

## Analysis of damage to an operator caused by mobile parts of the machines used in farms

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**Summary.** Application of modern tools and machines in agricultural farms facilitates the work, but the lack of skills in managing the machines often leads to accidents causing injuries of different degree of seriousness. The paper presents the investigation on the injuries sustained during the accidents involving tools and farm machines in the Krakow County in 2005-2010. It was examined what kinds of injuries were the commonest and in which group of machines the number of accidents was the highest. Also, the degree of seriousness of injuries was considered. The most frequent were the accidents involving sawing machines. The second group were angle grinders. Among the typically agricultural machines, the most frequent were the accidents involving combine-harvesters. The part of body mostly injured during the accidents was an upper limb. The most frequent type of injuries amid all the accidents was laceration. In case of the group of sawing machines and angle grinders, the injuries mostly caused rather low percentage of permanent health damage. In the accidents involving combine-harvesters, the percentages increased significantly and reached the values that indicated important health damage leading to the limitation of independent existence. The most frequent cause of accidents was carelessness, lack of concentration, inattention or the operator's tiredness.

**Key words:** agricultural farm, tools and machines, accidents, injuries.

machines within Krakow County in 2005-2010. It was investigated what kind of injuries were the commonest, in which group of machines the accidents occurred most frequently and what the level of damage severity was.

### CHARACTERISTICS OF THE REGION UNDER INVESTIGATION

The investigation included the accidents which took place in Krakow County. Krakow County is situated in North-West Małopolska directly within Krakow environment, bordering eight other counties and a town on the rights of the county. The area of Krakow County is 1231 km<sup>2</sup>, which is about 8% of the Province's total area. In terms of size, this County occupies the fourth place in Małopolska Province. In Krakow County there is a great diversity of soil kinds and types. The most common soil is loess. 80% of all soils in the county are used agriculturally – it is one of the greatest shares of arable lands amid the counties of Małopolska province [4, 5].

The districts within Krakow County have an agricultural character. According to the statistical data, more than 40% of Krakow County population work in the agricultural sector. The arable lands constitute definitely a predominant part of the County area, that is about 81.5 thousands of hectares. The remaining lands and wastelands constitute more than 20% of the County area. A characteristic feature of Krakow County is a high degree of farm fragmentation. The area of many farms does not exceed 1 ha. There are 50% of such farms in the County, while only about 1% of farms have the area larger than 10 ha. Because of the high fragmentation of farms, their economic condition is poor. That is why the main task of the farms is the production for family needs, then to deliver the products to the shops and markets in Krakow. Only 20% of the farms in Krakow County are oriented at the market production. Among 40% of the County inhabitants working in agriculture, only about

### INTRODUCTION

The agricultural engineering develops continuously involving a necessity to launch more and more modified agricultural machines of different kinds. Using the agricultural machines in farms facilitates the work and enables doing the farming better and faster. Nowadays, the farmer's work consists mainly in running the machines, so it is important that every operator is skilled at their management. The lack of such skills often leads to accidents causing injuries of different degree of seriousness.

The purpose of the study was an analysis of operators injuries sustained during the accidents involving agricultural

16% of households treat agricultural activity as their main source of income [5].

Because of the agricultural character of the districts and the significant amount of inhabitants with agricultural traditions, Krakow County is a place with a large number of accidents involving machines used in farms.

## MACHINES USED IN FARMS

### 1. FARM MACHINES

Farm machines and devices are necessary components of modern farm equipment. The term 'farm machines' includes a whole range of technical means used in the agriculture production for mechanization of production and works in farms. The farm machines, in the strict sense of the word, are the group of machines, where the working process is the consequence of the motion both of the whole unit in the field and of the active interior gear driving the working elements of the machine.

An appropriate connection of the machines to the energy sources, which enables mechanization of many activities in a farm, makes a unit. The farm tractors are the source of energy for the machines moving in the field, while in the case of stationary machines, the sources of energy are electric motors or stationary combustion engines. The degree of the diversity of the tasks realized in the farms is very high. Therefore, the agricultural machines and devices must include a wide range of possibilities of working in different production processes [5].

