PLC DRIVEN BAND SAW SHARPENER

Aleksandar Simevski, Goce Shutinoski

Department of Electronics, Faculty of Electrical Engineering & Information Technologies, Karpos II bb, 1000 Skopje, Republic of Macedonia, +389 2 3099 153, simevski@feit.ukim.edu.mk

This paper describes the automation process of a band saw sharpening used in the wood industry. More specifically, it focuses on the automation part of the machine which systematically, in a few steps sharpens each tooth of the saw, one by one.

When the authors confronted the machine and tried to bring it back to function (which was non-functional over 20 years), they found that it had non-functional PLC – programmable logic controller (the PLC was very old and its program was stored in an EPROM which was erased eventually).

This PLC supposed to drive four relays, which on their hand drive four 110V electro-hydraulic valves used for the actual sharpening. After systematical examination of the machine it was confirmed that the only non-functional part was the PLC, more exactly - the erased program from the EPROM.

Keywords: saw, tooth, sharpener, PLC

1. INTRODUCTION

In the wood industry, especially in larger companies which process the wood, before it can be used for manufacturing of the final products, there is need of big and powerful logging machines. These machines require various saws, rather circular or band. One specific machine that will be examined in this document is not a machine for logging, but for sharpening the saws for the machines which use them. This machine sharpens band saws, and these saws can be more than 8 meters in perimeter.

After a short review of the machine, we'll focus on the control electronics, the problems we dealt with, some of the solutions and results of our work.

The machine can sharpen band saws more than 8 meters long, as said, but it's actually a relatively small machine. It's 1.5 meters high, 0.5 meters wide and 0.5 meters long. The large saw stands on a special platform near the machine. Only the head of the machine positions over a tooth of the saw and sharpens it, and then automatically pushes another tooth for work-out.

The complete control of the machine is contained in the PLC which guides the execution of each step of the sharpening process, for each tooth of the saw. The steps are:

1. Push a tooth
2. Position the head of the machine over the tooth
3. Contract and squeeze the tooth from the sides (sharpening step 1)
4. Press the tooth from the front (sharpening step 2)

For each of these steps is responsible one of the four 110V electro-hydraulic valves ($V_1 - V_4$), which are driven by the PLC through four relays ($R_1 - R_4$).

The machine works in three modes:

1. Calibrate the head with the saw manually;

2. One tooth work-out;

3. Automatic work-out of all the teeth of the saw;

These work modes are controlled by two switches (S_1 and S_2) on the control panel, and they are some of the actual inputs for the PLC. Other inputs include a magnetic micro switch (Ms_1) used for counting the teeth, head position sensors (S_3 and S_4), and a start button.

To clear this out, the complete functional block-diagram of the machine is given in figure 1.
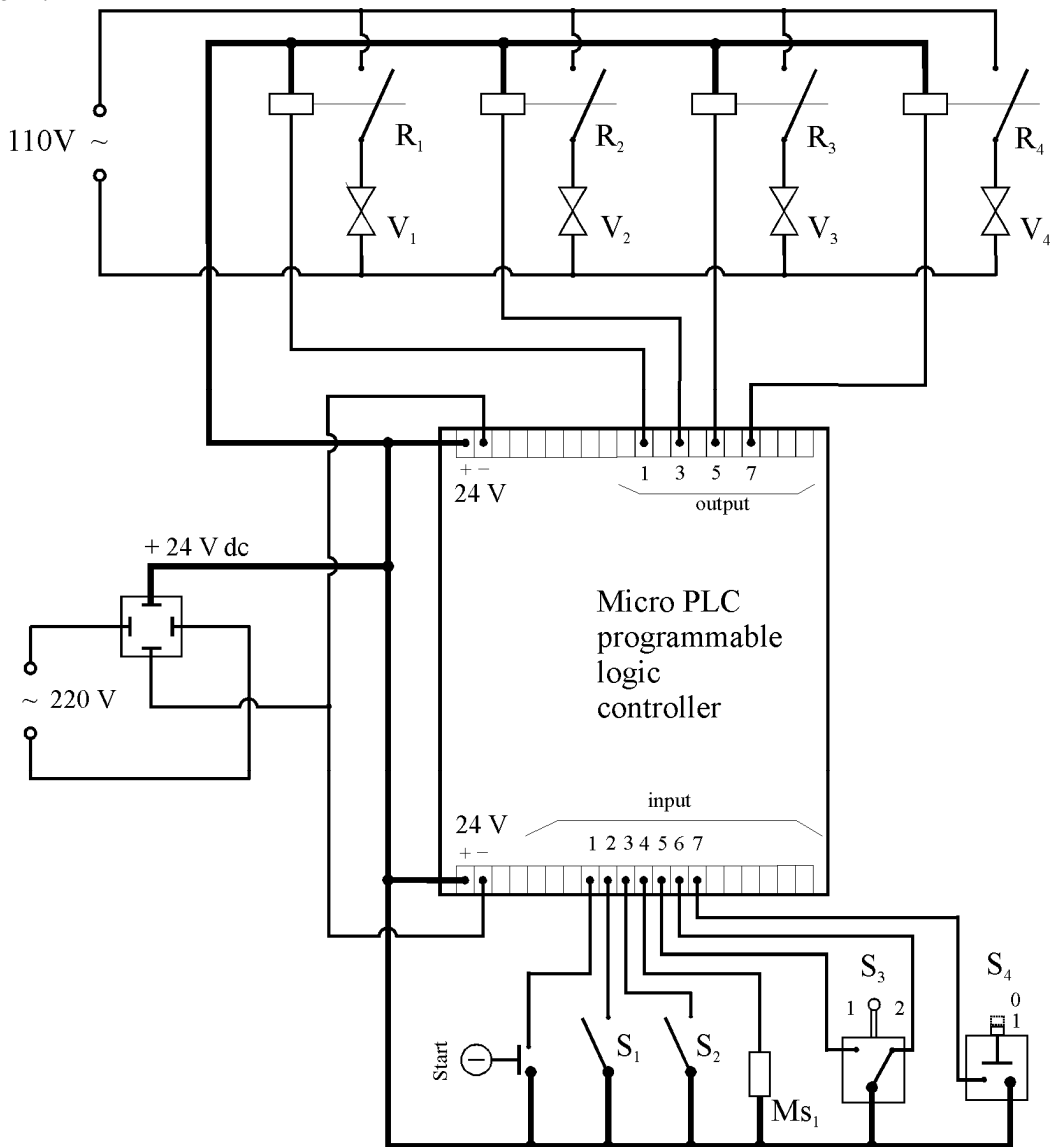

