MAINTAINING WORKING CONDITIONS AND OPERATION OF MACHINERY

Norén O.
Swedish Institute of Agricultural Engineering, Uppsala, Sweden.

Keywords: service, maintenance, operation of machinery, tillage, nutrients, crop protection, harvest, accidents, health hazards

Contents

Summary

It is of great importance to avoid stoppages and breakdowns when working with agricultural implements and machines. If seeding or harvesting is delayed, decreased yield, lower quality, and so forth may be the result. A system for periodic service and maintenance is essential. Service and repair must be done professionally. It is necessary to use lubricants and change oil and filters as recommended.

Farming is a biological production system. Consequently, the technical means and processes used must meet the demand of the biological system. At the most basic level, all farm production is dependent on the soil. The soil must have the right structure, hold enough water, and be a suitable temperature to be a favorable growing medium for the crops. Soil tillage has the objective of developing a favorable seedbed or rootbed, destroying and controlling weeds, incorporating plant residues, and minimizing soil erosion. Nutrients must be added to the soil; the sources of nutrients are fertilizer and manure. Using herbicides is the most common method of controlling weeds, but mechanical weed control is also used. Control of fungi, diseases, and insects is also mainly accomplished by chemicals.

In all harvest and preservation processes, it is essential to minimize losses of the crop and to prevent damage to the quality of the crop. Forage can be preserved as hay or silage. The most common method for haymaking is field drying, but barn drying is also used. Grain is harvested by combines and artificial drying is an important part in the

harvest process. When harvesting and handling potatoes, impacts must be avoided. Even small falls cause damage and it is essential to use cushioning devices. It is important that beets are adequately topped and well cleaned when they are harvested.

Operating farm implements and machines is associated with risks of accidents and health hazards. Consequently, measures must be taken to eliminate these risks.

1. Maintaining Working Conditions

It is of great importance to avoid stoppages and breakdowns when working with agricultural implements and machines. The most favorable times available to carry out most farm operations are very limited. It is, for instance, necessary that seeding take place at optimal conditions. If seeding is delayed only a few days it can affect the yield. Ripening may also be delayed. Even more sensitive is the harvest operation. Delayed harvest may lead to decreased quality, higher drying costs, and increased losses.

The consequences for stoppages and breakdowns are different for different implements and machines. Stoppages occur more often with combines, sugar beet harvesters, and potato harvesters than with implements like harrows, plows, etc.

Concerning tractors, about 50% of failures affect the transmission and represent more than half of the total repair costs for these vehicles. The engines are affected by ~20% of the failures, the front axle by 12–15%, and the hydraulic system by 8–12%.

There are many reasons for machine damage. Of course, all machines and implements are worn out by age and some accidents occur. There are also bad designs and some defects in materials. These causes cannot be controlled by the farmer–user. However many failures are due to bad maintenance, wrong use, incorrect service, and wrong repair. All these causes can be controlled by the farmer–user. Often a small initial failure leads to a more severe effect if the initial failure is not repaired.

1.1. Periodic Service and Maintenance

One very important measure to avoid breakdowns is to have a system for periodic maintenance. Interviews with mechanics in workshops and inspectors from insurance companies show that a large part of the breakdowns are unnecessary since they are caused by deficient maintenance and incorrect handling.

In the instruction manual for implements and machines there are usually recommendations for daily and periodic service. It is important to follow these recommendations. However it is also advisable to have an operating journal or notebook for every machine and implement in which important data concerning service dates, changes of oil, repairs, etc., can be written down. It is also suitable, at least on bigger farms, to make notes on a blackboard in (for instance) the farm workshop concerning the next service, the next oil change, and failures that must be repaired.

Many farms use computers. A good idea is to have a database concerning the implements and machines. In this database it is easy to get an overview of the status for

all machines; service, maintenance, repairs, and cost. It may also be of interest to enter the operating journals onto the computer.

Most implements and machines are used only for comparatively short periods every year. After use and before they are stored until the next season, they ought to be carefully cleaned. This is especially important for combines and other complex machines. At the same time or during the storage period it is also appropriate to look after screw units, wheel bolts, belt drives, bearings, and oil leakage.

1.2. Wrong Use

A great deal of breakdowns are caused by overloading the machines. One example of this is the use of high torque for a long time in combination with low speed and high gear. It is rather common to use big implements driving on high torque at low speed. The load on the gearbox will be very high. It is better to use smaller implements and drive faster. It is notable in this connection to remember that the length of life for a transmission in a tractor, for instance, will be more than doubled if at constant power the driving speed is increased from 4 to 7 km per hour.

In some cases the differential lock is not used during wheel slip conditions, which causes heavy wear on the differential gear on the tractor. To avoid incorrect practices of this kind, a computer on the tractor may be a solution. Systems of this kind are already in use on some contractor machines.

