PROCESS MONITORING FOR DEEP ROLLING IN THE SERIAL PRODUCTION

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ABSTRACT

While deep rolling as a method for fatigue enhancement is a well established process in the automotive and aerospace industry, process safety becomes a more and more important issue for companies using this technology.

As deep rolling parameters have a great influence on the components fatigue life and strength, an inaccurate process may cause premature failure and lead to damage or accident. Therefore ECOROLL and the Laboratory of Machine Tools and Production Engineering (WZL Aachen) developed tools with integrated sensors and software for monitoring the deep rolling process. The software can be adapted to almost any process setup and tool. Triggers and tolerances can be modified through a large number of parameters. Any possible process failures can be detected and parts being treated inaccurately are indicated.

KEYWORDS

Fatigue, Deep Rolling, Process Monitoring, Software, Tools

INTRODUCTION

Today deep rolling is a proven process for fatigue enhancement. The process is applicable to many security-relevant components in the automotive and aerospace industry, for example steering knuckles, turbine shafts or landing gear components. An inaccurate application of the process can lead to severe accidents by premature failure in the service life of that part. The deep rolling parameters have a significant influence on the near-surface zone properties of the treated work piece. Mistakes during NC-programming, tool wear or damage can easily lead to malfunctions in the deep rolling process.

As the near-surface zone properties after deep rolling are not easily measurable in a high volume production and the available measuring methods are destructive, i.e. indepth residual stress measurement or fatigue testing, process monitoring is of special interest for the deep rolling process.

TOOLING

Two different kinds of tool types are common for deep rolling: mechanical (spring loaded) tools and hydraulic tools, especially those combining hydraulic force generation with a hydrostatic borne ball as rolling element. By introducing sensors in the deep rolling tools and their attached hydraulic units process monitoring is made feasible.