The manure spreader is a farm machine used to deliver, grind down and spread evenly the manure in the field. The machines used to haul hay and other green fodders from the field are the mowers, which can be divided, according to their destination, into lawnmowers (electric, petrol) and tractor mowers. In both mower groups, the working set is a cutting set. Shear or rotational cutting set is a piece of equipment of the tractor mowers and it is used to cut stalks of plants [6, 8].

The harvester is a farm machine destined to combine the cereals and root crops. The use of a harvester reduces the transport way of the plant processing and resultant losses. Depending on the prime mover, the combine harvesters divide into self-propelled harvesters (with the own prime mover) and tractor harvesters (semi-mounted or trailed) [11, 12].

The hay presses are farm machines for gleaning hay, straw and green fodders. The press, besides collecting, presses hay or straw (bale forming), which significantly facilitates the collection and transport, and allows to save storage space used to store these materials [8].

The binder is a farm machine for automatically reaping rye and some kinds of rape. This machine also binds the reaped materials into sheaves [4].

Potato sorters are farm machines, which grade dug potatoes according to size.

Cutters for clean and healthy potatoes, beet shredders and grain mills are used to prepare and deliver feed. Straw cutters are used to cut green fodder and straw. Grain mills serve to grind the seeds of cereals and leguminous plants.

### 2. SAWING MACHINES AND OTHER MACHINES USED IN FARMS

In farms, besides the crop and harvest works, many activities are connected with logging and woodworking. Sawing machines are the main machines used to cut wood. There are different models of sawing machines. Diversity of equipment and design of these machines allow using them not only as professional machines for forest work, but also for other farm tasks, for home-garden work, for the urban greenery cultivation etc. Sawing machines can be classified, considering the type of engine, as combustion machines and electric machines [9]. Considering the cutting tool, they can be classified as chain machines and circular machines.

Many accidents in the farms involve the angle grinders. They are used for cutting, grinding and polishing.

Moreover, among the accidents involving machines there are the accidents with planers and lathes. A planer is a cutting machine used to plane wood. In planers, the machining tools can be flat cutters, saw blade discs, shafts or cutter heads. The lathe is a machine tool for machining the objects with a surface of revolution. The machining tool in the lathe is a turning tool, drill or a tool for threads.

## SCALES OF ASSESSING THE SEVERITY OF INJURIES

### 1. CLASSIFICATION OF THE SCALES OF INJURY SEVERITY

Many point scales have been developed to assess the severity of injuries. Some of them are based on anatomical assessment (structural injuries, for example fractures), the others – on physiological assessment (function changes due to the injury, for example change in the eye reaction to the light). There is also a scale based on the assessment of the disability and social losses.

Anatomical scales are used to describe the injury, considering its anatomic location, the type of injury and the severity level. These scales classify rather the injuries than their consequences. The most popular anatomical scale is Abbreviated Injury Scale (AIS). The anatomical scales distinguish the degree of human damage severity, depending on the fact if it is damage to one part of human body or to several parts. This scale has been modified, now the scale in force is "AIS 90" [13].

Physiological scales, describing physiological condition of a patient, are based on information about function changes due to the injuries. This condition and, in consequence, the numbers assigned to it, can change during the treatment of the patient. Therefore, such scales are applied mainly in clinics.

The last group of scales are the scales of disability and social losses. In this case, neither the injury itself nor physiological changes due to the injury are assessed. The assessment concerns the long-lasting consequences, also these relating to the economic situation. Illustrative scales are Injury Cost Scale (ICS), Injury Priority Rating (IPR) and HARM. All these scales are based on assigning economic values to different injuries [13].

