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Investigation of tillage elements of agricultural machinery

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Abstract. The efficiency of agricultural activity is significantly influenced by the condition of power machines used in the agricultural production. Among others, the formation and maintenance of suitable soil-conditions play a very important role in obtaining the desired harvest yield. Many types of wear have been recognized such as abrasive, erosive, corrosion, oxidation etc. The abrasive wear in agriculture equipments is the most common problem. The tillage elements are exposed to an extraordinary high load and a significant wear, therefore it is necessary to investigate the relationship between their active layer and durability. Abrasive wear is probably the most significant cause of mechanical damage of equipment components coming in contact with abrasive bodies. The purpose of our research work is to change the old, worn cultivator tines to tines having a longer durability; hot metal powder spray fusing has been used in order to realize our aim. The products made by us will be used in the agricultural production in the future therefore the type of layer build-up technology to be used during the production can be determined. As a cultivator is equipped with a lot of cultivator tines, the expenses can significantly be decreased by the use of cultivator tines made by a well-chosen layer build-up technology and a higher yield/agricultural area can be obtained during the cultivation.

1. Introduction

The size-decrease or breaking as well as the surface quality of parts exposed to significant wear and load can be improved by building up a new surface by using the traditional surface-layer welding [1] and the different metal powder spray fusing technologies [3]. By this, the construction of machine elements can be simplified and it is significant from economical point of view as well as it is not necessary to replace the whole workpiece [2]. A lower specific flame intensity is used during the surface-layer welding; the seams are not deep but they are wide instead.

A significant wear of machines used in the different fields of agriculture can be experienced (Figure 1). As a significant part of people living in Hungary deals with agriculture, it is very important to know how to ensure the cost-efficiency and the efficient agriculture. During the recent period of our research work, hot metal powder spray fusing of cultivator tines has been performed in order to investigate their durability.

Corn-stalk crushing knife and disc of corncob-breaking adapter of corn combine harvester

Cultivator tine used on combinators and cultivators

Figure 1. Worn agricultural machine parts.

2. Hot metal powder spray fusing of cultivator tines

Hot metal powder was built up on the surface of the samples which had been made preliminary for experimental purposes. Our experiments were performed in the Welding Laboratory of Technical Faculty of University of Debrecen. The metal powder was sprayed by using an UTP variobond type hot spraying gun as shown in Figure 2. The hot metal powder spray fusing is a layer build-up method which is based on heating of the initial material up to a liquid or plastic state then it is powdered, accelerated to a certain velocity and delivered to the workpiece – to the basic metal – by means of flame (spraying) [4].

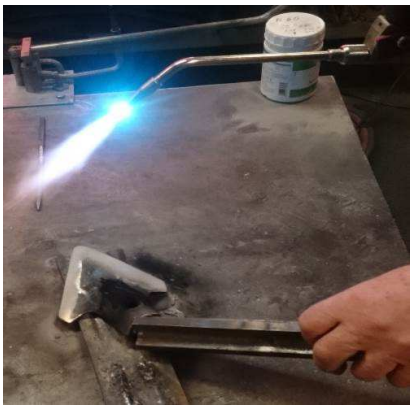

Figure 2. The layer-build-up of alloy powder by means of hot metal powder spray fusing.

In the course of the flame spraying method, the material (wire, rod or powder) placed in the spraying device (gun, burner, etc.) melts or it becomes plastic, passes through the flame and dashes to the surface of workpiece; by this a coherent layer develops. The selection or breaking into particles of the spraying material (rod, wire, powder, etc.) and the increase of their kinetic energy are promoted by a kind of accelerating gas – usually by means of compressed air - it means that the source of thermal energy is the gas flame developing during burning of the oxygen-combustible gas (acetylene, natural gas, propane-butane, hydrogen) mixture [6].

