

A Research on Metal and Metallurgical Properties of Chisel Plough Shanks

Zeliha Bereket BARUT¹, Serkan ÖZDEMİR^{1*}

¹ Çukurova University, Faculty of Agriculture, Department of Agricultural Machinery and Technologies, Adana, Turkey

Abstract. Reduced tillage forms a subgroup of conservation tillage. In this system, chisel or disc tools are generally used for primary soil tillage, and milling machines, disc tools or cultivators are used for secondary soil tillage and seedbed preparation. The entire area is tilled so that the plant residues are on the soil surface and prone to the surface. It provides significant fuel and energy savings compared to conventional tillage due to less machine traffic. In order to ensure sustainability, conservation tillage (using a chisel instead of the mouldboard plough that works by turning the soil) as an alternative to conventional tillage and the development of agricultural tools and machines used for this purpose have gained great importance. Chisel is a soil cultivation tool widely used in stubble destruction and conservation tillage system. It is known that the chisel provides significant savings in terms of fuel consumption compared to the mouldboard plough. For a chisel construction that can operate at an optimal level, the basic requirement is to have optimal material quality, optimal weight and optimal cost. In this research, the physical and chemical processes of chisel shanks produced as cast steel were examined. It is of primary importance that it provides minimum fuel consumption with its optimal chemical content, easy mounting to the chassis, unbreakable model structure and angles. A casting and agricultural machinery company that helped with the study was visited and the GS-52 steel casting process, which is widely used for chisel shank in our country, was examined and tensile, yield and rupture tests were performed. As a result, it has been observed that a better construction can be created by changing the chemical content of GS-52 steel. Different trials to be carried out as the continuation of the research will help determine the optimal structure of the chisel shank.

Keywords: Reduce tillage, Chisel shank construction, Material quality.

1. Introduction

Soil tillage, which is considered the first stage of crop production; In short, mechanically changing soil conditions is manipulation of the soil (Figure 1). Soil tillage is applied for purposes such as optimum seed bed preparation, weed control, plant residues on the soil, mixing fertilizer and seed into the soil, soil aeration, preservation of soil moisture, erosion control and agricultural irrigation.*



Figure 1. Conventional tillage application

The losses and problems that soil and water resources have suffered due to human factors based on agriculture for many years have been investigated by researchers in order to protect and ensure the sustainability of these resources, which are of vital importance for future generations. By using conservation tillage (using a chisel instead of the mouldboard plough that works by turning the soil) as an alternative to conventional tillage and the methods used for this purpose. It has gained great importance in the development of agricultural tools and machinery (Ozdemir, 2020).

Reduced tillage forms a subgroup of conservation tillage. In this system, chisel or disc tools are generally used for primary soil tillage, and milling machines, disc tools or cultivators are used for secondary soil tillage and seedbed preparation (Figure 2). The entire area is tilled so that the plant residues are on the soil surface and prone to the surface. It provides significant fuel and energy savings compared to conventional tillage due to less machine traffic.

* Corresponding author: cansa.serkanozdemir@gmail.com



Figure 2. Reduce tillage applications

Chisel, which can be described as a kind of cultivator, is a soil cultivation tool widely used in stubble destruction and conservation tillage system. The narrow tip of the chisel, also called the heavy cultivator, is iron-clad, and it swells the soil by tearing it, without overturning it, and ensures that the stubble remains on the surface. Although it is described as a second-class soil tillage tool with its structure and functions similar to the chisel cultivator, used in places where soil compaction is a problem, at a working depth of 30-40 cm, it is used as an alternative to mouldboard plough in some regions, especially in sunflower agriculture. It is known that the work success is higher and fuel consumption is lower compared to mouldboard plough. It is known that the chisel provides a 50% saving in terms of fuel consumption compared to the mouldboard plough (Yalçın et al., 1997).



Figure 3. Chisel plough



Figure 4. Chisel plough

The chisel consists of 5, 7, 9 or 11 operating organs placed on a roof consisting of two parallel rows (Figure 3,4). There are 3 operating organs in the front row of the roof and 4 operating organs in the back row. In contrast to this arrangement, that is, if there are 4 shank in the front row and 3 shank in the back row, the traction force and the traction force requirement increases. If any shank encounters an excessive load while working in the soil, it prevents damage to the tool or tractor by cutting the safety pin and moving backwards.

