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Concept and implementation of a milking laboratory

The concept and development of the milking laboratory at the Institute for Agricultural Engineering and Animal Husbandry of the Bavarian State Research Center for Agriculture are presented in this paper. The milking laboratory is designed to enable study under standardised conditions of current questions relating to milking technology. It also allows more graphic demonstration of milking and measurement technologies for the training of advisory staff. Advantages of the redesigned milking laboratory are its modularity and internally created user-friendly software as well as its compatibility with the DIN ISO 6690 standard.

Keywords
Milking laboratory, vacuum measurement, experimental technology, PC-based data acquisition

Abstract
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Scientific investigation of aspects of milking technology and milk production under practical farming conditions aiming to help in advisory work and further education is one of the research topics examined at the Institute for Agricultural Engineering and Animal Husbandry (ILT). The design and conception of a research facility in this respect (milking laboratory) must be flexible enough to allow for fitting the necessary measurement technology enabling research into new questions raised regarding progressive developments in milking technology. New issues emerge through the application of new technologies such as automatic milking systems, quarter-specific milking procedures and further techniques that influence the vacuum conditions under the teat ends (new designs of electronic milk-flow recorders, head ventilation of the teat liners, etc.).

A further task for the instrumentation for measurement implemented into the milking laboratory is the evaluation of devices for monitoring milking equipment used in commercial farming systems. The accuracy and reliability of recorded results considering alternative measurement points or of evaluation methodologies, e.g. measurements of pulsation pressure via needles inserted into pulsator hosepipes, can be evaluated.

Requirements on milking laboratory equipment and infrastructure

To process different issues with required accuracy, the following requirements on the applied instrumentation for testing, data acquisition and data streaming have to be taken into account:

- The layout of components should allow measurements under various simulated conditions (e. g. high and low positioning of the milk lines).
- The design, as well as the milking equipment components and instrumentation for measurements, should be as interchangeable as possible so that subsequent integration of supplementary systems can be possible.
- Data acquisition and streaming with a sampling rate of up to 5 000 Hz should be possible.
- The continuous data acquisition and streaming of the prevailing liquid flows should be possible because the vacuum conditions under the teat are directly dependent on actual liquid flow.
- The acquisition and streaming of the vacuum conditions or vacuum deviations on different positions of the milking system should be possible exactly, simultaneously and with a high resolution.
- The acquired measured values must be saved for later evaluation.