Fig.1 functional block-diagram of the band saw sharpener

After proper placing of the saw on the platform, the machine operator first calibrates the head of the machine with the saw (S_1 and S_2 are open). When she pushes the start button, the head goes down and stays there. Then she can calibrate the head. With the second push of the start button the head goes up, after calibrating the head with the saw.

Then, she can run a test to see if the machine will successfully sharpen the teeth by working-out just one tooth. (To run the test, she closes S_1, opens S_2, and pushes the start button). The machine will execute the four steps mentioned above automatically for one tooth.

If she is satisfied with the one tooth work-out, she can start the automatic mode of the machine for sharpening all the teeth of the saw. (To run the automatic mode, she closes S_1, and S_2, and pushes the start button). The machine will execute the four steps mentioned above for all the teeth of the saw automatically.

2. PROBLEM STATEMENT

The authors' task was to restart and bring to function this band saw sharpener which was non-functional. Thorough examination of the machine showed that the EPROM which holds the PLC program was erased. All its outputs (data lines) were high, regardless of the input (address line) combination. That's not unexpected, having the fact that the machine was not used more than 20 years. Fortunately, all other elements of the machine were functional.

Facing the problem and looking for solutions, the authors considered these facts:
- lack of documentation for the old PLC and the legacy EPROM
- familiarity with the functions of the machine
- the power and ease of use of the new cheap PLCs
- the desire to add new functionalities to the machine

These facts led to the decision to completely replace the old PLC with brand new Micro Jazz OPLC from Unitronics, reprogram it from a scratch, and add new functionalities.

This decision carried other smaller problems with it. For instance, the old PLC was powered by 24V ac directly from the transformer, the new PLC needed 24V dc. All these problems with the powering of the elements were overwhelmed. The only work left was programming the PLC.

The program for the PLC is of course directly dictated by the functions of the machine. It can be recognized three parts of the program, one for each of the modes of operation. These modes of operation are identified by the controller from the state of the S_1 and S_2 switches.

Considerations were taken for the multifunctional start button. This was solved with the use of a few memory bits. Based on the state of this memory bits the controller "knows" what the next push of the start button means. A part of the implementation of this technique is presented in figure 2.

For example, the first push of the start button, activates the valve for pushing one tooth. When the push is over, the MB1 bit is set which indicates that the next push of the start button means "position the head down". Then MB11 is set which means "position the head up".

