Monitored gas springs

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In order to control a process, it is necessary to constantly monitor it and thanks to the progress in data mining, it is now possible to continuously evaluate the information collected by the sensors. By monitoring the gas springs, not only can you have control over the effort that these elements are making, but you can also use this information from the sensors to optimize the process and reduce the effort of the gas springs to the optimal point where the piece comes out well and not so much energy is spent on moving the press, or by redesigning the die if it is detected that a gas spring is heating more than the rest because in one of the same loads are occurring with a lateral component. The recording of the information allows an *a posteriori* analysis of the die behavior in case of having detected any incidence in the stamped parts. In this way it is possible to know if the gas spring variables were within the acceptable operating limits and the problem has come from another point, or on the contrary, the operating limits must be redefined to prevent the incident from recurring.

Keywords: Gas Springs; Monitoring; Sensors.

1. Introduction

In the realm of contemporary metal sheet hot forming technologies within the automotive sector, gas springs emerge as indispensable components for regulating forces. Conventionally, the monitoring of gas spring integrity involves integrating them into a control system alongside pressure gauges, enabling real-time assessment of gas pressure across the interconnected gas springs network. However, this methodology is not without its limitations: susceptibility to system-wide depletion due to leaks in cylinders or conduits, limited accessibility to pressure gauges during press operation, and an over-reliance on pressure centric metrics.

The consequences of reduced pressure within gas springs are multifaceted, leading to the production of defective parts requiring rework or scrapping, thereby incurring significant costs inherent to hot forming processes in the automotive industry. The overarching objective thus revolves around identifying optimal variables conducive to assessing gas spring performance and devising precise measurement methodologies.

2. Sensor design

Gas springs are commonly used in stamping processes, especially in the automotive industry, where high elastic forces are required for sheet metal forming. Gas springs can develop a great effort in a small space, which makes them highly valued elements in the design of dies, but at the same time this reduced space makes it difficult to integrate any

Y. Zhang and M. Ma (eds.), *Proceedings of the 7th International Conference on Advanced High Strength Steel and Press Hardening (ICHSU 2024)*, Atlantis Highlights in Materials Science and Technology 3,
https://doi.org/10.2991/978-94-6463-581-2_70

measuring device inside. Therefore, the first challenge was to design a sensor so small that it could be integrated into as many gas springs as possible.

The sensor components are:

- Ceramic sensor for pressure measurement,
- Thermistor for temperature measurement,
- Signal amplifier for measuring elements,
- Analog signal to digital signal converter. The RS-485 interface has been adopted for the digital signal.
- Connector for information communication.

The technical characteristics of this sensor are:

- Pressure measuring range: 0 - 60 MPa.
- Temperature measuring range: -10ºC - +125ºC.
- Small size. For this purpose, the service thread is removed, and the pressure seal is made directly on the pressure measuring element.

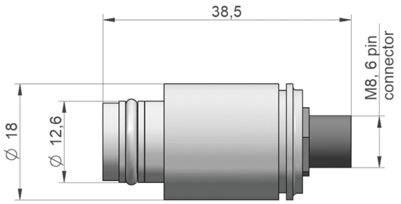

Fig. 1. Dimensions of the sensor (in mm.).

This sensor is designed to be mounted inside the gas spring, so that it makes the pressure and temperature measurements in the closest possible area to where the variation of the physical phenomenon occurs, and also so that the gas spring itself protects it from the environment.

3. Temperature Measurement

Measuring the temperature inside the gas spring will give us information on whether the gas spring is having a malfunction and therefore its temperature is higher than normal (compared to the rest of the gas springs) or on the contrary its temperature is lower because it has lost pressure (although the pressure measurement will also give us that information).

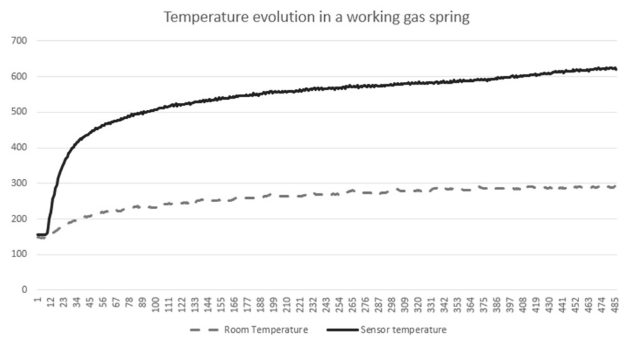

Fig. 2. Graph about the temperature evolution in a working gas spring. Ordinates: Temperature in ºC*10. Abscissae: temperature captures, every 90 seconds.

