PNEUMATIC ACTUATION OF LASER BEARING ENGRAVING STATION

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ABSTRACT: The paper presents the design and construction of a laser bearing inscription station. The station is designed in a SolidWorks program, each mechanical component is draw in a Part file and late all components are assembled into a final drawing. The execution drawing of each element is thus transmitted for processing. What is important for carrying out the project, the pneumatic control elements are also generated in SolidWorks too, by the manufacturing company and thus their design can be used to complete the assembly. An important thing in the work was the simulation of the pneumatic circuit which allowed the choice of the components according to the program. The practical manufacturing of the project also required the realization of the electrical installation. The company makes specialized equipment and prototypes for automotive companies. One of the novelties was the use of the filter during the laser inscription to improve the ergonomics of the work environment.
KEYWORDS: bearings, laser engraving, pneumatic, filter, electric.

1. INTRODUCTION

The laser bearing engraving station is designed to automate the process of bearings marking. It aims to increase labour productivity and eliminate human error during the enrolment process. This station was designed and built for one of the top bearing manufacturers. The client currently uses a laser engraver operated by a worker. The operator takes the bearings from the washing system, and then inserts each bearing into the writer. He must position the bearing carefully, turn on the pen and, after finishing the operation, take it out and put it in a box. All these operations are performed manually and the productivity is between 80 and 100 bearings per hour. At the same time, due to operating errors, a small percentage of scrap also appears.

2. STATION DESCRIPTION

The overall dimensions of the new station have been designed so that it integrates perfectly on the production line between the washing-drying installation and the lubrication plant that the manufacturer already owns. It was also taken into account that the height of the conveyor belts should be the one indicated by the customer so that no further changes are needed to the pre-existing installations on the production flow, [1]. The basic structure (1) was made of rectangular steel profile joined by melt welding. The lower part and the lateral parts are closed tightly with metal sheet (2), being provided with access doors both in front and in the back. Above this frame an aluminium base plate (3) with a thickness of 20mm is fixed. An extruded aluminium profile frame (4) was fitted over it, also with access doors on which a plexiglass was mounted. At the top, the station is closed with a lid (5) made of aluminium sheet fixture on the base plate on which the writing unit (7) is mounted by means of rails. They allow the unit to be removed from the working position in the maintenance position, figure 1. The precise positioning of the marking head is done by means of fine adjusting screws. The laser unit used is Keyence and comes with the computer (14), the monitor (9) and the related software.

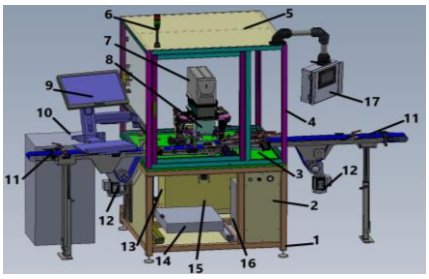

Figure 1. The component parts of a laser bearing engraving station

The minimum operating distance is obtained by inserting an inscription and exhaust chamber (8). It also has a protective role, not allowing light to come out of it. The smoke resulting from the writing is aspirated from here by means of a pipe reaching the filter unit (10). Two conveyor belts (11) engaged by electric motors (12) were also attached to this station. At the back of the station there is the pneumatic panel (13) and the electrical panel (15), and the entire lower cabinet is air-conditioned by the unit (16). The station also includes the pneumatic circuit with the six double-acting cylinders and also the electrical circuit. The station is operated using the control panel (17).

3. THE STATION PROGRAMMING AND OPERATION

To start the station, the block scheme is presented in figure 2, first open the compressed air valve, and then switch on the main power switch, both of which are located on the panels behind the station. There follows a short moment of loading the software after which the station will perform short movements making references, [2].

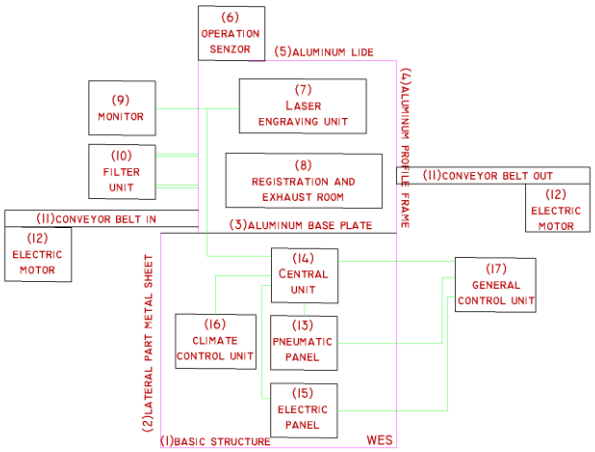

Figure 2. The block schemes

The programming and operation of the station is done in two stages, figure 3. The Keyence laser engraving unit is accompanied by a dedicated computer located inside the lower part of the station. For its stable operation, that area is tightly closed and in addition a small air conditioning unit has been installed in that space. A monitor and keyboard located on the right side of the station are used to schedule the recording.

