Reliability Analysis and Automation of the Equipment for Pressing Axial Bearings in the Gearboxes

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Abstract: *This paper aims to highlight the development of industrial modernization of a simple process: the pressing of axial bearings in the gearboxes, which is a crucial step in the assembly process, as it ensures that the bearings are securely fitted and able to withstand the forces that will be applied to them. In the past, this task was performed manually, which was time-consuming and prone to errors. However, with the development of industrial modernization, new methods and technologies have been introduced that make the pressing process more reliable and efficient.*

Keywords: *Axial bearing, gearbox, mechanization, electronic drives*

1. Introduction

Press-fit is an operation whereby a shaft-type part and a bore-type part are brought into the physical state where clamping forces occur between them, to cause the assembly to lock together. Bearings are used to restrain parts that perform rotating or oscillating motions. The following steps must be considered when fitting them:

1. Select the bearings and the other components of the assembly according to the size and the force applied to the assembly.
2. Check the symbolization (radial and/or end shields).
3. Check cracks and bearing.
4. Ensure that the elements to be assembled are correctly positioned.
5. Actual mounting of bearings.
6. Check the clearance, insertion of the shaft into the bearing housing and fitting of the covers.

Manual assembly of an axial bearing inside a gearbox is carried out by an operator or worker and consists of carrying out the assembly operation by hand, without the need for tools. Usually, the parts to be assembled in this way have clips in their construction so that they can be easily pressed or the assembly between the bore and the shaft does not require great pressing forces. Even if it implies low process costs, it comes at the price of low reliability and low process repeatability, and even assembly errors [1-5].
The mechanization of the assembly process aims to replace manual labour with machines, apparatus, stations, tools and mechanisms, etc., to be able to carry out some operations, with the worker being responsible only for adjusting and controlling the action of the machines.
In assembly work, simple mechanization is carried out using tools, devices, and stations, which make work easier or even replace it. It has the advantage of ensuring high productivity and better-quality work carried out. Complex mechanization consists of the introduction of assembly lines on which actual assembly work but also preparatory, auxiliary or finishing work is carried out.
The automation of a process is defined as the installation of devices to ensure that assembly operations are carried out without operator intervention. As the degree of automation increases, so does the need for sensors and actuators (Various types of local networks have been created to communicate between them). To have high-speed connections, closed local systems have been implemented in some facilities, which work for real-time signal processing without delays [4-7].

The operator must be sufficiently and timely informed without errors to make the right decisions. The control panel must be easily accessible and intuitive for easier understanding [8].
Following the results of the research on the state of the art, it has been found that automated operation is the most reliable and improves the pressing process.

Fig. 1. Mechanised vs automated (pneumatic) bearing pressing station

As safety methods, compliance with all rules is an important condition for creating safe machines and systems [9].

2. Material and methods

The most reliable solution analysed was the fully automated one, using a fully autonomous system and with exceptional results provided by Kistler.
It consists of a servo motor assembly with an electric motor connected to a precision ball screw. Inside the assembly, there are a piezoelectric force sensor and a distance sensor.