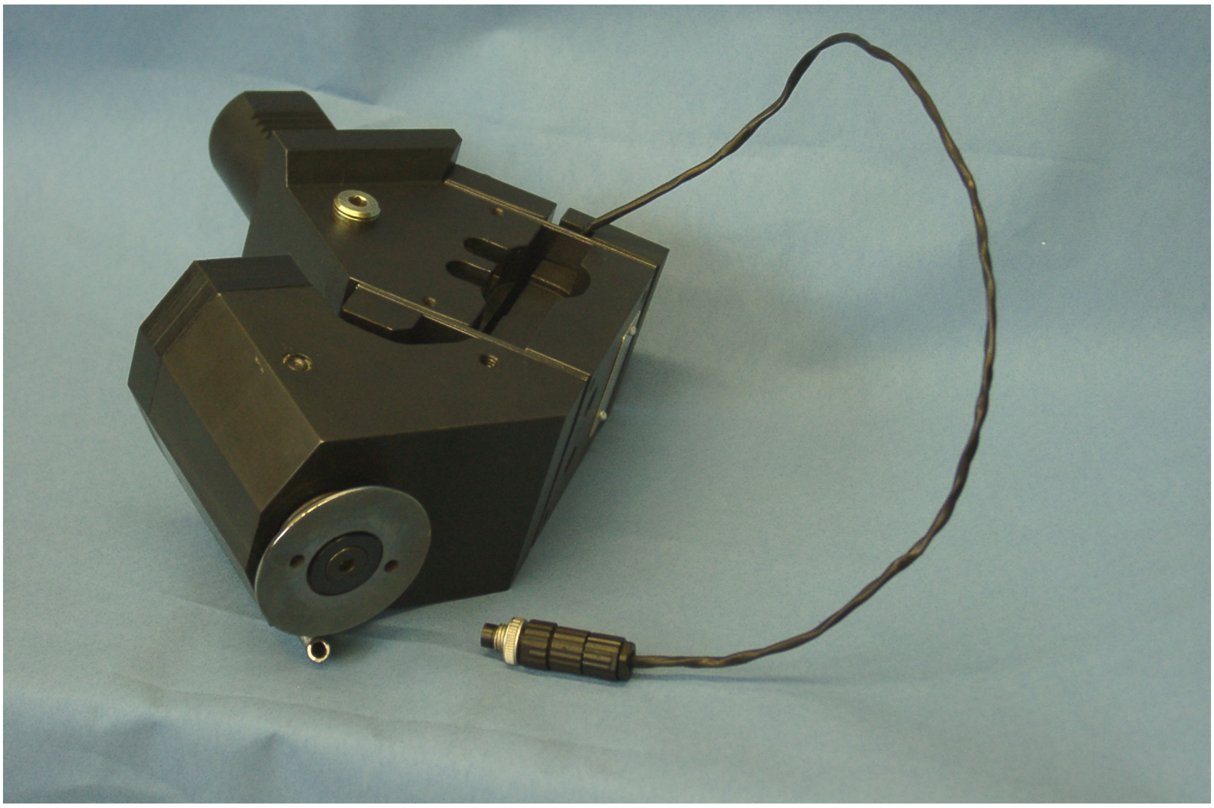

Fig.1: Spring loaded rolling tool with integrated sensor

For spring loaded deep rolling tools this is done by measurement of the rolling force, either by measuring spring displacement or strain directly in the spring through integrated strain gauges (Fig.1). Through a telemetry unit the signal can be transferred from a tool turret to the machine tool or a PC. Through the same way the power is supplied to the sensor. For hydraulically loaded deep rolling tools a pressure transducer provides the necessary signal. In deep rolling tools with hydraulic rolling force generation and hydrostatic borne rollers the measurement of pressure and flow can guarantee a safe process. Here the flow measurement indicates the correct work of the hydrostatic bearing. Low flow for example may indicate contamination in the fluid and as a consequence a clogged throttle. It may also indicate wear in the pump

which might cause a decreasing pump output. Both would lead to incorrect rolling conditions at the work piece surface.
These or more signals can be monitored either with a display or through a special software. Only monitoring the most important parameters during the deep rolling process can guarantee constant part-properties for each part in the manufacturing process.

PROCESS MONITORING SOFTWARE

ECOROLL and the Laboratory of Machine Tools and Production Engineering (WZL Aachen) developed deep rolling tools with integrated sensors and a software for process monitoring, especially for the deep rolling process.
The software can be used for all different kinds of process layouts, both for mechanical (spring loaded) and hydraulic/hydrostatic tools. The software monitors and provides documentation for each manufactured part. Each process-run is compared to a previously recorded master process, which is declared as an OK-process with certain tolerances. After each deep-rolled part the software indicates an OK or NOT-OK process.
The software can be adapted to many different kinds of process layouts through a large number of parameters, for example different kinds of triggering and tolerances for each signal.
A typical process is shown in figure 2.