2.1. The process of hot metal powder spray fusing

It is very important to prepare the specimen as no proper bond can develop between the two different materials in case if even a minor contamination can be found on the material. First of all, the impurities were removed from the surface by using an angle grinder. Then the workpiece was heated to a temperature of around 250-300 °C. It is called a wetting process. The proper choice of basic material is very important in order that a suitable bond can develop between the powder and workpiece during the hot metal powder spray fusing. During the hot metal powder spray fusing, the workpieces are in a high temperature range therefore the character of cooling is very important in order to ensure the suitable hardness – in our case the workpieces are cooled in open air. The complete workpieces can be seen in Figure 3.

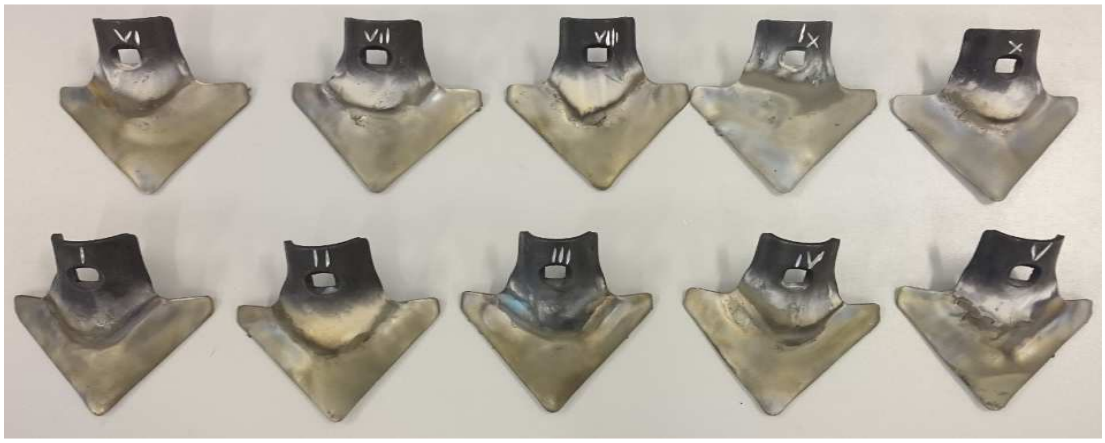

Figure 3. The complete sprayed workpieces.

2.2. Investigation of the build-up layer by a Scanning electron microscope

The basic material of cultivator tines is a C60 grade hot-rolled steel plate. In the course of the hot metal powder spray fusing, the different layers were built up on a steel plate the grade of which corresponded to the material-grade of cultivator tine by this a specimen was made in order to investigate the intermediate layer developing between the build-up layer and the basic material. A sample was taken from the specimen; this sample was imbedded in synthetic resin then it was grinded, polished and etched and investigated by a Scanning electron microscope (Figure 4). Then a photo was taken in order to determine the grain diameter of the applied alloy-powder (Figure 5).

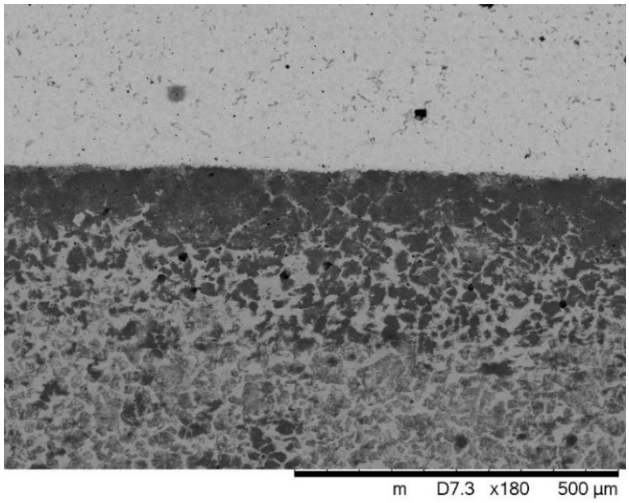

Figure 4. Investigation of the intermediate layer. Magnification: 180x.