Figure 3. The programming area of the data to be engraved

The programmer enters various data such as bearing diameters, bearing liner diameters, bearing thickness, arc size, font type, character intensity and engraving text. The program then simulates the inscription offering the possibility to make corrections or modifications. If everything fits, the program is saved being prepared for registration. On the other side on the left is another Siemens control panel with a touch display.

Figure 4. Siemens control panel with a touch display

On this board we also find some physical buttons: the Start / Reset (figure 4) button that start the whole burning process, the Stop button, the Start Equipment button that starts the conveyor belts and the Emergency mushroom button. From the touch screen choose the program you want to use and which is made and saved as shown above. Also here are introduced the data regarding the communication with the neighbour stations that ensure the supply, respectively the disposal of the lanes. Once all the settings have been made, the conveyor belts are launched from the Start Equipment button. The belts are made of PVC articulated by bolts so that in length it can be wrapped over the drive rollers, without deforming in width. This material is able to provide the necessary adhesion to transport the bearings but also to allow them to slide when they encounter an obstacle. Their edges are lined by Teflon profiles that prevent the bearings from falling off the belt. The belts are driven by two geared motors, figure 6. The next step is to start the work cycle using the Start / Reset button. At the left end of the conveyor belt, sensors 1 and 2 are located on both sides which confirm the presence of the bearing at the beginning of the belt.

Figure 5. Two geared motors

Their role is to send a signal to the PLC, which in turn communicates with the previous station (in this case the washer-dryer bearings) to order the release of a bearing on the belt only if there is empty space. This avoids overlapping the bearings. Once the bearing has been taken over, it will pass between sensors 3 and 4 which have the role of counting.

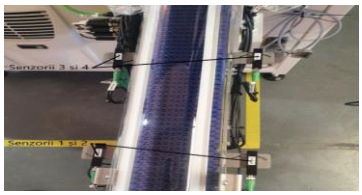

Figure 6. Conveyor belt

The bearing then advances until it meets the first cylinder's piston which is extended to the maximum over the belt forming a barrier. A sensor confirms the presence of the bearing and the PLC controls the solenoid valve for cylinder 2 by supplying it with compressed air. Thus, the piston of cylinder 2 will be pushed maximum forward separating the first bearing from the next bearings. Thus, the latter can no longer advance and will slide on the belt. When the position sensor on cylinder 2 confirms the extension of its piston, the PLC controls the solenoid valve of cylinder 1. This will open the supply of cylinder 1 through the front of the piston which will retract inside the cylinder, figure 7.

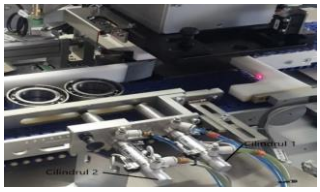

Figure 7. Piston and bearing presence sensor

In this situation the first bearing is free to be carried by the belt further until it meets the bracket L_1. Another sensor confirms that the bearing has reached the bracket L_1, and the PLC will control the solenoid valve of cylinder 1 resulting in the extension of the piston over the belt.

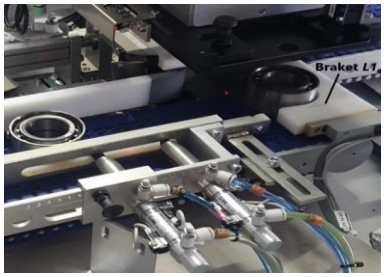

Figure 8. The L-shaped bracket L_1 is mounted on the piston of cylinder 4

The L-shaped bracket L_1 is mounted on the piston of cylinder 4, figure 8. As the length of cylinder 4 is limited by the space intended for mounting, it was decided to mount it on the piston of an additional cylinder 3. Summing the passage of the two pistons, the expected displacement was obtained. Thus, once the bearing has reached this position, the PLC controls the solenoid valves related to cylinders 3 and 4 which will open their supply resulting in the extension of the pistons and implicitly the movement of the bracket L_1 which pushes the bearing on the conveyor belt to the position set for engraving.