## 2. SCALE OF THE PERCENTAGE OF PERMANENT DAMAGE TO HEALTH

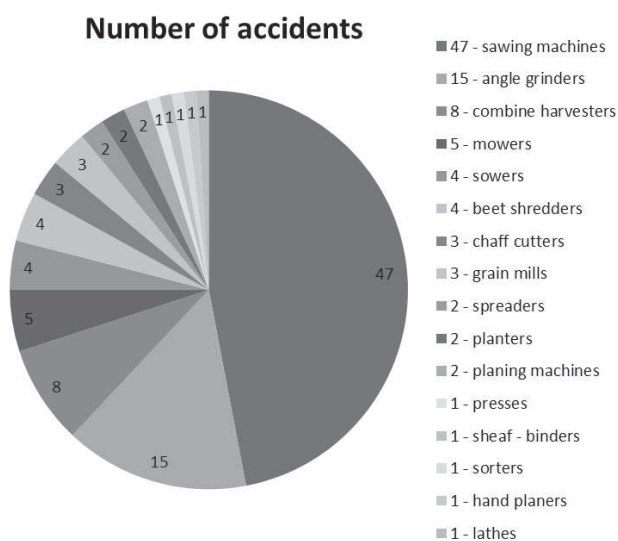
The scale of the percentage of permanent damage to health is used by the insurance firms, for instance by Agricultural Social Insurance Fund. On the reason that during the accidents people sustain permanent damage to health, these scales are applied wherever the compensation is awarded. For a percentage of permanent damage to health, a determined sum of money is awarded as compensation. The greater the permanent damage to health is, the higher the compensation. The percentage of permanent damage to health is determined by a medical commission. Determining the permanent damage to health, the doctors rely on the tables "Principles of assessing permanent damage to health". The tables contain all possible injuries with percentage values of damage. The doctors determine permanent damage to health assessing individual damage to physical fitness in medical terms. In the case of disturbance of many physical and mental body functions as a result of an accident, the degrees of damage to health for all the impairments are summarized. The only condition is that the value after summarizing does not exceed the percentage of permanent damage to health responsible for the total loss of the damaged part of a limb [3].

## RESEARCH METHODOLOGY

Necessary information about the accidents in agriculture was developed and analysed using the documentation from Agricultural Social Insurance Fund (KRUS) – regional unit in Krakow. Studies include years 2005-2010.

## ANALYSIS OF INJURIES SUSTAINED DURING ACCIDENTS

The principal purpose of the analysis is to determine the most frequent injuries caused by mobile parts of machines



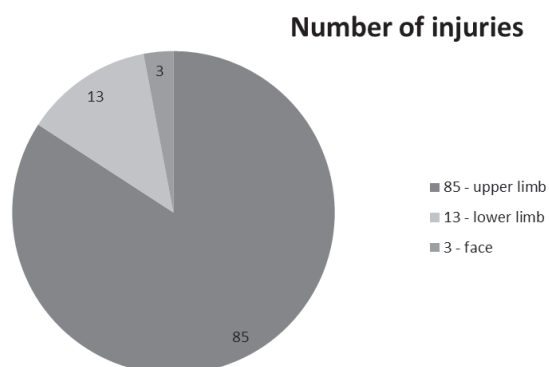
**Fig. 1.** Number of accidents in different groups of machines used in farms

used in farms, as well as the severity of these injuries. The relations between the number of accidents and the type of the farm machine, the percentage of damage to health and the kind of the injured body part were analysed.

The analysis of the number of accidents in different groups of farm machines used in the farms shows clearly that in the group of sawing machines, the number of accidents was the highest, i.e. 47 for 100 examined accidents. Many accidents (15) were involved with grinding machines. The analysis of the accidents run showed that the main cause of accidents was the ignorance of the rules of work safety, tiredness, carelessness, inattention of the operator or inefficiency of the machine. A frequent cause of the injuries was the effect called 'rebound of sawing machine'. It occurred when a moving saw suddenly touched the wood causing a violent turn of the sawing machine. The accidents often happened during the approaches to jerk out a saw jammed in wood, or during the work using a chain saw which was too blunt or improperly stretched. A frequent cause of the accidents was the incorrect, forced position of the operator during work (mostly bending), causing tiredness of the operator and break of the cutting disk.

