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Stanisław Borkowski[1], *Marek Krynke*[2], *Krzysztof Nowak*[3]

THE MACHINE EXPLOITATION SYSTEM INNOVATIONS IN THE MALTING PLANT SOUFFLET POLAND OF POZNAN

Abstract: The following chapter describes innovative actions implemented in the machine exploitation system in the Malting Plant Soufflet Poland of Poznan. It presents the main preventive actions aimed to increase the safety level of the malt production process. In particular, the test system to check the sensors and emergency switch effectiveness in the line for malt sprout and dust granulation is described. It was emphasized that only automatic mode of the technological installation can guarantee safe production and work conditions. Moreover, some other diagnostic and preventive actions undertaken in the malting plant are discussed, like thermovisual analysis, vibroacoustic measurement and oil quality inspection.

Keywords: technical capability condition, thermovision, vibroacoustics, oil quality inspection.

1. Introduction

Malting Plant Soufflet Poland Ltd. in Poznan city (Poland) belongs to the food industry branch, brewery section. Its product is the barley malt, basic element crucial for the final quality of the beer. Beer-industry sets certain requirements to this product, independent on a season. That forces production to be organized in the way adjusted to the climatic changes the barley is the subject to. The barley is the initial material of the malt production. It is formed by nature and therefore is a subject of natural laws. Dependent on a season, barley grains differently react to the

[1] Multi prof. dr hab. inż., Czestochowa University of Technology, Department of Management, Division of Production Engineering, e-mail: bork@zim.pcz.pl
[2] Dr inż., Czestochowa University of Technology, Department of Management, Division of Production Engineering, e-mail: krynke@zim.pcz.pl
[3] Mgr inż. Malting Plant Soufflet Poland Ltd. Maintenance Manager, e-mail: krzysiek-nowak7@o2.pl

humidification and later drying, germination process goes differently, and so on. In the malt production, the main process is malting which lasts ca. 8 days. During the malting, in the soaked and germinated barley grains biochemical processes run (KUNZE W. 2010, ULLRICH S.E. 2011).

Very important thing is, that the grains once humidified must undergo the whole malting process finished with the drying cycle of the malt. After drying, the malt contains only ca. 4% humidity, and it can be stored in silos for many months without serious damage of its quality (BAMFORTH C.W. 2006).

In the malting process the important problem is, that it is impossible to stop the germination process after it starts. It is only possible to prolong it slightly (LEWIS M.J., BAMFORTH C.W. 2006). If on that stage any machine fails, the processing time could not be kept which is potential threat to the final quality of the malt.

The other important problem of the malt production is bound with the fact that the technological load varies substantially. The subject of variation are: amount and quality of the malt ordered; sort and quality of the barley delivered; version of the humidification, germination and drying programs; failures of the machines, their maintenance and other exclusions from the process. Moreover, it depends on the actual season, the volume of production, humidity of outer air, etc.

Quality requirements and variations of the technological loads require the machine maintenance according to the proved exploitation system which guarantees appropriate technical abilities and full efficiency in the proper time. Rational organization of the technical ability of the machines and devices, as well as the proper technological process control provides the faultless technological process run.

2. Automation of the technological processes

Nowadays, the entire malting technological process is performed automatically with the programs recorded in controllers. Those programs collect the information from active feedback sensors and safety switches, as well as from various outer sensors like those of temperature, vibrations, pressure, etc.

Automatic supervision on the machines and devices engaged into the technological process enables to register all the emergency states. Automatic control of the technological process also prevents from wrong input data that may threat the safe work of the machines and devices, and hence, the safety of the staff (ŻÓŁTOWSKI B. 2011).

Automation of the technological process enables also to project a safe checking procedure for infallibility of all the protection devices installed in the technological line. To give an example, the existing line for malt sprout and powder granulation is equipped with an option to perform the test of the installed safety devices. Unlike the normal technological process, during the test no screw conveyor is in motion, so no granulated material (sprout and powder) is moved. Test procedure is only used to simulate the emergency states that normally would switch the machines off leaving the raw material inside which could lead to its blockage or even damage. During the test, any sensor or emergency switch could be checked separately.

It is absolutely necessary to perform tests of sensors and emergency switches regularly to guarantee trouble-free work of the system. That is why the control system after certain preset time period is signaling to the staff that such a test must be performed. If ignored, after some time the system switches into emergency state, and the only way to restart it is to perform the regular test of the sensors and switches first.