1.3. Incorrect Service and Repair

Service and repairs are often done on the farm by farmers. Many farmers are skilled and do good jobs. However, in many cases, the repairs are not done correctly and this may in some cases lead to after-effect failures.

One common and serious mistake is to neglect to clean the machines carefully before the repair to prevent impurities entering the sensitive parts. Bad welding is another common failure. The reason is often bad preparation of the joint, which may lead to poor strength. There are, however, many other faults that can be easily repaired by a person without specialist knowledge and experience.

1.4. Hydraulic System

Hydraulic systems are common on most implements and machines. All components in these systems are very sensitive to contamination, so cleanliness is of great importance. After a breakdown, there are often impurities (like small metal particles) in the oil and in the system. Therefore, changing the oil is essential. Before filling, it is necessary to wash the system and to change filters.

1.5. Lubricants

Friction and wear occur where two surfaces move against each other. The objective of lubrication is mainly to reduce friction and wear and so to minimize the energy

absorbed and wasted. The lubricant prevents contact between two metal surfaces. This is effected by a film of oil between the two surfaces. The friction between two metal surfaces is thereby replaced by friction between the lubricant and the metals and by friction within the lubricant.

It is off the utmost importance to use the right lubricants in order to maintain a good function of the machines, and to prevent wear and breakdowns. Very common problems are too low an oil level, the wrong oil, and too long an interval between oil changes.

One of the most important properties of oil is the viscosity. The correct viscosity is dependent on temperature and pressure. The ability of the lubricant to carry a load increases with the viscosity but so do energy losses. It is essential to follow the recommendation given by the manufacturer concerning the viscosity of the oil used. The viscosity decreases when the temperature rises. As a measure of viscosity variation, the viscosity index (VI) is used. A low VI means big changes in viscosity while a high VI means low changes. Consequently a high VI is desirable.

There are many other properties of an oil that are of great importance. Such factors are specific gravity, flash point, solubility in various liquids, emulsibility, susceptibility to oxidation, filterability, ability to separate water and air, influence on tightening, and protection against corrosion. In order to change and improve the properties of the oil, additives are used.

The manufacturers of machinery provide recommendations concerning the choice of oils. These recommendations are based on experience and knowledge concerning the driving conditions and the properties of the oil recommended. Consequently, it is important to follow the recommendations concerning the type of oil, the interval between changes of oil, and use of filters.

On many farms, oil is bought in barrels. To avoid contamination with water and impurities, it is of great importance to store the barrels in a proper way. The best way is to store them in a house.

1.6. Bearings

One very important machine element is bearings. Maintenance has great importance for the function and the lifetime of the bearings. Bearings, housings for bearings, and tightening elements must be kept clean. The bearings must always be supplied with clean lubricants. The grease nipples must be cleaned before greasing.

Frequent inspection of the bearings is recommended. If the sound from a bearing is suspicious or the bearing is too warm when running, it is better change the bearing to avoid a breakdown.

1.7. Changing of Wearing Parts

Many implements, for instance plows, harrows, and so forth, do not do a good job if the shares or tines are worn out. They must be replaced as required to keep the implement

functioning properly.

2. Operation of Machinery

The objective of farming is the production of agricultural crops of high quality in an efficient and cost-effective way. In the production process, the farmer uses many kinds of implements and machines in order to minimize the input of labor—which often is expensive—and to meet the demands of timeliness. However, it is important to remember that farming is a biological production system. Consequently, the technical means and processes used must meet the demand of the biological system.

Furthermore, the high quality of the products and product losses are of major importance. Of course, high yield is an important goal and to reach this objective it is important to operate the implements and machines in the right way. In the following sections, the operation of implements and machines will be discussed on the basis of scientific knowledge and practical experience and also from a biological–technical view.

3. Tillage

3.1. The Soil

All farm production is basically dependant on a very thin layer of soil on the ground on which all biological life is dependent.

The structure and function of the soil have been the subject of comprehensive scientific analyses. In the soil there is solid material, liquid, and air. The solid material, which consists of mineral particles and organic substances, constitutes the soil skeleton. In ordinary arable land the soil skeleton occupies about half of the space.

Depending on the construction of the skeleton, the soil consists of a complicated system of channels and cavities—a pore system, which under the groundwater level is completely filled with water. The pore system is correlated to the particle-size distribution in the soil. The fraction of clay is of great importance, as is the organic fraction.

3.2. Soil Compaction

During the twentieth century, there was a dramatic change in the implements and machines used and the methods applied in farming. One of the trends has been that the tractors, implements, and machines gradually have become heavier. The reason for this is that by using bigger implements and machines, work time is decreased and the work can be done more quickly to meet the timeliness demand.

This, however, will be in striking contrast to the possibility of treating the soil in the best way. The soil is exposed to heavy forces, which lead to a collapse of the pore system, and the soil is compacted. This is a very serious development, especially on heavy soils. The soil compaction may influence the yield and the energy consumption

for tillage.