The most frequent accidents involving farm machines were these with the combine harvesters. In 2005-2010 there were eight accidents involving combine harvesters. A harvester is composed of many active working elements, so the harvester operator should have a considerable knowledge on the operation of these elements. Most accidents resulted from the lack of knowledge about the work of the harvester elements or from the lack of a full cover of a working part in the machine. Most of the accidents with combine harvesters were caused by the carelessness, inattention or lack of experience of the operator, often leading to widespread injuries and sometimes even to the operator's death. In the case of tractor harvesters, the cause was the lack of or bad signalling between the operator of the harvester and the driver of the tractor.

The lowest number of accidents – one in each group – involved presses, sheaf-binders, sorters, planers and lathes. The main cause of these accidents was insufficient concentration during the work and lack of covers for mobile machine mechanisms. The carelessness of the machine operators, even during the simplest operations, can lead to accidents and to permanent health damage.

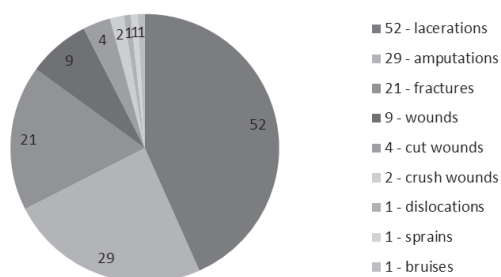


**Fig. 2.** Number of injuries to different body parts

Based on the analysed accidents, it can be confirmed that the part of the body mostly injured is an upper limb. Upper

limbs were injured in up to 85 accidents. It is so because most of the accidents occur during the works involving sawing and grinding machines, where the operations are performed using the upper limbs – hands. Moreover, most of farm works, like repair or adjustment of machines, are done using upper limbs. Another body part that sustains frequent injuries is a lower limb. There were 13 accidents causing damage to lower limbs. The face is the part, which is the most rarely injured. For a hundred of accidents, there was only one causing more than one injury. This was the situation during an accident involving a spreader, when an upper and a lower limb were injured.

**Number of different types of injuries**



**Fig. 3.** Number of different types of injuries

The analysis results concerning the relation between the number of accidents and the type of injury are presented graphically in Fig. 3. Amid all injuries, the most frequent were: lacerations – in 52 accidents, amputations – in 29 accidents and fractures – in 21 accidents. The rarest were the following injuries: bruise – 1, sprain – 1, dislocation – 1. In total, the number of injuries in 100 accidents came up to 120. There were accidents with many different injuries for one body part. Frequent were both the amputations with fracture and the lacerations with fracture.

The wounds are caused by breaking anatomical continuity of the skin, of deeper tissue or of organs. The most frequent reason is a mechanical injury. Wounds can be divided depending on the force’s acting way and its mechanism, into lacerations, cut wounds, bruises, puncture wounds, crush wounds and many others [1, 10].

The lacerations are inflicted with the objects tearing the tissues. A laceration has uneven, jagged edges, walls and bottom. In case of a cut wound, the skin was cut with a sharp object. The break of the skin occurs throughout the thickness, it can also damage the tissues lying deeper.

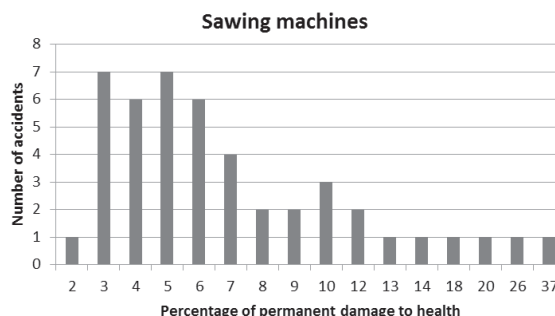
The cut wounds are distinguished by smooth edges, while a bruise is caused by a blow made with a blunt-ended object. In case of a bruise, besides breaking anatomical continuity of the skin, the tissues adjacent to the wound are crushed. Afterwards, the necrosis spreads on the crushed tissues. A bruise has uneven and swollen edges.

The crush wounds are kind of bruises with the difference that the injury surface is larger. Crushing causes a strong injury to tissues surrounding the wound.