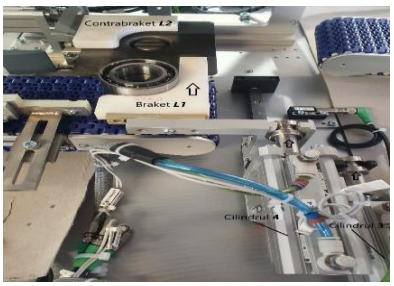

Figure 9. Contra-bracket and bracket

An L_2 contra-bracket of the same shape, mounted on the piston of the cylinder 5 at 180̊ from the first bracket contributes to the precise positioning of the bearing in the predetermined place for inscription, figure 9. For the precision of the movement of the two brackets actuated by the pistons, they are mounted on the rails by means of ball slippers, figure 10. In this position the bearing must be concentric with the hole of an interchangeable plate mounted. The confirmation that the bearing has reached the correct position is very important for the further development of the technological process.

Figure 10. Interchangeable plate

For this purpose, a new sensor has been installed to verify this, figure 11.

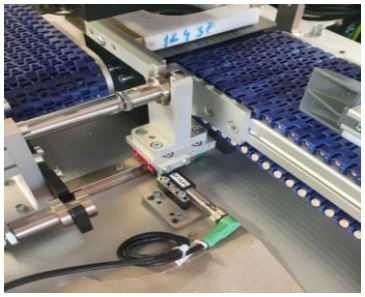

Figure 11. Bearing presence sensor

The plate is interchangeable depending on the size of the bearing because its hole has a diameter equal to the outer diameter of the inner lining of the bearing. Through this hole will come out a two-stage piece mounted on the piston head of the cylinder 6. It fulfils a double role: centring the bearing and pushing it up, figure 12.

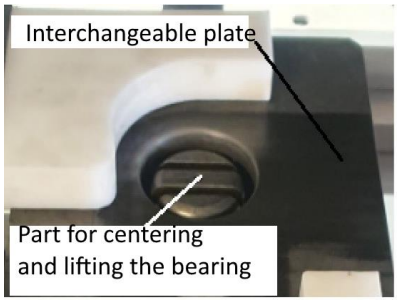

Figure 12. The plate is interchangeable depending on the size of the bearing

Having confirmed the correct position of the bearing, the PLC will control the solenoid valve corresponding to cylinder 6 (figure 13) which will open the circuit to this cylinder (mounted under the interchangeable plate) and its piston will push the bearing upwards through the stepped piece. Thus, the bearing is fixed on the lower plate of the inscription chamber. This plate is also interchangeable depending on the dimensions of the bearing, being provided with a hole with a diameter equal to the outer diameter of the inner lining of the bearing. The pressure in this cylinder keeps the bearing in contact with the housing throughout the inscription, also ensuring a seal, so that the laser light and the resulting smoke do not come out.

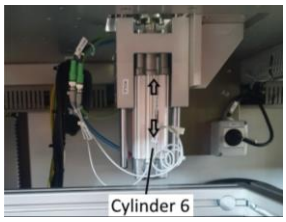

Figure 13. Solenoid valve corresponding to cylinder 6

Another sensor (figure 14) confirms the new bearing position and the PLC commands the actual inscription to start. This is done by scanning the laser beam on the x and y axes operation controlled exclusively by the computer of the Keyence recording unit. The smoke emitted during laser engraving is sucked from the inscription-exhaust chamber through a hose connected to a Purex suction and filtration unit behind the station. After inscription, the PLC controls the solenoid valve of cylinder 6 which opens the reverse supply of the cylinder so that the bearing descends to the table.

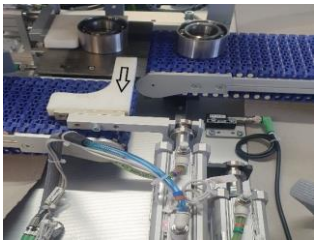

Figure 14. Sensor confirms the new bearing position

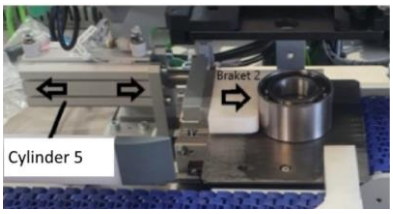

Figure 15. The solenoid valve for cylinder 5

Once a sensor confirms that the bearing has been lowered, the PLC controls the solenoid valves for cylinders 3 and 4 which will be fed backwards and their pistons will retract the bracket L_1. After the complete retraction of the bracket L_1, which is confirmed by the stroke sensors mounted on the cylinders, the solenoid valve for cylinder 5 (figure 15) opens the supply of this cylinder and its piston will push through the contra-bracket L_2 the bearing on the second conveyor belt driven by the other engine.