It should be mentioned that the operator merely has to run the automatic technological process and then the program is performed automatically with no need of the human interference. The entire procedure may last few hours.

After two years of operation of the test procedure, it proved its positive influence on the safety of the machines and the staff employed to operate the technological line.

3. Periodic thermovisual examination of the machines and devices

The described company obtained extensive experience in the analysis of machine faults based on the data collected from the thermovisual examinations. Since 2001, Poznan University of Technology (Poland) is regularly performing this kind of examinations for the malthouse, and many threats have been revealed and dealt preventively.

Effective repair in short time after the fault is revealed with no doubts reduces the inflammation hazard of the installation and damage of the machines, and increases the safety of the staff. The quarterly checks with a thermovisual camera also suggested the idea to equip the transformer stations with the additional Freon ventilation system. The thermovisual examinations are performed in a safe way, bear no threat to the staff or machinery, do not require to stop the process, and give the immediate result to evaluate the technical conditions of the object. The results may also serve as guidance to other enterprises for optimization of the exploitation and maintenance of the machines and devices involved in the technological process (NOWAK K. 2013, NOWAK K. 2012, BORKOWSKI S., NOWAK K. 2012).

The Fig. 1 presents the examples of the images registered by thermovisual camera. The images were made in 2007, when various objects were examined this way in the described malthouse.

In the Fig. 1a, there is a main switch of the gas-burner No 1 installed in the drying heating section. The Fig. 1b presents the contactor of the circulation pump which serves for the cooling aggregate No 2.

According to the accepted methodology of the thermovisual examinations, every case of the temperature higher more than 10°C compared to other faultless elements of the object, should be registered and reported as a defect. The measurement results are sorted out into three categories: strong, medium and little warming of the details. Fig. 7.1a gives an example of the little warming of the electric element, when the defect was repaired during the upcoming maintenance operation next day after the problem had been identified.

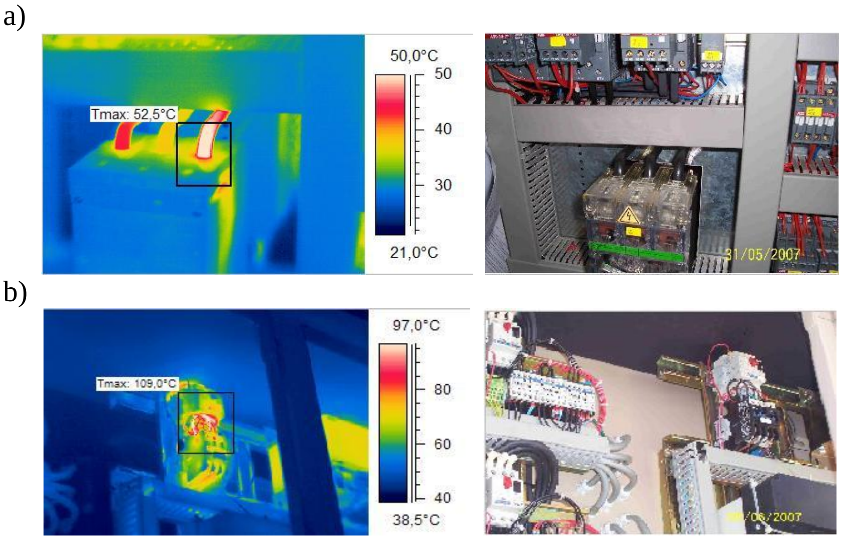

Fig. 1. Examples of the objects examined with the thermovisual camera:
a) main switch of the gas-jet No 1 in the malt drying heating section,
b) contactor of the cooling aggregate circulation pump No 2.
Source: Report made by Poznan University of Technology team, 2007

On the other hand, Fig. 1b shows the case when the contactor had warmed up in a high degree, and the defect had to be removed immediately as an emergency action. In both cases, the damaged electrical cables were removed and replaced with the new ones. The new ferrules were made on their ends, too. Afterwards, the repaired areas underwent the examinations with a pirometer.