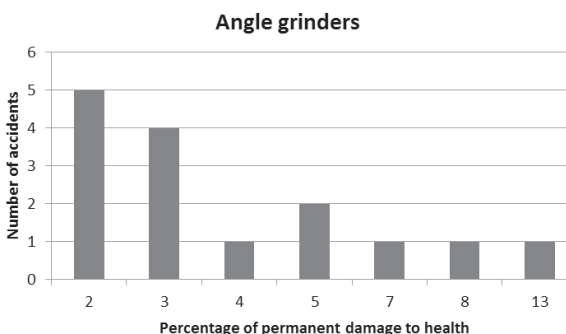
The amputation also is a kind of wound, caused by the action of a crushing force resulting in partial or total detachment of a perimeter body part such as upper limb, lower limb, ear, nose, from the whole organism.

The fracture is an interruption of the bone continuity under the influence of the inside or outside factors. A fracture occurs when the force acting on the bone is too great. Among the analysed injuries, frequent types of fractures are multiple fractures. It is a very grave type of fracture caused by high forces, in which the bone has broken into several pieces and the bone fragments are driven into each other. A dislocation is a displacement of the bones in the articular capsule under the action of the force causing a transposition of articulation surfaces [1, 2, 10, 13].

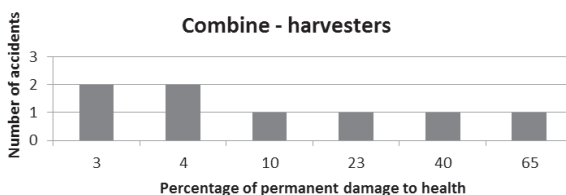
A sprain consists in damaging the articular capsule as a result of surpassing the allowed limit of the articulation motion.



**Fig. 4.** Relation between the number of accidents involving sawing machines and the percentage of permanent damage to the operator health



**Fig. 5.** Relation between the number of accidents involving angle grinders and the percentage of permanent damage to the operator health



**Fig. 6.** Relation between the number of accidents involving combine-harvesters and the percentage of permanent damage to the operator health

The analysis of the relation between the number of accidents and the percentage of permanent damage to health was done for three groups of machines with the highest number of accidents, i.e. for sawing machines, angle grinders and combine-harvesters. The analysis results are presented graphically in Figs. 4, 5 and 6. In the analysis, the scale of the percentage of permanent damage to health was used. The analysis using the AIS scale showed that the injuries in all examined acci-

dents belonged to the same group – AIS I. However, applying the scale of percentage of permanent damage to health, we can distinguish accidents in terms of the intensity level of sustained injuries. In case of the group of sawing machines, we can note, that most of accidents caused, in principle, not very large permanent damage to health, within 3-7%. However, there were more serious accidents, involving more severe consequences, where the permanent damage to health came up to 20% – 37%. Accidents with sawing machines also caused small permanent damage to health, usually 2-3%. The highest damage to health caused by an angle grinder was 13%. The accidents involving combine-harvesters, because of their complexity, cause different damages to health. They can be small damages of 3-4%, but they can also be damages coming up to 40% or 65%, resulting even in the limitation of independent existence of the accident's victim.

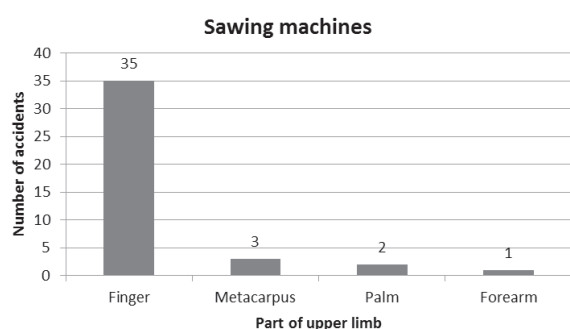


Fig. 7. Relation between the number of accidents involving sawing machines and an injured part of the upper limb

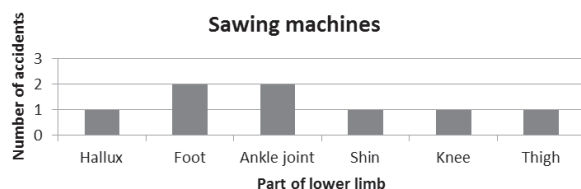


Fig. 8. Relation between the number of accidents involving sawing machines and an injured part of the lower limb