Figure 16. Inscribed bearing

At the end of the second belt the inscribed bearing (figure 16) is delivered to the lubrication station. This is a bearing engraved during the operation tests before the delivery to the beneficiary.

4. THE COMPOSITION OF THE PNEUMATIC CIRCUIT

The main parts of the pneumatic circuit are: pneumatic panel, connecting elements, hoses for compressed air circulation, cylinders, drossels and manometers, [3]. The pneumatic panel (figure 17) consists of: Preparation group, Valve Island with Profinet communication and Exhaust part.

Figure 17. The pneumatic panel

The first element of the preparation group is a 3/2 red valve with two positions and three ways VSH SNC 20 F02. In the open position it allows the upstream pressure to enter the station, and in the closed position it allows the pressure to escape from the internal

circuit. This is followed by a regulator filter with automatic close purge AW20-F02C equipped with an analogy pressure gauge. The next element is a valve with progressive opening of the flow with solenoid valve (coil) AW2000-5DZ-F02.

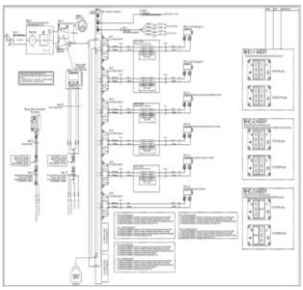

Figure 18. The pneumatic diagram of this station in detail

This station is designed to operate at a pressure of 5 bar. The valve island consists of an 8-position manifold AN SNC 08 AN20 F02 on which were mounted 6 solenoid valves of SY5300 5UDU type, one for each cylinder and two compensating elements that were armoured. The solenoid valves are 5/3 closed centre and their supply and exhaust are done in a common way. The control part communicates with each solenoid valve via Profinet technology. The logic control part is provided by the PLC. The exhaust part consists of a sound absorber general exhaust composed of several cells that have the role of eliminating the noises characteristic of the air exhaust. The cylinders are double-fed which means that when they are fed through the back of the piston it will be pushed outside the cylinder, respectively inside when the supply is made through the front. Electromagnetic limit switches were mounted on all cylinders. Cylinders 1 and 2 are of the CNS type CD85E16-25B. Cylinders 3, 4 and 5 are of the CNS CD55B32-80M type and cylinder 6 is of the CP96SDB32-80C type, figure 18.

4.1 The electrical panel

The electrical panel (figure 19 a) is located at the back of the station and from here all the electrical circuits start.

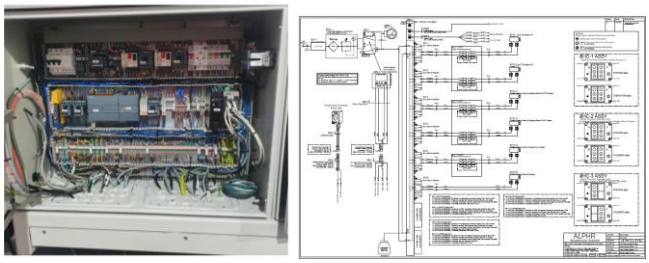

Figure 19. a) The electrical panel, b) The electrical scheme

The main components of the electrical panel are: The main switch, although mounted inside, can be operated from outside the switchboard by switching on or off the mains, Main safeties fuse with differential, Contactors, Phase control relays, Thermal protection for motors, Automatic fuses, 24 V power source, the logic programming controller known by the abbreviation PLC and Terminals, the electrical scheme is presented in figure 19b.

4.2 Filtration plant

The smoke is emitted during laser engraving, for this smoke not to alter the air,

Figure 20. Filtration plant

the marking chamber was connected to a filtration system by means of a hose, the Purex filter (figure 20).

5. CONCLUSIONS

Using the new bearing inscription station, the customer wants to completely automate his production line by placing it between the washing and greasing installation. It will also ensure the transport of bearings between these phases, being provided with two conveyor belts. Once adjusted, the station will operate automatically without the need for an operator. As a registration capacity, the new station will mark between 500 and 600 bearings per hour, depending on their size. A team of 19 people from 8 departments contributed to the construction of this bearing engraving station. The total working time until the time of the final rehearsals was 1258 hours and took place over 59 days. References

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