To reduce the negative effects of heavy loads, some measures can be taken. The degree of soil compaction in the topsoil is dependent on the tires used and the inflation pressure. To minimize the compaction in the topsoil, low inflation pressure—as a rule about 0.5 bar (0.05 MPa)—is recommended as well as dual tires on the tractor. Some implements and machines are also designed so that wheels do not traverse in the same track.

In the subsoil, compaction is only dependent on the total load. To reduce the effect of heavy total loads, the load must be divided on two or three axles. It is recommended that the total load on one axle may not exceed 6 tonnes.

3.3. Objective of Soil Tillage

The soil must have the right structure, hold enough water, and be a suitable temperature to be a favorable growing medium for the crops. Consequently, soil tillage has the objective of developing the right structure for a seedbed or rootbed. Other objectives are to destroy and control weeds, to incorporate plant residues, and to minimize soil erosion. Good growing conditions imply that the soil is loose and contains air and water.

3.4. Soil Tillage

To achieve the objectives of tillage, many different implements and machines are used. They are described in Febo´s chapter on Tillage and Seeding. Because there are many tillage systems used, it is not possible to state that one system or one method is the most favorable on all soils and during all conditions.

Furthermore, there is little scientific basis for traditional practice and no evaluation system by which it is possible to measure when you should till and when you have the most favorable seedbed. Instead, it is the farmer who makes this decision based on experience and assessment.

Plowing has traditionally been the base for tillage. However, in many places the plow has been replaced by disc harrows, cultivators, and other implements. One reason for this is to prevent erosion because crop residues left in the topsoil will be a hindrance for wind drift and water erosion.

Another reason not to till is that energy consumption will be decreased. At the beginning of the twenty-first century, it is more and more common to use a combination of implements and machines so that seedbed preparation and seeding take place in one operation. This is also favorable to reduce soil compaction.

However, under some conditions it is an advantage to use the plow. Experience has proven that plowing can effectively reduce attacks by fungi and insects. If harvesting has taken place in wet conditions, there are often deep tracks in the fields. Plowing may in this case be a necessary operation. The plow may still be the base implement in many situations. (Figure 1.)

Figure 1. The plow is still the base implement in many tillage operations. Överums Bruk, Sweden

-
-
-

Bibliography

Bell B. (1996). *Farm Machinery*. Ipswich, UK: Farming Press Books & Videos. [This book contains basic knowledge of tractors and farm machinery.]

Bohm M. and Norén O. (1994). *Machinery Breakdowns on Agricultural Tractors*. Paper 94-D-022. Ag Eng 94. Milano. [This is a report from a study in Sweden of about 2000 breakdowns (in English).]

Culpin C. (1986). *Farm Machinery*. Eleventh Edition. London: Granada Publishing Limited. [This book contains basic knowledge on farm mechanization.]

Eriksson J., Håkansson I., and Danfors B. (1974). *The Effect of Soil Compaction on Soil Structure and Crop Yields.* Meddelande nr 354. Uppsala: Swedish Institute of Agricultural Engineering. [This book

contains basic knowledge on the relationship of soil compaction and crop yields (in Swedish).]

Jonsson N., Pettersson H., and Schnürer J. (1997). *Study of the Relationship between* S*torage Conditions and the Growth of Moulds and Production of Ochratoxin A in* G*rain—Preliminary Results.* Paper No 976037. Minneapolis: ASAE. [This is a report from a study in Sweden (in English).]

Karlsson S. (1991). *Guidelines for Spreading Manure. Part 2—Slurry.* Meddelande nr 432. Uppsala: Swedish Institute of Agriculture Engineering. [This book contains basic knowledge and result of development work (in Swedish).]

Srivastava A.K., Goering C.E., and Rohrbach R. (1993). *Engineering Principles of Agricultural Machines.* St. Joseph, Michigan: American Society of Agricultural Engineers. [This book contains basic knowledge of farm machinery (in English).]

Svensson L. (1993). *Ammonia Volatilization from Land—Spread Livestock Manure; Effects of Factors Relating to Meteorology, Soil/Manure and Application Technique.* Doctoral thesis. Swedish University of Agricultural Sciences, Uppsala. [This is a development of a measurement method and result of studies (in English).]

Thylen L. and Ringstad K. (1997). *GPS in Agriculture—Economics, Quality, and Environment. Modern Positioning* No 4. Stockholm: Orbit Communications. [This is basic text on GPS in agriculture (in English).]

Biographical Sketch

Olle Norén
Mech. Eng. Research Director and Deputy Managing Director at Swedish Institute of Agricultural Engineering. Retired. Now Resident consultant at the institute.
Member of The Royal Swedish Academy of Agriculture and Forestry.
Member of Ag Eng Working Party 1986 – 1992.