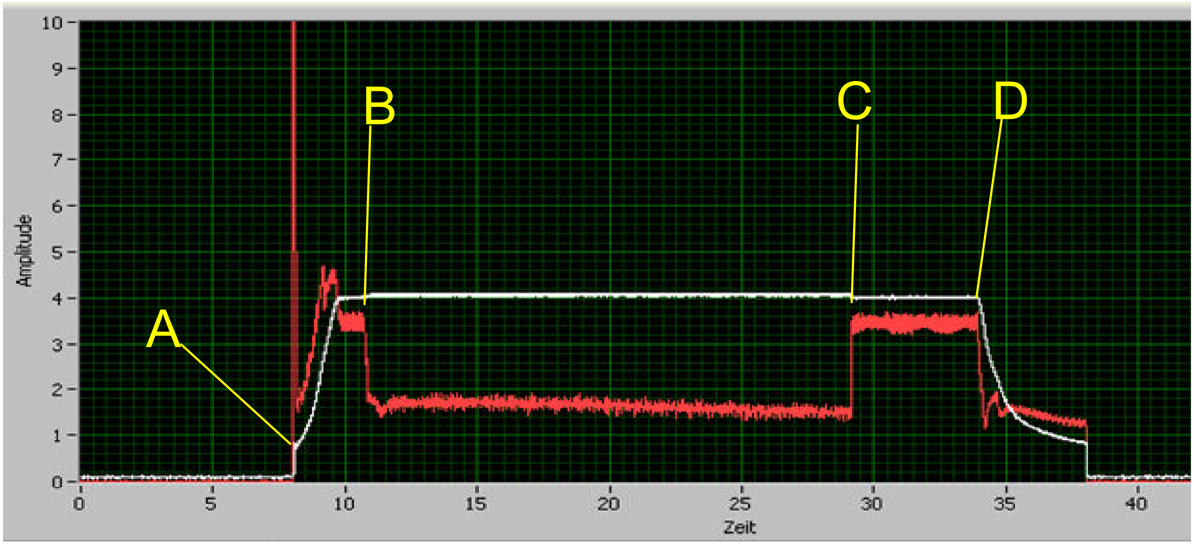

Fig.2: typical process using a hydrostatic deep rolling tool (pressure – white; flow – red)

The signal shows switching on the pump at point ‘A’, followed by a pressure increase, which can be used as a start trigger for the program. At Point ‘B’ the tool touches the surface and the ball is pressed into the bearing which leads to a decrease in flow. At point ‘C’ the deep rolling process is finished and at point ‘D’ the

pump is switched off. Turning the pump on and off must be done repeatable in each run and is usually done through the CNC.
After this signal is recorded, start and end trigger and tolerances are defined, serial production can begin.
For each part the program records the signal curve and saves it to a file. At any later date this file can prove that a part with a certain serial number or which was manufactured in a certain period of time was deep rolled with the correct parameters without any faults.
If a fault is detected the software may stop the process and inform the user.
Figure 3 shows the program in the mode for serial production.

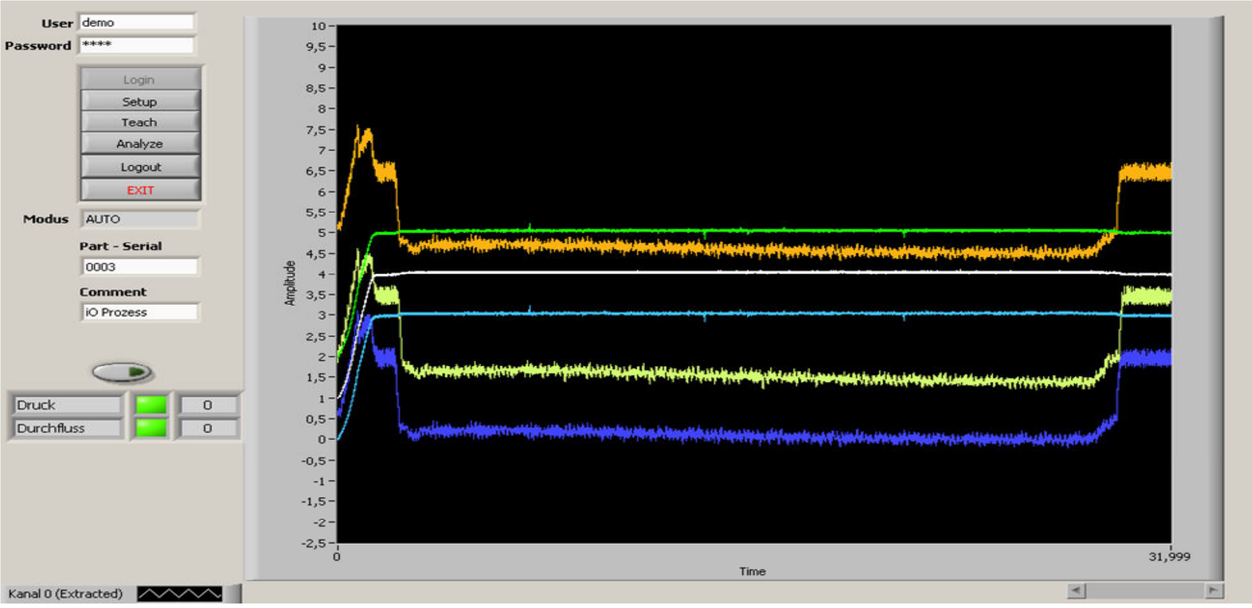

Fig.3: Screenshot of monitoring software in serial mode

The picture shows the flow and pressure curve including upper and lower limits. These limits are defined through the “teach curve”, which is the reference curve for the following process turns. If the signal crosses the limits the program informs the user.
Figure 4 shows such a case where a pressure drop occurred during the process.

