

Determination of Wear Characteristics of Drill Cultures of Precision Drilling Machine Made of Different Materials

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Abstract : For the determination of the long life and economical material of drill cultures, 27 cast chromium materials, two Ni-hard 4 cast material produced at different times, C 1050 (C 45) cast material, materials produced by filling worn C 1050 materials with Oerlikon Citadur 600 B hard filling electrodes and grinding in regular ranges, were tested. The experiments are performed by 5 rows mechanical precision drilling machine. 8 sets of drill cultures were marked distinctively in order to be recognized later, their initial weighs were taken, and mounted randomly to the mostly used precision drilling machines in Afyon and Bor Sugar Factories. After the finishing of the sowing phase, drill cultures were cleaned and weighed again. The differences between the initial and last weighs were compared by calculation of wear amount according to the unit surface and the distance. As the result of this research: Drill culture blades produced from 27 chromium materials were determined to be 44% less worn comparing to Ni-hard 4 (1), 61 % to Ni-hard 4 (2), 90% according to the blades filled with Citadur 600 B and 306% comparing to the C 1050 wrought iron material .

Key Words: Sugar beet, Drill culture, Wear amount, Precision drilling machine, cast material, wrought iron material, filled material

Farklı Malzemeden İmal Edilmiş Hassas Ekim Makinesi Balta Ayaklarının Aşınma Karakteristiklerinin Belirlenmesi

Öz: Balta ayak bıçak malzemesi olarak kullanılabilecek uzun ömürlü ve ekonomik bıçak malzemesi belirlenmesi amacıyla; 27 Krom döküm malzeme, farklı zamanlarda imalatı yapılmış iki farklı Ni-Hard 4 döküm malzeme, C 1050 dövme malzeme, Aşınmış C 1050 malzemelerin Oerlikon Citadur 600 B sert dolgu elektrodu ile doldurulması ve normal ölçülerde taşlanması ile oluşturulan dolgu malzemeden oluşan beş farklı malzemeden imal edilmiş balta ayak bıçakları denemeye alınmıştır. Denemeler beş sıralı mekanik hassas ekim makinesi ile yapılmıştır. Denemeler için hazırlanan 8 takım balta ayak, tanınması için özel olarak işaretlenerek ilk ağırlıkları alınmış ve Afyon ve Bor Şeker Fabrikaları ekim sahalarında en fazla ekim yapan makinalara tesadüfi olarak monte edilmiştir. Ekim sonrasında balta ayaklar temizlendikten sonra ikinci ağırlıkları alınmış ve aradaki farktan birim alan ve mesafe başına aşınma miktarları hesaplanarak karşılaştırılmıştır. Araştırma sonucunda; 27 Krom malzemeden imal edilmiş balta ayak bıçaklarının, Ni-Hard 4 (1) malzemeden imal edilmiş bıçaklara göre % 44, Ni-Hard 4 (2)' e göre % 61, Citadur 600 B ile doldurulmuş bıçaklara göre % 90 ve C 1050 malzemeden dövme olarak imal edilmiş malzemeye göre % 306 oranında daha az aşındığı belirlenmiştir.

Anahtar Kelimeler: Şeker pancarı, balta ayak, aşınma miktarı, hassas ekim makinesi, döküm malzeme, dövme malzeme, dolgu malzeme

Introduction

To grow qualified agricultural crop is only possible by providing optimum conditions. The life of agricultural machines and devices depend mostly on their style, features, type of usage and maintenance and repair conditions. The kinds of the materials used to produce those machines are as important as the proper usage and maintenance, since they have to work on very different conditions.

The choice of materials of agricultural machines which contacts with the soil are closely related to manufacturing techniques and heat treatments. The improper selection of material brings a lot of additional problems in functioning the machines and the devices.

The repair works of processing components are usually because of breaking and wear. The wear amounts in testing different soil cultivation machines were

determined as: 150 g/ha for plough share, 90 g/ha for cultivator and duckfoot cultivator, 135 g/ha for the harrow tines (Keçecioglu and Ulusoy 1975). Owsiak (1999) has mentioned that the wear in sandy soil is 40-100 % more than the wear in clay.

The principal factors that affect the performance of steel are the bonds between crystals, resistance to wear and hardness. The amount of wear of the materials depends on its chemical composition, alloy amount, crystal structure and the type of heat treatment as well as its dimensions. According to this, the wear amounts of different materials are different. If different heat treatments are applied on the same different materials, their hardness values change. The increase in hardness decreases the wear but in the same time increase the fragility of the material. Therefore hardness is not the only criteria in determining the type of the material against the wear (Kantarci 1982).

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In agricultural machinery, because of the variable loads on the parts which are in direct contact with soil, materials are continuously subjected to wear. In order to reduce the wear amount, as well as being hard enough and resistant to breaking the material should be provided to be intensity enough by heat treatments (Ulusoy 1977).

The sugar-beet is a plant that produces sugar by using solar energy and nutrients in soil. Sugar beet has to be used in an optimum way the solar energy and nutrients in soil to maximum sugar production. In order to achieve this aim, for the purpose of ensuring equal living space to each plant, sugar beet seeds have to be planted on the same depth by leaving equal space in the rows and between the rows.

