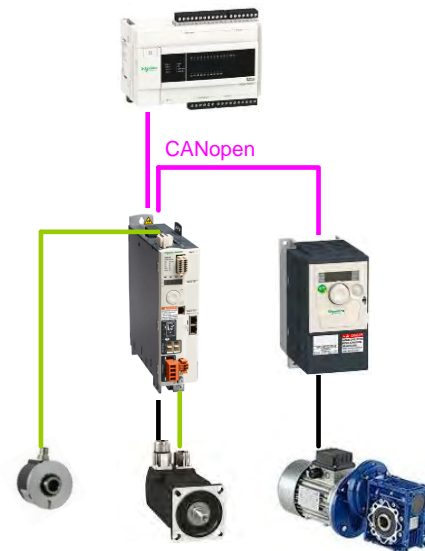


Fig. 3. Connection diagram

Master encoder is classical industrial incremental encoder with 1024 pulses per turn. He has two phases A and B. Based on the pulses number from encoder length of the cutting pease is tracked. Also, the instantaneous speed of line is calculated.

V. REALIZATION OF ALGORITHM IN CODESYS

PLC controller used in this project is in according with standard 61131-3. The main part of algorithm is created using

higher abstraction language sequential functional chart (SFC). Steps inside SFC program are created using functional block diagram (FB). Using this type of programming created program looks like algorithm [10][11].

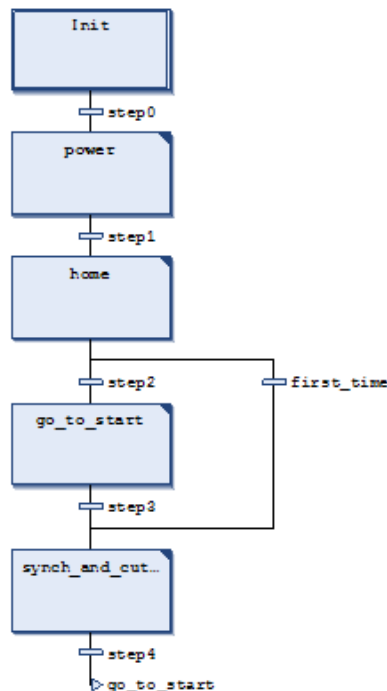


Fig. 4. SFC program

In the SFC program next steps can be noticed:

Init – in this step the starting initialization of the system is done.

Power – during this step the energetic part of VFD and motion servo drive are enabled. Also, if there is a need for device resetting it can be done in this step.

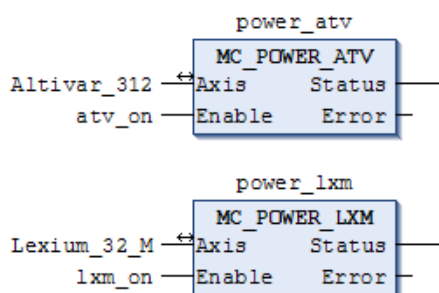


Fig. 5. Powering VFD and motion servo drive

Home – this is the step in which system is seeking for reference – zero point. Method used for homing is method with limit switch without reference switch. During this operation linear axis is moving until stepping on the switch. In that moment linear axis is stopping and returns for couple

encoders pulses. That is reference or home position. The next Fig. 6. shows layout of function block for homing. As it can be seen on block the following parameters like: homing mode, homing speed, number of pulses for returning, has to be entered.

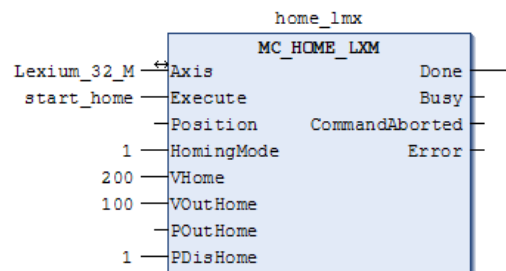


Fig. 6. Function block for homing

Synch_and_cutting – in this step synchronization of axes is in progress. When the axes synchronization is done, specific operation during synchronized movement can be preceded. After the operation is done, axes are ending their work in synchronization and linear axis goes back to reference point. Function block for synchronization of axes is GearIn. This block needs parameters like numerator and denominator to be entered. And with them the ratio of speeds is achieved. Function block GearOut is used, for desynchronization.

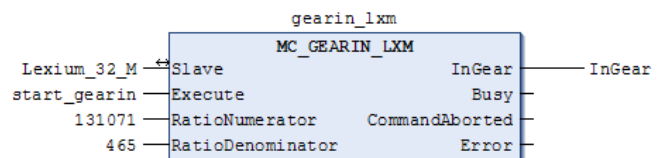


Fig. 7. . Function block GearIn

Go_to_start – during this step carriage returns to its start position. This step is very different from homing step. Reference point is known so there is no need to seek limit switch, and carriage is sent to start point with functional block MOVEABSOLUTE.

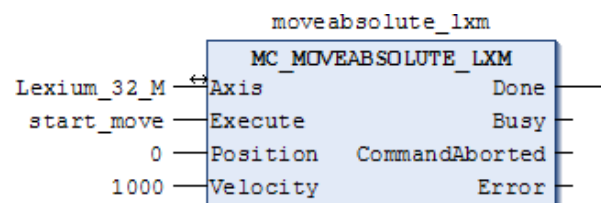


Fig. 8. . Function block move absolute

After return to start position, cycle start again from go_to_start point in program.