Moreover, the inspection of the proper work of the malt sprouts and powder granulation processing line is being performed in the malting plant, too, with the thermovisual camera. The granulation process in particular generates high hazard of inflammation, mostly because of the high temperature of the process itself, but also because the raw material is easily inflammable. Therefore, it is crucial to gain proper knowledge on the actual temperature which takes place during the process. Thermovision gives immediate information on the temperature of the granulate and effectiveness of its cooling. This information is of the high importance, because the granulate is destined to be stored in the silos, and before being stored the granulate must be cooled properly. When the whole installation is examined with the non-invasive thermovisual camera, the operator can quickly evaluate the work efficiency of the cooler and aspiration line. In addition, the performed measurements indicate the thermal condition of the motor, the granulator matrix and the bearing of the main shaft. The thermal record of the granulator during its normal work cycle, hence, can guarantee high safety of its work.

The results of the measurement performed in December 2012 are presented in the Fig. 2. The temperature outside building was +3ºC. The registered temperature of the electric motor was the normal exploitational temperature, i.e. thermovisual examination revealed little warming of the working motor. That meant good condition of the rotor bearings, and no overload in the malt sprout and dust granulation process. The examination proved that the operator had adjusted the process properly, and that the technical condition of the matrix, pressing rolls and electric motor is good.

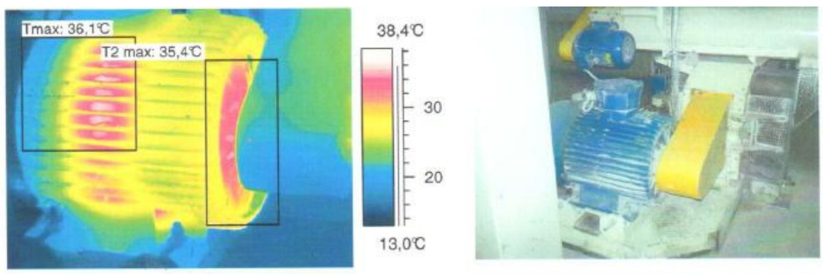

Fig. 2. Thermovisual examination of the granulate production line.
Source: Report made by Poznan University of Technology team, 2012

4. Periodic inspection of the gear oil quality

To ensure good lubrication of all friction systems in the factory, various systems may be adopted. It should be noted, however, that in the industrial practice, not always the recommendation made by gear boxes manufacturers define the best time for oil replacement. When this is the case, the inspection of the oil helps to determine the realistic periods between oil changes in each gearbox.

Normally, the oil change should take place when the oil has lost its quality parameters. In many cases, the exploitation conditions and the higher quality of today's oils allow to extend the worktime of the oil compared to the time recommended many years ago by the manufacturer of the gearbox. In October 2013, the malthouse started a program aimed to perform the periodic analysis of the oil quality in some chosen machines and devices. First the main attention was paid to the transport line which moved the soaked barley from the steeping tanks to the germination boxes, where the germination process takes place, and then from the germination box to the kiln. The analysis indicated that in some cases the previously binding periods for oil worktime should be changed. In the Table 1, two examples of the performed analyses of oil quality are presented. The oil was used in the belt conveyors gearboxes in the malt transport line to the kiln.

One analysis result was positive, and the other was negative. The positive result confirms the safety of the gearbox exploitation and allows to save time and money avoiding unnecessary oil change.

Of no less importance is the negative result. It indicates that the oil in the inspected gearbox should be replaced immediately, even though the maintenance time did not expire. Oil change will prevent the damage of the belt conveyor which appearance is highly probable as a result of bad lubrication. It saves even more money and time because it is very likely that the oil change is cheaper than the repair of a damaged gearbox. The negative result of oil quality inspection may suggest also that the check and repair work should be done in case of this particular gearbox, because it had worked some time in conditions of bad lubrication. Thorough check could prevent the possible breakdown and all its undesirable consequences.

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Table 1. Report on the oil quality inspection of the line conveyor gearboxes: T-05 (positive) and T-03 (negative)