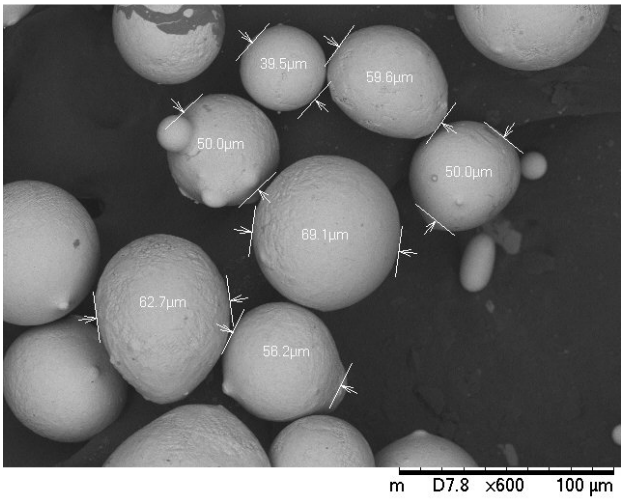

Figure 5. Investigation of the alloy powder (N 60 Mogul powder). Magnification: 200x.

3. The use of complete workpieces for soil preparation

The experimental workpieces were given to János Illyés agricultural entrepreneur in Hajdúszovát who mounted them on the combinator seen in Figure 6 and performed the soil-preparation of a land of 200 hectare. The mass of tines was measured both before using them and after the soil-preparation of the land of 200 hectare. The obtained results are demonstrated in Table 1. The worn experimental workpieces are shown in Figure 7. It can be stated that Sample No. 5 (indicated by red colour in the Table) and Sample No. 7 (indicated by blue colour in the Table) wore in the less extent of the samples treated by hot metal powder spraying. Such a result could be anticipated at these samples as this powder had got the highest hardness (60 HRC).

In case of the samples No. 9 and 10, a powder-type with a hardness of 40 HRC was applied – a significant material loss was experienced at these samples – so we are not going to deal with this type of powder during our further experiments. A scattering can be observed as far as the material-loss of samples treated by the powders of identical types is concerned. It can be explained by the fact that the load of cultivator tines mounted on the agricultural machine was not equal; the tines overlap each other and the tines working in the tractor wheel track were exposed to a higher abrasive power owing to the compression of soil.

Figure 6. Agricultural machine equipped with cultivator tines.

Table 1. The mass of cultivator tines before and after use.

No of sample	Performed procedures: Spray welding by using	Mass of workpiece [g]		
		Before use	After use	Difference
1.	10009 Borro Tec powder	246,89	199,1	46,98
2.	10009 Borro Tec powder	245,82	187,33	58,49
3.	10009 Borro Tec powder	251,57	198,41	53,16
4.	N 60 Mogul powder	248,54	197,34	51,2
5.	**N 60 Mogul powder**	**258,01**	**227,24**	**30,77**
6.	N 60 Mogul powder	248,66	193,21	55,45
7.	**Deloro 60 powder**	**253,49**	**220,09**	**33,4**
8.	Deloro 60 powder	249,83	191,27	58,56
9.	N 40 Mogul powder	265,92	159,05	106,87
10.	N 40 Mogul powder	256,94	184,68	72,26

Figure 7. The experimental workpieces after use.

4. Conclusions

The pre-experiments of long-term research work performed at the Department of Mechanical Engineering of Technical Faculty of University of Debrecen are described in our present paper. In the course of our earlier research work, cultivator tines were made by means of free-forming forging for experimental purposes. The cultivator tines were a wear-proof layer was developed of tines by means of the hot metal powder spray fusing. In order to investigate the durability of these tines, they were given to an agricultural entrepreneur who used them for soil-preparation in real circumstances. By utilizing the results obtained during our present experiments, our research work will be going on in the future as well. The workpieces produced such a way will be used in agricultural circumstances as well in addition the metallographic investigations of these workpieces will also be performed. The research work aiming at the increase of agricultural productivity is of an extraordinary significance as the topsoil is of an excellent quality in Hungary and the agriculture plays a determining role in the economic life of our country.

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