Next, the authors considered that it's best to eliminate the sensors (Ms_1, S_3 and S_4) and integrate their function in the PLC through the use of timers. This is possible because every operation takes some defined time. With the old PLC, the finish of an

operation was indicated with these sensors. By measuring the time needed for every operation the authors set timers for indication of the finish of each one of them. The values set in the timers could be easily changed for optimal and fastest execution.
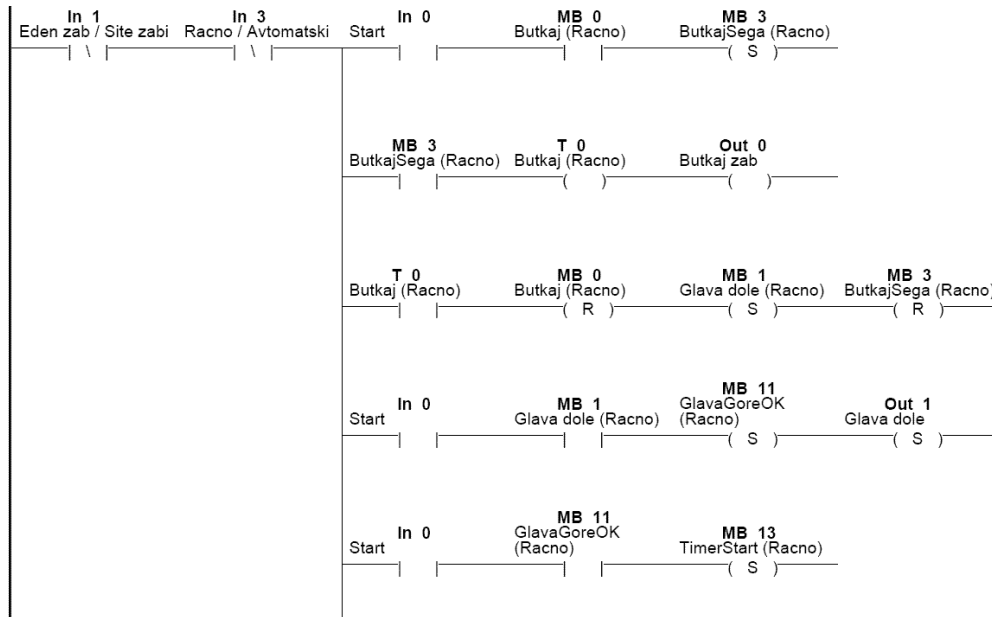
Fig.2 implementation of the multifunctional start button

Figure 3 presents a part of the solution which replaces the function of the sensors with timers. When timer 1 (T1) finishes counting down, it positions the head down (Out 1 is Set) – this is step 2 (step 1 is omitted in this description because of space limitations). This action starts another timer T2. When T2 finishes counting down, it contracts the head and squeezes the tooth (step 3). Along with this action, another timer T3 is started, and when it finishes counting, it executes step 4 – pressing the tooth from the front.
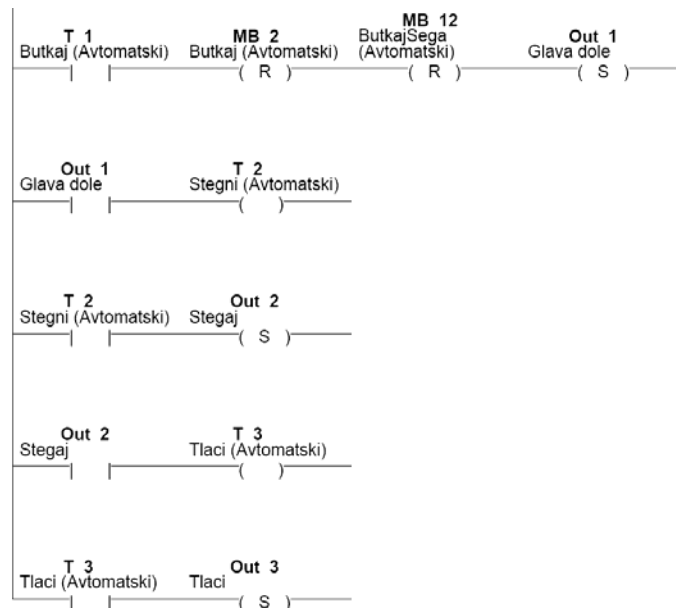
Fig.3   replacing the function of the sensors with timers

Another function which was added is teeth count. The old PLC had predefined number of 260 teeth, and after sharpening 260 teeth, the machine stopped working. Here this number is also predefined, but the operator can easily change it through the HMI (human machine interface) of the PLC to accommodate saws with various number of teeth.