The traction force requirement of soil tillage tools increases or decreases depending on the shape of the tool, soil working conditions and advance speed. Generally, increasing the working speed negatively affects the traction force requirement in heavy soil conditions. In evaluating the performance of tools, it is important to determine the speed-dependent traction force requirement of the tools (Kushwaha and Linke, 1996; Manuwa, 2009). In addition, it has been reported by many researchers that the shank indentation angle, individual working widths of the chisel shank and the forward speed, which depend on the shank geometry, have direct effects on the tool performance in soil cultivation (Stafford and Tanner, 1983; Tong and Moayad, 2006; Manuwa, 2009;).

Chisel plough shank subjected to low stress abrasive wear generally made of carbon or low-alloy steels. Since their abrasive wear resistance is dependent on the tribological system, it depends not only on the intrinsic conditions of the material, but also on the soil conditions. The influential factors are: the chemical composition, production history, mechanical properties and microstructure of material; the particle shape, size, the soil strength, density and moisture, and rock and gravel content the relative velocity and impact angle between soil and the shank. Therefore, there is no simple relationship between the abrasive wear resistance and

the common mechanical properties (Yu and Bhole, 1990).

In a study conducted by Gulsoyly et al., they tested 3 different chisel shank (Figure 4). The traction resistance, fuel consumption and work performance of the chisels with different types of shank used in the experiment changed with depth and the differences were found to be statistically significant. In general, as the depth increases, the traction needs and fuel consumption of the chisels increase and their work success decreases. In the trials, the cast-shank chisel (C) was forced in the field, causing the tractor to skid and stopping the tractor's engine. When the fuel consumption at different speeds in only the A and B charts was examined, it was found that the speed increased the traction force, reduced the fuel consumption per unit area and increased the work success. With the increase in speed, a more comfortable plowing process, thus a decrease in skidding and fuel consumption, was achieved due to the easier dynamic flow of soil particles in chisels A and B with parabolic shank, except for chisel C (Gulsoyly et al, 2010) .

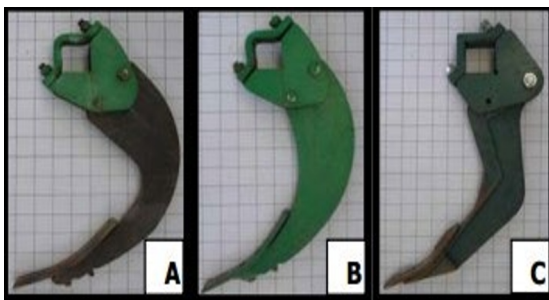


Figure 4. Three different chisel shanks

When designing chisel machines in our country, machine manufacturers use materials with high safety coefficients or increase the wall thickness of the main parts of the machine units, such as the chassis and shank, to prevent possible damage during work in field conditions. Although these measures prevent possible machine damage, they increase the cost and weight of the machine. For a chisel construction that can operate at an optimal level without any problems, optimal material quality, optimal weight and optimal cost should be the main consideration. In this regard, while creating the design of chisel machines, material selection, wall thickness, shank types, upper and lower cap types, end iron types and metallurgical contents were investigated in this study. Common type chisel shank preferred by manufacturers in our country.

In a research conducted by Ahmed and Jabbar (2008), a plough of three different shank shapes was used. These shapes were vertical, inclined forward and curved with two plough depths of 8-12 cms and 13-17 cms successively with three speeds 3.70, 7.15 and 9.64 km/hour. In order to study the effect of the shank shape on the power requirements -which include the draft force, rate of fuel consumption, slippage ratio and the

power loss due to slippage. The main results of this research, The vertical shank outperformed at the first site and the inclined forward outperformed at the second site in recording the lowest requirement with their means, the 8-12 cm depth outperformed at the two sites with their means in recording the lowest power requirement, the 3.70 km/ hour speed recorded the lowest power requirement except fuel consumption at the two sites with their means, The second site (clay loam texture) outperformed records the lowest power requirements (Ahmed and Jabbar, 2008).