For this application, graphical user interface in Codesys visualization is also developed. In that way the user can enter parameters like speed of the line, length of the piece etc.

Beside entered parameters user can monitor current values of variables like position of carriage, speed of line.

VI. EXPERIMENTAL RESULTS

In this PLC controller object called trace can be added. His function is to show some variables in form of time diagram. On next figure position and speed of servo axis is shown.

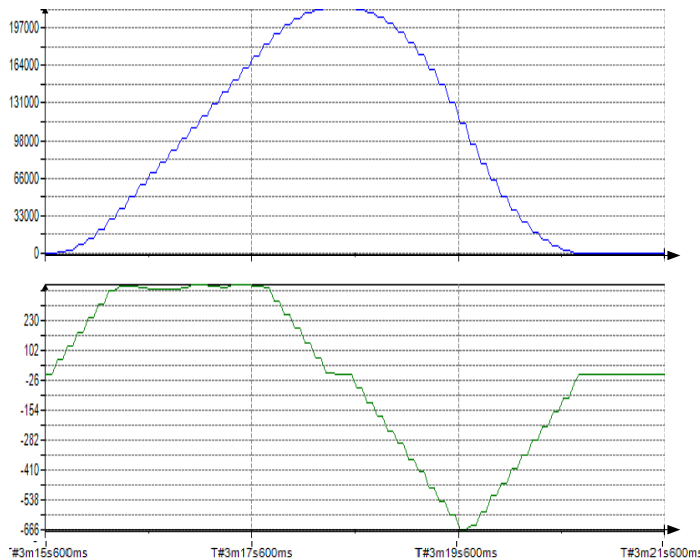


Fig. 9. Position and speed of servo axis

VII. CONCLUSION

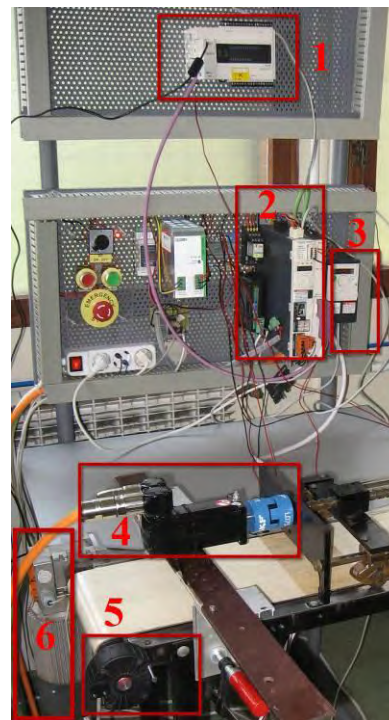
In this paper is presented the realization of flying shear application intended for laboratory and educational purposes. It has parallel structure.

Using this laboratory model many different algorithms can be developed. Here is presented a simple application with PLC. More advanced applications require motion controller. By using the motion controllers possibilities are much higher. Function block like flying shear is also available.

This application model is very practical for students work. It allows them to change parameters and test model of flying shear in safe laboratory environment. From this model students can adopt a different knowledge's, like:

- Setting up variable frequency drive;
- Setting up motion servo drive;
- Programing of PLC using standardized Codesys software package
- Creating of different control algorithm

Future steps will be improvement of dynamical features on mechanical part of system. Also the real motion controller will be used.



1. PLC M238
2. Servo drive Lxm32M
3. VFD ATV312
4. Servo motor
5. Master encoder
6. Induction motor

Fig. 10. Flying shear system in mechatronic laboratory

REFERENCES

- [1] Controller for Flying Operation (Flying Saws, Shears, Punchers etc.), Motrona GmbH, http://www.motrona.com/cutter_control_1.html, april 2013
- [2] Linear flying shear Yaskawa, <http://www.yaskawa.com/site/industries.nsf/applicationDoc/appflyinghear.html>, april 2013
- [3] Emerson Industrial automation, <http://www.emersonindustrial.com/en-EN/controltechniques/products/industrysolutions/flyinghear/Pages/flyinghear.aspx>, april 2013
- [4] Baldor motion, <http://www.baldormotion.com/support/supportme/downloads/docslib/AN00116-003-%20Flying%20shear.pdf>, april 2013
- [5] Flying Shear Position Control, <http://www.control.com/thread/1265720499>, discussion forum, april 2013
- [6] Motion tutorials, <http://www.galilmc.com/learning/tutorials.php>, april 2013
- [7] Logic controller modicon M238, manual, <http://www.schneider-electric.com/download/>, march 2013
- [8] Motion servo drive Lexium32, manual, <http://www.schneider-electric.com/download/>, march 2013
- [9] Variable frequency drive ATV312, manual, <http://www.schneider-electric.com/download/>, march 2013
- [10] 3S-Smart Software Solutions, Codesys manual, www.codesys.com/support-training/self-help/codesys-manual.html, april 2013
- [11] Motion Control, PLCopen organization, www.plcopen.org/, april 2013