Figure 4 shows the implemented solution. The tooth counter is implemented with two comparators, adder and an auxiliary variable MI 0 which holds the teeth count. When a tooth is pushed, the value in the MI 0 is examined. If it's smaller than #260 this value is incremented by one, the machine continues its work. If it's equal or greater than 260 the machine stops working, and MI 0 is assigned a zero value.
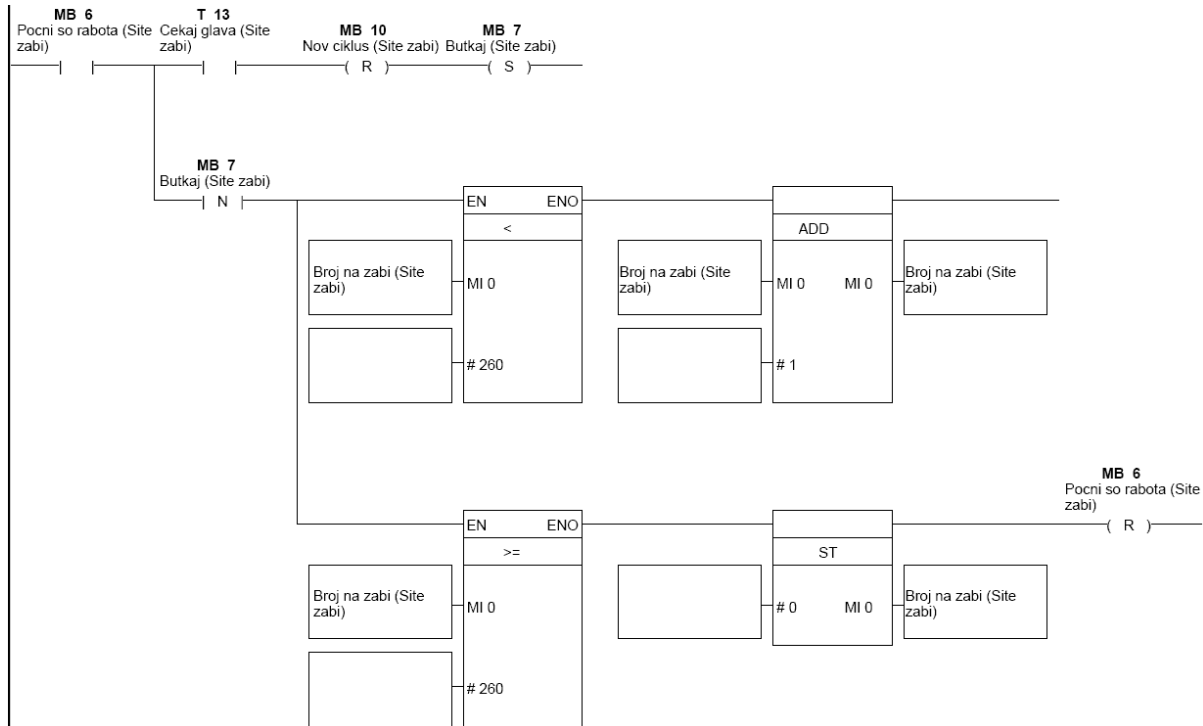

Fig.4   counting the teeth

3. RESULTS

This strategy of the authors worked well. The machine is now in full use, executing each step with precision, ticking like a clock.

We want to make some analysis of the speed of this machine. Let's consider the 260 teeth saw. Each of the four steps enumerated in the introduction take less than a second to execute. If we set each timer to one second, that means 4.5 seconds for one tooth work-out. (0.5 sec is the cumulative delay introduced by the machine). For all 260 teeth, 19.5 min. are needed. This cumulative delay is computed in the following manner: the time needed for all the 260 teeth work-out is measured. (That's 19.5 min divided by 260 equals 4.5 sec.) The sum of all timers is 4 sec, the 0.5 sec is the introduced delay per tooth.

With some analysis and trials, we can lower the timer values to 0.7 sec. for step 1, 0.8 sec. for step 2, 0.7 sec. for step 3 and 0.8 sec. for step 4. This means 3 seconds for

one tooth work-out plus 0.4 sec. cumulative delay equals 3.4 sec. Taking all the 260 teeth, it means 15 min. for the whole saw.

The datasheet for the machine with the original PLC says that the time needed for one tooth work-out is 5.5 sec, which is approximately 24 min for the whole saw. This means that we've gained significant speed-up of 9 min. besides the additional functions that we've added for variable teeth count and besides the fact that we're not using three of the sensors (but which function is embedded in the PLC). This also increases the life expectance of the machine.

4. CONCLUSIONS

Although this old machine is now fully functional and useful, a remaining challenge for the authors is adding a fourth work mode – automatic calibration of the head with the saw. For this mode we can use the unused combination of S_1 and S_2 when S_1 is open and S_2 is closed. If we can successfully encode this mode into a PLC program, we can also make the whole process work in the following manner:
1. Put the saw on the platform;
2. Start the machine by simply pushing the start button;
3. Wait for the machine to work-out all the teeth and stop itself;

5. REFERENCES

[1] Manuals for the Micro Jazz OPLC
[2] Manuals for the band saw sharpener