The graph of the temperature in a gas spring over time during its work usually presents two phases: a first phase where the temperature rises rapidly, and a second phase where it grows very slowly and asymptotically approaches the equilibrium value (the heat dissipated by the gas spring is equal to the heat generated due to its work).

4. Pressure Measurement

The main parameter of gas springs and thanks to which the working characteristics of the gas spring are achieved, is the pressure. The force developed by the gas spring is the product of the gas pressure by the effective working section of the gas spring, so that, knowing the gas pressure, we indirectly know the force that is developing at each moment.

Gas springs are devices charged with nitrogen gas at a typical pressure of 150 bar. When compressed by the external stress of the press, the pressure of the gas inside the gas spring increases, and thus also the force exerted by the gas spring. In each press working cycle (stamping of each part), there is an increase of pressure inside the gas spring and its subsequent expansion. In addition, due to the continuous work of the gas spring, the gas spring heats up and so does the gas contained inside it, which causes the gas pressure to increase as a result of this heating (and as already mentioned, as the pressure increases, the force exerted by the gas spring increases).

The frequency of data capture will depend on the work process that the gas springs have to perform. For fast duty cycles, where the press moves at high speeds and frequencies to stamp the highest number of parts per minute (cold stamping), the data acquisition rate has to be high (around one piece of data every 100 ms.), while in applications where the press has to move slower to ensure, for example, part tempering, a lower data acquisition rate is acceptable. A higher data acquisition rate means higher power consumption by the sensors and communication electronics, and more data storage space on the disk.

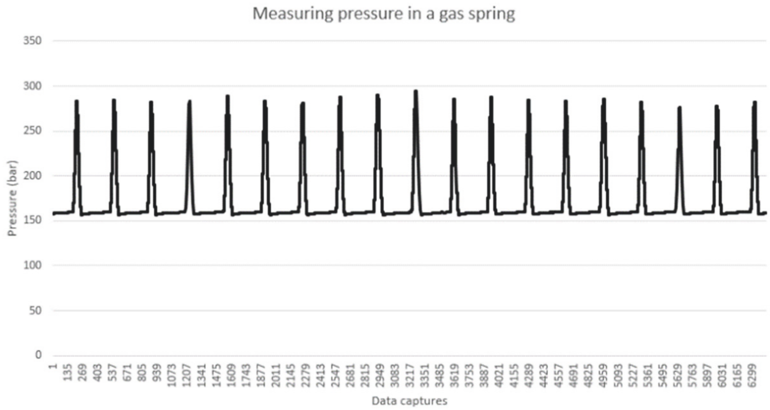

Fig. 3. Graph about the pressure evolution in a working gas spring. Ordinates: Pressure in bar. Abscissae: pressure captures.

From the observation of the graph, it is interesting to note the effect that the press working speeds have on the gas pressure. In the graph it can be seen that after each work cycle (peak of the graph), the pressure drops slightly below the initial pressure value, and this is due to the fact that the speed of the press in the backward movement is usually faster than in the downward movement, and this causes the gas to remain colder than initially due to the rapid expansion. After a few seconds you can see that the gas warms up and returns to the pressure values it had at the beginning of the previous cycle.

Continuous measurement of the pressure in the gas springs by installing a pressure sensor on each gas spring can provide valuable information about its operating condition:

- Detection of a pressure loss - force loss - in a gas spring. The manufactured part can be checked to see if the pressure loss is affecting the quality of the part. If it affects part quality, stop production, and do not manufacture defective parts, and recharge or replace the gas spring. If it does not affect, continue production, and monitor its pressure, and make a more rigorous inspection of the stamped parts.
- By identifying the pressure of each gas spring, maintenance knows exactly which gas spring has the problem and only the problematic element is disassembled from the die and replaced.
- In case of a problem with a stamped part, the data of the individual gas springs can be subsequently analyzed to rule out that the problem is caused by them if the parameters are within acceptable limits.
- Production optimization. By individually controlling the pressure of each gas spring, minimum pressure thresholds can be set for each gas spring position, so that the press operates with the lowest effort necessary for the correct production of parts (and lower energy consumption).

5. Conclusions

By sensing gas springs used in hot stamping processes it has been possible to measure the pressure and temperature of the nitrogen gas and it has been found that the values are approximately in agreement with the theoretical values, only affected by changes in gas temperature.

In essence, the integration of sensor technology not only enhances the efficiency and reliability of hot stamping processes but also empowers manufacturers with the means to optimize production quality and minimize downtime.

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