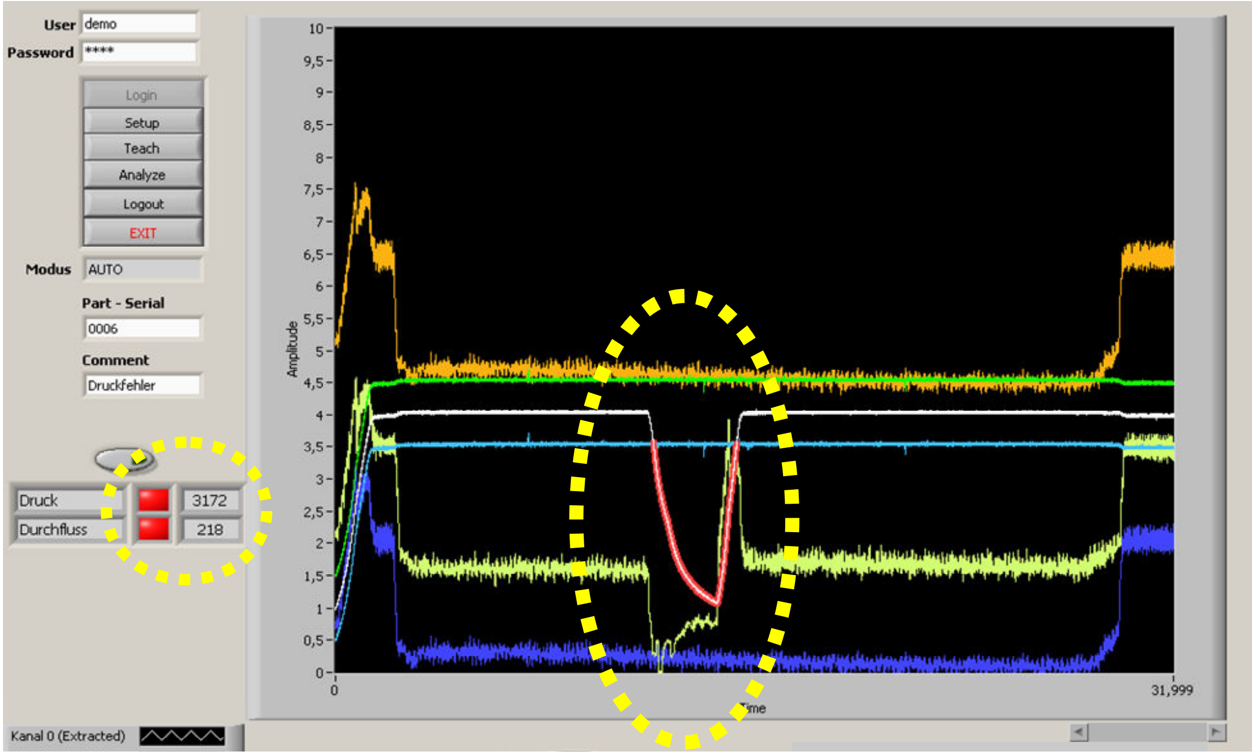

Fig. 4: Screenshot of monitoring software in serial mode showing a pressure drop

The interference with the lower limit is shown with red dots. Moreover the “lights” on the left side turn red and indicate the number of points which are outside the limits. These values can be used to evaluate if this is a severe failure in the process or still acceptable. Process failures such as a pressure drop would also cause a switch to be activated which can be used for stopping the machine tool and the process.

So the program can reduce the number of scrap being produced by alarming the user at a very early point.

CONCLUSION

By introducing sensor technology and a software package for deep rolling this process can be made safer and more reliable. Constant part quality can be guaranteed while rejected parts due to deficient surface treatment are reduced to a minimum. Adapting sensors and hardware to existing processes is easy especially for hydrostatic tool setups.