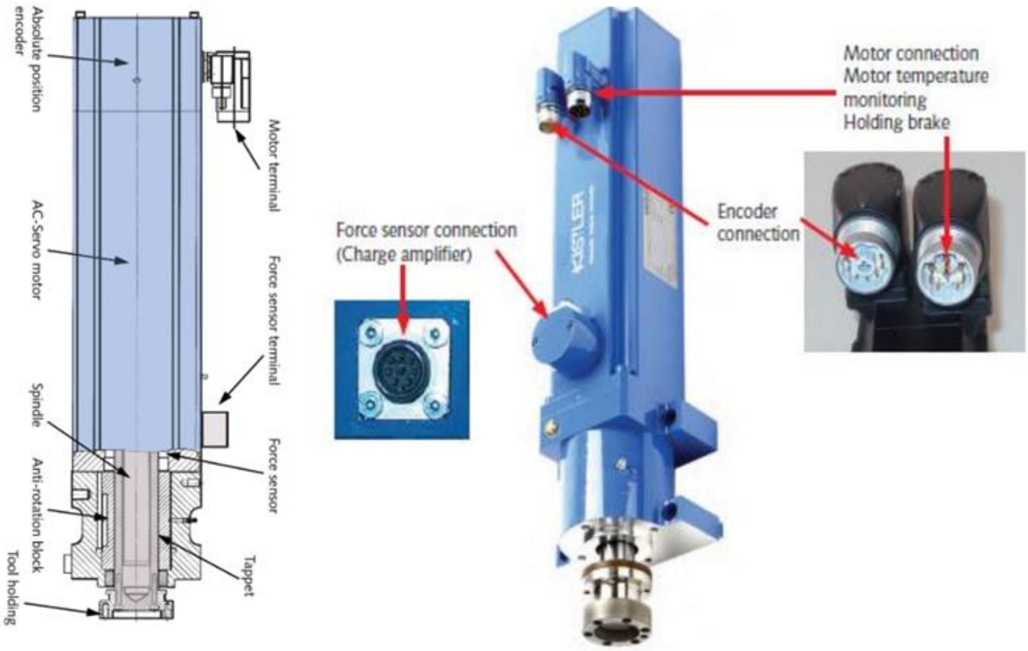

Fig. 2. Kistler pressing system

User communication is via the maXYmos communication interface, which is a PC unit that links the PLC of the station with the control drive of the servo press.

The signals received from the force and distance sensors are interpreted by the interface, and by using user-created pressing windows the system decides whether the pressing process has been performed under the conditions imposed by the user.

Fig. 3. maXYmos communication system

The drive is based on the tubular shaft motor principle. The extremely compact design means that the screw drive passes through both the force sensor and the drive motor.
A specially designed servo motor with high dynamics drives the ball screw, so that the rotation is converted into a forward motion through the integrated ball groove.
The force sensor can absorb compression and tension forces; thus, joining processes with subsequent tensile testing are possible.

3. Results

The pressing process will be determined by the operator (positions, displacement speed rates ...). With integrated process control in the maXYmos NC (fig.3) monitoring and evaluation system, the pressing process is controlled according to the machine and the PLC of the plant.
For this purpose, the pressing sequences (e.g. movement of the press into working position, speed rates, etc.) are parameterized for the pressing process in the maXYmos NC type 5847A monitoring and evaluation system.