For the sawing machines, as it is a group of machines with the highest number of accidents, an additional analysis was made – which of the limbs sustained injuries and on what area. The results of the analysis are presented in Figs. 7 and 8. In most of the accidents involving sawing machines, 38 for 47 accidents, the upper limb was injured. The most frequent were the injuries to the upper limb fingers. It results from the fact that most of accidents involving sawing machines concern stationary circular saws, where the operator shifts the cut wood with his hands. There were some more dangerous accidents, in which more than one part of the upper limb is injured.

The accidents in which the lower limb was injured were less numerous – 8 accidents. There was however a great diversity among them. Almost all parts of the lower limb were injured in the same number of accidents. The foot and the ankle joint appeared only in two accidents. Injuries to the lower limb occurred during the works using portable chain sawing machines, where the operator was injured when trying to jerk out a jammed chain. In one accident with a sawing machine, the operator's face was injured.

## CONCLUSIONS

- On the area of Krakow County in 2005-2010, most of accidents involved the sawing machines. It is due to the fact that the number of such machines used in farms is the highest. These machines, apparently simple, often are operated by people without proper acquaintance with such work and this leads to accidents. Another group of machines with numerous accidents were the angle grinders. Among the typically agricultural machines, the frequent accidents were those involving combine-harvesters.
- The part of the body frequently injured in the accidents was the upper limb. In the accidents involving sawing machines, most of the damage to an upper limb concerned fingers.
- The most frequent types of injuries amid all accidents were the lacerations. Also, frequent types of injuries were amputations (occurring mainly during the works with the sawing machines) and fractures.
- In case of the group of sawing machines and angle grinders, the injuries sustained involved, in majority, a low percentage of permanent damage to health.
- In the accidents involving combines, the percentages were significantly higher and reached the value that indicated important damage to health leading to the limitation of independent existence.
- The most frequent causes of all the accidents were carelessness, lack of concentration, inattention or the operator's tiredness.

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ANALIZA OBRAŻEŃ OPERATORA  
SPOWODOWANYCH PRZEZ RUCHOME CZĘŚCI  
MASZYN UŻYWANYCH W GOSPODARSTWACH  
ROLNICZYCH

**Streszczenie.** W gospodarstwach rolniczych użytkowane są coraz to nowsze narzędzia i maszyny, które ułatwiają pracę. Brak umiejętności do ich obsługi prowadzi często do wypad-

ków, których efektem są urazy o różnym stopniu nasilenia ciężkości. Przeprowadzono badania obrażeń powstałych podczas wypadków z udziałem narzędzi i maszyn rolniczych na terenie Powiatu Krakowskiego w latach 2005-2010. Zbadano jakie rodzaje obrażenia występują najczęściej, w jakiej grupie maszyn jest najwięcej wypadków, a także oceniono stopień nasilenia ciężkości obrażeń. Najwięcej wypadków miało miejsce z udziałem pilarek, drugą grupą są szlifierki kątowe. Wśród maszyn typowo rolniczych najczęściej zdarzały się wypadki z udziałem kombajnów. Częścią ciała, która najczęściej doznawała obrażeń w wypadkach jest kończyna górna. Najczęstszym rodzajem obrażenia wśród wszystkich wypadków były rany szarpane. W przypadku grupy pilarek i szlifierek kątowych występujące obrażenia w większości mają niewielki procent trwałego ubytku na zdrowiu. W wypadkach z udziałem kombajnów wskaźniki procentowe ulegają znacznemu wzrostowi i osiągają wartość procentową, która wskazuje na znaczne ubytki na zdrowiu prowadzące do ograniczenia samodzielnej egzystencji. Najczęstszą przyczyną wszystkich wypadków jest brak zachowania należytej ostrożności, brak koncentracji, nieuwaga, a także zmęczenie operatora.

**Słowa kluczowe:** narzędzia i maszyny gospodarstw rolniczych, wypadki, obrażenia.

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