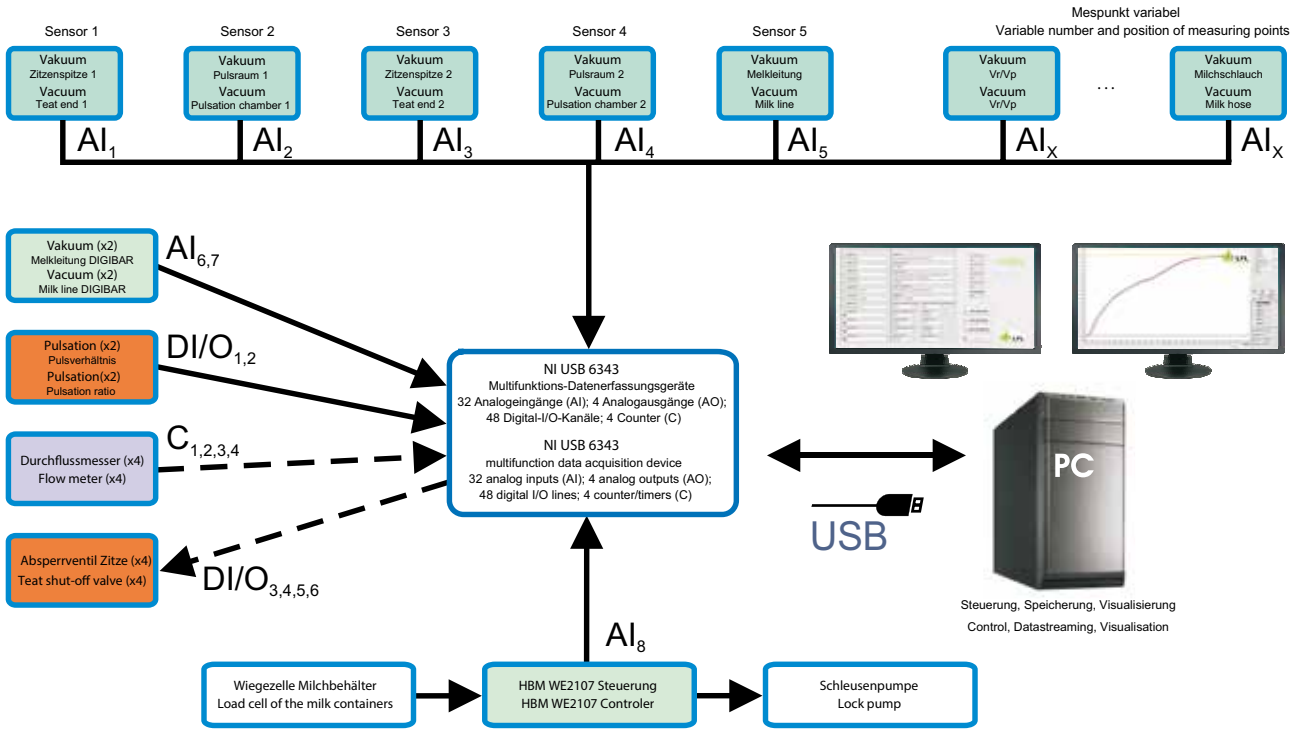
The requirements for technical details, e. g. the design of the artificial teats and the measurement equipment needed in the milking laboratory, are oriented on the requirements of the currently applicable standard DIN ISO 6690:2010-04 [1]. In addition, the measurement scenarios are defined with variable sampling rates and lengths so that exact results can be achieved even where vacuum fluctuations or peaks are extreme, such as with air ingress at a teat liner.

With the above mentioned requirements in mind, a milking laboratory was designed, constructed and put into operation from 2011 to 2012 at the Bavarian State Research Center for Agriculture.

Material and methods

In the milking laboratory implemented PC-based measurement system (National Instruments, NI USB 6343), a multifunction-

Fig. 1



Concept of the milking laboratory with integrated sensors and data acquisition system (— implemented; - - - under testing)

al data acquisition device, enables simultaneous recording of 16 analogue, 48 digital and 4 counter inputs with a sampling rate of up to 500 kS/s (S = Sample, all parallel events or states). The software solutions for the data acquisition in the milking laboratory were developed with LabVIEW Developer Suite from National Instruments and adapted for the special requirements. The aim was to generate the test reports automatically and to graphically illustrate the measurement results parallel to data acquisition.

The software solution was optimised for application with the multicore desktop computer used for the data acquisition, enabling simultaneous acquisition of up to seven vacuum readings (vacuum conditions) via a Keller PR-25 pressure sensor and one vacuum reading (vacuum condition) via a Keller PR-9 pressure sensor. All the pressure sensors could be fitted flexibly within the model teats or in the milk or pulsator hoses.

Additionally, it is possible to record two vacuum values via the HBM PE 350 pressure sensor in the vacuum line, the weight of the milk container as well as three pulsator signals with a frequency of up to 5 kHz. Currently the total flow is only controlled via rotameter gauge. A direct measurement of flow per teat is in the test stage. **Figure 1** shows the concept of the milking laboratory's integrated measurement system.