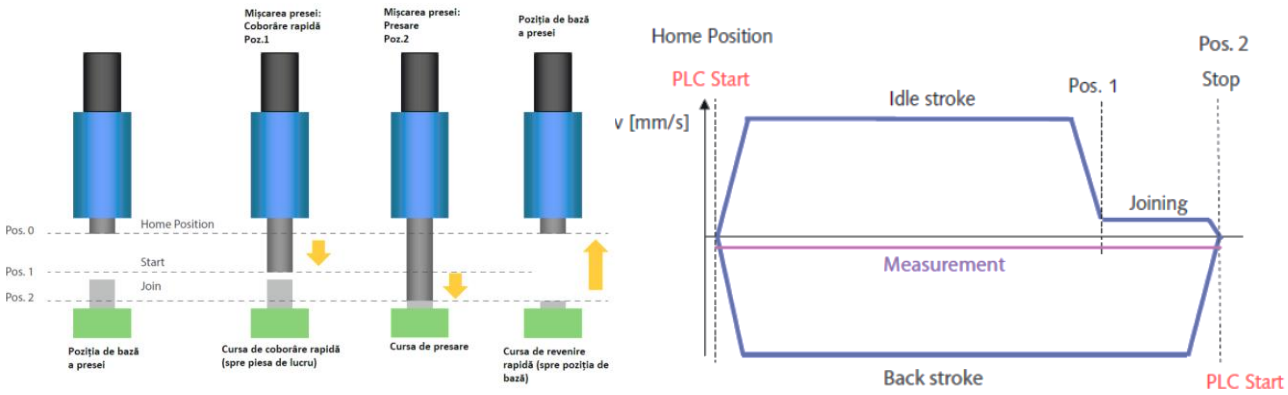

Fig. 4. Diagram of the pressing process

The PLC starts the sequence in "sequence" operating mode. The required speed reduction to the end of the pressing stroke is performed by triggering an error and is reported by the monitor. Now the PLC can start the return stroke to ‘home position’.
Position 0 represents the place of the press that is located at 0 mm, i.e. the press is in the ‘home position’. This position is not editable in automatic operation but is editable only following a repair; the servo press encoder must be taught-in with its mechanical position.
Position 1 represents the distance to which the press descends at full speed (up to 76mm) and from here the pressing process starts at a slower speed until it reaches position 2 (80 mm - maximum pressing point). The measurement process follows and the data is sent to the maXYmos

(maximum pressing force and distance) PLC, and following the pre-set graphs, the measured data are compared; they must correspond to the pressing process data (figure 5). At this point, the maXYmos PLC sends a response to the PLC of the station whether the pressing process has been completed successfully or the part resulting from the process is scrap.