1. ANALYSIS RESULTS			Actual sample	Actual sample
LABORATORY GIVEN NUMBER			2490207	2490220
FINAL RESULT			Positive	Negative
Analysis date			15.10.2013	15.10.2013
Date of sample taking			04.10.2013	04.10.2013
Date of the last oil change			-	-
Oil added after change			-	-
Run after last oil change			-	-
Was the oil changed?			-	-
WEAR				
Iron	Fe	mg/kg	9	463
Chromium	Cr	mg/kg	0	1
Tin	Sn	mg/kg	0	0
Aluminum	Al	mg/kg	0	12
Nickel	Ni	mg/kg	0	0
Copper	Cu	mg/kg	0	1
Lead	Pb	mg/kg	0	0
Manganese	Mn	mg/kg	0	3
PQ Index	-	mg/kg	<25	446
POLLUTION				
Silicon	Si	mg/kg	24	35
Potassium	K	mg/kg	1	4
Sodium	Na	mg/kg	0	4
Titan	Ti	mg/kg	7	1
Water	%	mg/kg	< 0.10	< 0.10
OIL CHARACTERISTICS				
Viscosity in 40 °C		mm2/s	207.83	218.01
Viscosity in 100 °C		mm2/s	27.79	22.02
Viscosity index		-	171	122
Oxidation		A/cm	1	1
ADDITIONS				
Calcium	Ca	mg/kg	3	10
Magnesium	Mg	mg/kg	0	0
Boron	B	mg/kg	0	0
Zinc	Zn	mg/kg	4	152
Phosphorus	P	mg/kg	366	785
Barium	Ba	mg/kg	5	1
Molybdenum	Mo	mg/kg	0	0
Sulfur	S	mg/kg	205	5135
ADDITIONAL TESTS				
Neutralization number		mgKOH/g	0.39	0.83

Source: Compiled from the report by Ecol Rybnik – October 2013

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5. Periodic vibroacoustic inspection of the driving systems

Vibrodiagnostics helps to evaluate a dynamic condition of the machines and devices from the registered vibrations generated by the inspected system. The measured functional parameters are compared with the collected set of the diagnostic parameters which characterize the vibrational processes. The intensity of the vibrations is the basis of the vibroacoustic evaluation of the dynamic condition of a machine. The vibration intensity measure could be any value of the vibration characteristics: motion of the vibrations, velocity of the vibrations or acceleration of the vibrations. Vibroacoustic processes have got complicates structure in terms of time, amplitude and frequency. As a result, they bear large amount of information for the evaluation of a whole machine or device, as well as its part or unit (ŻÓŁTOWSKI B., ŁUKASIEWICZ M. 2012).

In the malting plant , since 2011 a range of the vibroacoustic measurements is being performed to evaluate some chosen driving systems, e.g. those of the fans in conditioning system of the germination room. The results of those measurements were basis to the repair works and the replace of some units in the inspected fans. Such a preventive works reduced substantially the hazard of the fan damage and effectively increased the safety of malt production, not mentioning the safety of the employed staff. It is planned to cover with vibroacoustic inspection all the fans working in the malting plant, and other machines and devices like the gearmotors and pumps (KRYNKE M., SELEJDAK J., BORKOWSKI S. 2012,).

In the nearest future, the new gearbox for the radial fan (500 kW power) will be mounted in the kiln. It will be equipped with the vibration sensors, oil level sensors and thermometers to measure temperature of the bearings. The dedicated controller will gather all the information from those sensors in order to ensure the active safety of the malt drying process.

Actually, the continuous measurement of the temperature and vibration of the bearings of both kiln fans is being performed. The measurement results are registered by the controller and confirm technical capability of those fans (ŻÓŁTOWSKI B., ŁUKASIEWICZ M. 2012).

The Table 2 presents the records of the vibroacoustic inspection of aspiration fans in operational tower, performed for the first time in September 2013. The main assumed criteria were as following: level of the vibration velocity V_{rms} (dynamic conditions) – up to 4.5 mm/s means good state, 4.5 – 7.5 mm/s means acceptable state, over 7.5 mm/s means inacceptable state.

Table 2. Results of the vibroacoustic measurement of aspiration fans in operational tower.

No.	Unit	Dynamic condition		Bearing condition		Comments
		Before	Actually	Before	Actually	
2.1	**Fan V1**					
	Motor	-	good	-	good	
2.2	Rotor	-	good	-	acceptable	Ad. 2.2
2.3	**Fan V2**					
	Motor	-	inacceptable	-	inacceptable	Ad. 2.3
2.4	Rotor	-	good	-	inacceptable	Ad. 2.3

Source: Inspection report Predict Piła – September 2013.

In case of the fan V1, measured peak values of the vibration acceleration in the rotor bearing on the side close to the motor were high. The next measurement was appointed two months later. On the other hand, for the fan V2, the dynamic condition of the motor was found inacceptable. In that case it was recommended to check foundation and the condition of the pulley (its wear and tear). The measurement also revealed relatively high peak values of the acceleration in the motor bearing 28 g [0-P] and rotor 180 g [0-P], frequency analysis confirmed the advanced wear of bearing (Fig. 7.3). It was recommended to replace them as soon as possible.