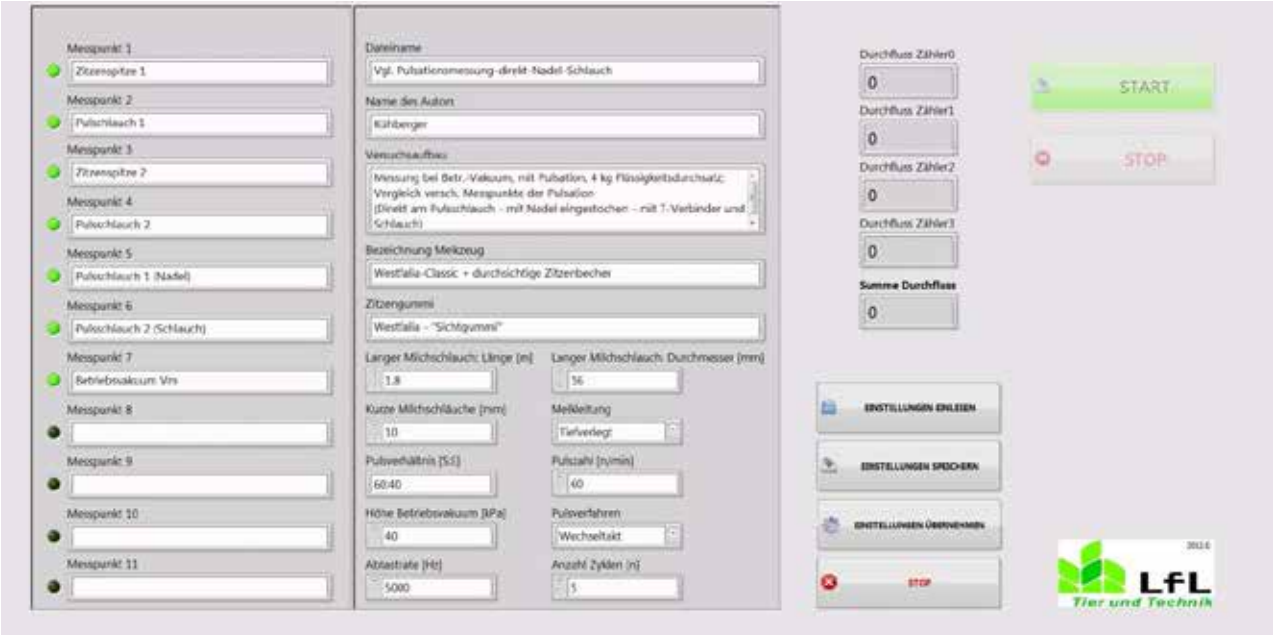
Results

In that the ILT milking laboratory is also used to demonstrate relationships in milking technology or measuring procedures as part of its training role, particular importance is attached to giving a clear presentation of the measurement data. For this reason the measurement data is presented simultaneously with the actual recording on a second 28" monitor screen (**Figure 2** and **3**). The software user interface allows configuration of all important measurement parameters. The parameters describing a particular measurement sequence can be saved and, in the case of a repeat experiment, are then available from the saved file.

After parameterisation, the settings are accepted and the measurement started. Through configuring a parameter, conducting the measurements with a defined number of cycles becomes possible. Alternatively, a measurement can be conducted until the responsible person manually stops the procedure. During the measurements the data are saved in blocks (streaming) in TDMS format (manufacturer-specific data flow) and presented in graphic form. The measurement example emphasises the damping effect with measurements of the pulsation curve a-phase (**Figure 3**, compare the blue and red vacuum curves). This can be caused by different points of measurement, or by different recording set-ups. The standard measurement considers exactly 5 pulsation cycles. The sampling rate of the vacuum sensors was 5 kHz.