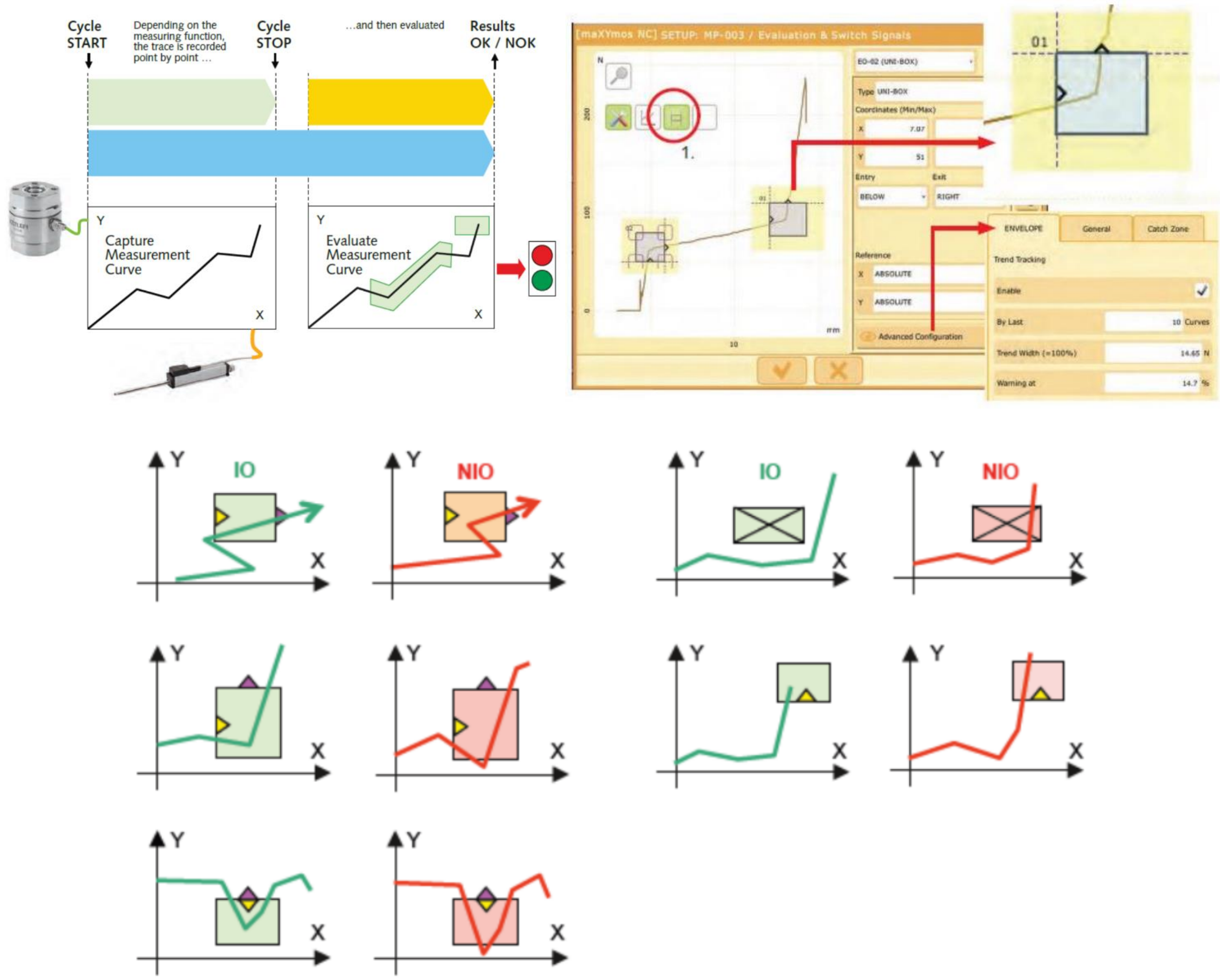

Fig. 5. Scheme of the pressing process evaluation

In the graph on the left, one can see the pressing force and distance, and in the graph on the right, the results are interpolated over the reference values of pressing. If the results of the pressing do not fall between the set limit values of the reference graph, the pressing result is NOK (NOT OK), and the pressing was not performed properly.
Catch zones are positioned around a particular EO (programs) in different ways, depending on the specified input and output configuration. When the EO configuration is complete, tap the "Show catch zone" button (see figure 5). The catch zones now appear on the graph as yellow areas.
ENTRY and EXIT process values are caught when they intersect BOX lines defined as the input and output sides and from there along their extensions (marked with broken lines) to the boundary of the catch zone.
The process values for the vertical reference lines will be Y values, and for the horizontal lines will be X values.
The measurement curve shall enter once through the specified input side and exit once through the specified output side. Any part can be specified as an input or output part.
The first point at which the curve crosses the boundary of a box is the input event, and the next to intersect a box boundary is the exit event.

How UNI-BOX process values are delivered depends on the configuration used. The best way to view them for a particular EO is by selecting Process View, Value table. These process values can either be subsequently displayed in the PROCESS value table or transferred via the Fieldbus.

INPUT - Process value

This is caught at the point where the curve intersects the first box line designated as the INPUT side and from there to the boundary of the catch zone (the extended input line). A value will only be generated if an input side has been defined.

EXIT - Process value

This is caught at the point where the curve intersects the first box line designated as the EXIT side and from there to the boundary of the catch zone (the extended exit line). A value will only be generated if an exit side has been defined.

Fig. 6. Pressing station after modification/ Port bearing piece/ Starting and ending of the pressing process

4. Conclusions

- The new pressing concept has meant major changes in terms of station reliability, quality and safety of the pressing process. Analysis results prove that the process has been improved.
- From the point of view of plant maintenance, the maintenance of the equipment is very easy to carry out, as the system is a simple construction.
- Preventive maintenance (checking visual, greasing and functional checks) can only be carried out by maintenance staff with the help of instructions and maintenance plans from the equipment supplier.
- While automation may require a higher initial investment, it can save money in the long run by reducing the need for labour and increasing the output of the assembly line. Automated systems are also flexible and can be easily adjusted to handle different types of parts or assembly tasks.
- In summary, the use of automation in the assembly process can improve the reliability, repeatability, and quality of the final product, while increasing productivity and efficiency. While it may require a higher initial investment, the long-term benefits of automation make it a worthwhile consideration for any company looking to improve its assembly process.

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