It is important that these shank provide minimum fuel consumption with their high steel quality, optimal chemical content, most suitable structure for soil cultivation, easy mounting to the chassis, unbreakable model structure and angles.

2. Methods

The study was carried out in the workshop of a private casting and agricultural authorities company, KOSGEP laboratory and Çukurova University Faculty of Agriculture, Department of Agricultural Machinery and Technologies Engineering. GS-52 steel casting, which is generally used in chisel construction, is prepared according to the following contents (Table 1).

Table 1. Chemical content (%) of GS-52 steel, which is widely used in the production of chisel shank in our country

C	Si	Mn	P	S	Cr	Mo	Ni
0,26 9	0,43 6	0,48 6	0,48 6	0,00 7	0,18 4	0,01 7	0,14 2
Al	Co	Cu	Nb	Ti	V	Pb	Fe
0,01 4	0,01 0	0,07 1	0,00 9	0,00 9	0,00 5	0,00 5	98,3 3

The casting processes used in making chisel shank are as follows (Figure 5).

- Preparation of the mold,
- Molding process,
 - Preparation of steel with chemical composition at 1650° with the help of induction melting furnace,
 - The process of pouring the prepared mineral into the previously prepared mold with the help of a crucible,
- Grinding cleaning and sandblasting process (Figure 5).

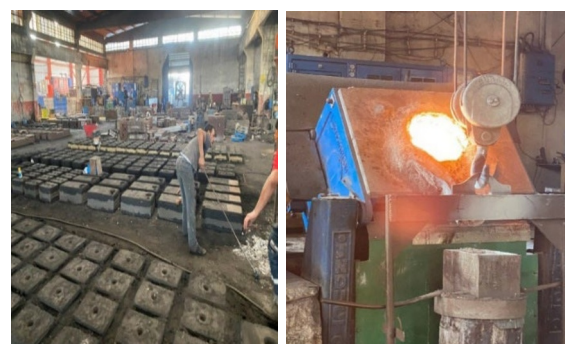


Figure 5. Mold preparation and chemical composition preparation at 1650° with the help of a melting furnace.

Before the tests, the material was heat treated by normalizing at 920° in heat treatment furnaces. A sample called Y block was taken from the melted metal to examine its physical damage and processed according to the test. These processed samples were subjected to tensile tests and notch impact tests in the KOSGEB laboratory (Figure 6).



Figure 6. Samples taken from the melted chemical composition

3. Results

In this study, it is aimed to increase the tensile strength and wear resistance of the steel material used in chisel shank construction; The average carbon (C) rate of GS-52 steel material is 0.26% and the average manganese (Mn) rate is 0.48%. In this study, by adding manganese (Mn) and carbon (C) to the standard steel casting material, the Mn ratio was brought to 1% and the C ratio to 0,4%. Tensile strength, yield strength and elongation at break according to test results;

Table 2. Tensile strength, yield strength and elongation at break test results.

GS-52	Tensile strength	Yield strength	Elongation at break
C; %0,26 – Mn; %0,48	526 N/mm ²	438 N/mm ²	%20
C; %0,4 – Mn, % 1	620 N/mm ²	580 N/mm ²	%24

According to the test results, the tensile strength was increased up to 620 N/mm², the yield strength was increased up to 580 N/mm² and the elongation at break was increased up to 24% (Table 2).

4. Conclusion

Chisels can be described as a kind of cultivator, is a soil cultivation tool widely used in stubble destruction and conservation tillage method. It is shown that the chisel provides a 50% saving in terms of fuel consumption compared to the mouldboard plough. In this study, it was aimed to increase the tensile strength

and wear resistance of GS-52 steel used in chisel shank construction as a result of metal and metallurgical changes. When the C and Mn contents of the steel material were changed, changes occurred in the tensile strength values. Although increasing the C ratio increased the hardness of the material, it also increased its brittleness and the flexibility of the material decreased. This will reduce the resistance of the chisel shank against sudden impacts during operation and cause it to break. Increasing the Mn content increases the impact resistance of the material and will ensure safer operation of chisel shanks in hard and resistant soils.

It is important to continue similar studies to develop abrasion and breakage resistant chisel shank material and appropriate shank shape by using different alloys in different proportions.

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