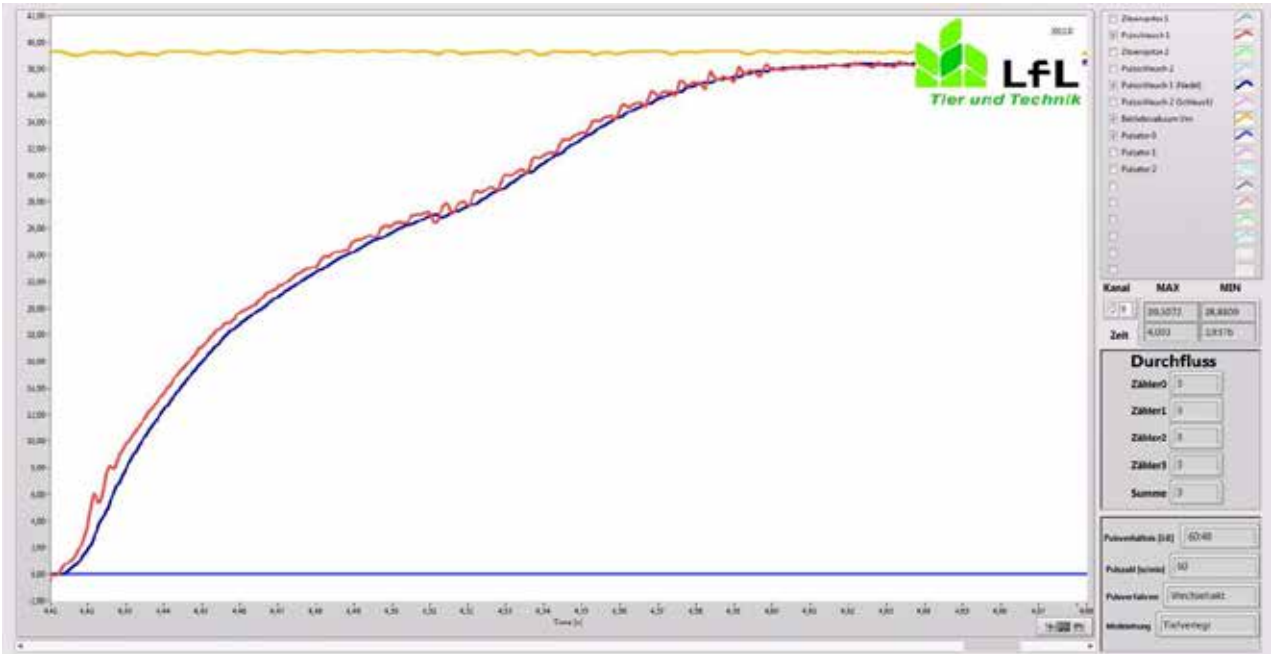
As shown by the illustration of the a-phase over a period of 0.23 seconds, fluctuations in the pulsation chamber vacuum caused by the damping effect of larger volumes of the applied measurement components, or through the smaller ingress from

Fig. 2



Screenshot of the graphical user interface of the data acquisition software

Fig. 3



Results of an example measurement (yellow - operating vacuum; red - measuring point within the short pulse tube; blue - measurement with needle and tube (inside diameter Ø 4 mm, 30 cm long))

the needle used, were significantly reduced or could no longer be measured (**Figure 3**).

The recording of the milk or water flow has so far not been realised because no suitable sensor solution has been found yet. The main problem is the accurate reproduction of the fluctuating flow of the milking process while keeping the resultant fall in pressure as low as possible simultaneously so that the aimed-for maximal total flow of 10 l/min can still be achieved. Up until now, four sensors from three different manufacturers have been tested during milking whereby the totalled flow

amounts were compared with the weight of the collected water. The pressure drop at the flow sensors was too large with only one of the sensors and acceptable with the others. With all systems, however, the targeted value becomes increasingly imprecise the higher the flow fluctuations are. Hereby, variations of over 10 % were determined.

Conclusions

By implementing novel hardware and software solutions, a milking laboratory was conceived and built at the Institute for Agricultural Engineering. The system is redesigned according to DIN ISO 6690 standard requirements [1]. In order to be able to simulate the pressure conditions under the teat end through the entire milking sequence in future, current work is aiming at controlling flow of liquid per teat via suitable valves.

Using the described technology could lead to precise assessment of new milking systems or system components for their effects on vacuum conditions under the teat ends. Measurement procedures used under practical farming conditions for assessing milking equipment can be evaluated under standardised conditions with regard to the precision of the presented results.

The assessment of the measurement results enables further development of appropriate measurement procedures and standards. At the same time training measures for advisors within the milking laboratory regarding the technical relationships involved in the milking process can be presented and demonstrated in a clear way.

References

[1] DIN ISO 6690:2010-04 (2010): Melkanlagen - Mechanische Prüfungen (ISO 6690:2007)

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