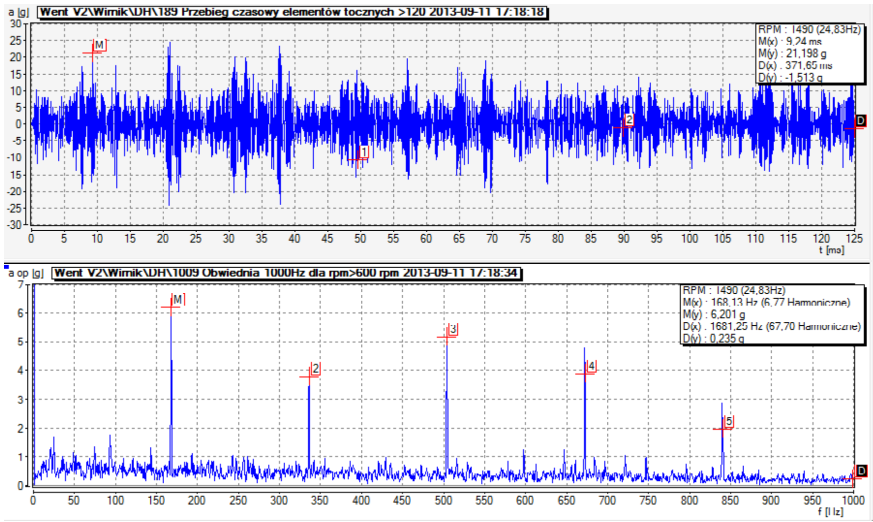

Fig. 3. Sample of the time performance and envelope spectrum of the bearing vibration acceleration of theV2 fan rotor.

Source: Inspection report Predict Piła – September 2013.

In the Fig. 3, there are presented registered measurement results from vibroacoustic inspection of the V2 aspiration fan rotor. The upper graph shows the acceleration amplitude change in time (waveform) of the V2 fan rotor bearing. The lower graph presents the envelop spectrum of the vibration acceleration (gE), which enable to identify particular components (files) registered as a function of frequency.

The software applied for the analysis of the above results contains the full database of all types of bearings made by renowned manufacturers. After the bearing is defined (1315K), the program automatically calculates the characteristic frequency for the particular bearing detail fault (inner track, outer track, rolling parts and the basket).

In the lower graph (Fig. 3), the point marked with M means the main cursor marker. Here it was used to mark the basic frequency 168 Hz generated by the failure of outer ring of the bearing 1315K. The files marked as 1, 2, 3 are the harmonics of basic frequency. They are the multiplications of the basic value M = 168 Hz, respectively: 1 (336 Hz), 2 (504 Hz),

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etc. When many harmonics appear in the graph, it indicates the advanced damage of the bearing.

After the bearings were replaced with new ones, the visual inspection confirmed the substantial damage of the track and rollers of old bearings. There were good reasons to replace them and the replacement prevented serious breakdown and its consequences.

6. Conclusions

The decisions on maintenance of the devices and machines in order to keep their technical capability are of strategic importance for any factory. It has to be adjusted to the actual technical conditions of the working machines and the sort of the final product. To obtain that, all the available methods of diagnosis should be implemented to supervise the operation of the machines. The engineers have to undertake some basic and some additional actions. The division of the actions into two mentioned groups is not ultimate, because the methods and exploitational tasks evolve constantly. The above presented innovations implemented in the malthouse may be suitable for any other branch of food industry as well.

It is very important that the technological process is not controlled manually, because the manual mode generates many threats to the technical capability of the working machines and devices. Moreover, it decreases the safety level of the process and especially for the employed staff.

The entire technological process of the malting plant is performed in the automatic mode. As a result, the machines and devices work in stable way and fulfill the malt production technological process with increased level of safety of the process and the staff. It is also sensitive to the emergency signals from the installed sensors and emergency switches.

Besides of that, among innovating actions aimed to the maintenance of the machines in capability to work, the application of various diagnostic methods should be emphasized. The above chapter described implemented in the malting plant vibroacoustic diagnosis, thermovisual solu-

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tions and oil quality inspection which enable to reveal failures early enough to prevent the serious damage.

The practice proved that when all the mentioned innovative actions are fulfilled (both basic and additional actions), the technical capability of the machines is kept on the high level. Innovations substantially contributed to the safety of the operators, to the expenses costs decrease, and they guarantee the final quality of the produced malt.

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