These conditions could be guaranteed by the performance of the precision drilling machine and controlling the wear amount of drill cultures that occurs according to the working time of the sowing machine.

The only and the most important connection between soil and the unit is the drill coulter. Homogeneous sowing depth is an important factor for the maximum crop germination. That's why the wear on the coulters has a negative effect on sowing quality. Fletcher (1984) has examined the wear characteristics of drill cultures on 13 different regions in England, especially on soils which have high wear effects such as sandy, sandy loam, sandy clayey and stony soil. During his researches, Fletcher has used Stanhay 5 rows and Webb style sowing machines.

At the end of 3000 acres of sowing he concluded that drill cultures made of ceramic material has 3 times long life and better performance at the final field emergence comparing to steel material.

Although preventing wear on the soil cultivation machine is impossible, it is possible to reduce the wear such as choosing the right material and applying heat treatment. The choice of material and the heat treatment can only be determined by the examination results (Ulusoy 1977).

Generally, it is hard to suggest an ideal material which can be used in manufacturing drill culture. But the most appropriate way is to choose the most suitable materials for working conditions according to soil conditions.

In this research, it is aimed to determine the most economical and long life blade material which can be used as drill culture material.

Materials and Methods

Field experiments were carried out in Turkish Sugar Factories Corporation, Afyon and Bor Sugar Factories sowing fields in 2004. Both fields are in Central Anatolia and have the continental climate conditions. Summers are warm and dry, winters are cold and rainy. The precipitation and temperature differs considerably comparing to night

and day, months and seasons. The warmest months in this region are July and August (35/37 C), the coldest months are January and February (-13/-15 C). The mean annual precipitation is about 400 mm.

In this experiment: Ni-hard 4 cast material manufactured in two different times in conformity with DIN 1695 (G-X 300 CrNiSi 9 5 2, material no: 0,9630), wrought iron material of C 1050, filled material manufactured by filling Oerlikon Citadur 600 B hard filling electrode and regular grinding of worn C 1050 material, 27 cast Chromium (G-X 300 CrMo 27 1, material no: 0,9655) are used as drill cultures.

After completing the heat treatments, all drill cultures were cleaned and marked significantly and specifically in order to be recognized for the test. Later each drill culture was weighed with 0.001 g of accuracy. Four sets of drill cultures were prepared with each set containing one of different drill cultures manufactured before and were distributed to fields from the districts of Afyon, Emirdağ, Bolvadin and center of Afyon Sugar Factory and to fields Aksaray, Eskil, Sultanhanı, Yeşilova districts of Bor Sugar Factory. Drill cultures were mounted randomly to the precision drilling machines in these fields and used as much as possible in sowing till the end of the season.

Soil samples were taken from the regions in which sowing machines worked and the texture and the amount of organic material of these samples were determined. The soil classification of the research area are Fluvisol soil texture, amount of organic materials and amounts of sowing per machine for each region are given in Table 1. At the end the sowing season all drill cultures were dismantled, cleaned and after-work weighs were taken with 0.001 g of accuracy. Drill culture materials were evaluated according to the criteria such as wear amount, total sowing amount of that machine, soil texture and amount of organic materials contained.

Wear amount of drill culture per unit surface and distance were calculated by these formulas.

$$EAUS = (IW - LW) / SAPU \quad (1)$$

$$EAUD = (EAUS / 22222) \times 10000 \quad (2)$$

Where EAUS is wear amount per unit surface (g/ha), EAUD is wear amount per unit distance (g/km), IW is initial weight (g), LW is last weight (g) and SAPU is sowing amount per unit (ha)

The test material used in manufacturing of drill cultures and the heat treatments applied to these materials were fulfilled as,

1. The drill culture made of C 1050 wrought iron material, drill culture side plates and blades used in all test subjects:

- Hardened in salt bath and tempered to 42-44 HRC as the last hardness.

Table 1. Sowing amount of sowing machines

Factory name	Region	Sowing amount (ha)	Texture				
			% Sand	% Silt	% Clay	Class	Org. Mat.
Afyon	Emirdağ	41,5	29,2	26,60	44,20	Clay	2,33
	Afyon	51,0	42,51	24,21	33,28	Clayey loam	1,99
	Bolvadin	51,5	22,42	24,64	52,94	Clay	1,78
	Merkez	49,0	30,55	42,61	26,84	Clayey loam	2,19
Bor	Aksaray	127,8	38,45	24,17	37,38	Clayey loam	2,33
	Eskil	55,0	31,06	26,70	42,24	Clay	2,19
	Sultanhanı	71,8	47,05	22,22	30,73	Sandy clayey loam	1,37
	Yeşilova	56,6	10,38	33,09	56,53	Clay	1,30

2. Naturally worn drill cultures filled with applied Oerlikon Citadur - 600 B filling weld: without an additional heat treatment, simply obtained by after-welding hardness of 57-62 HRC.

3. In drill cultures blades made of cast Ni-hard 4/1-2

- Blades kept in 780 C for 8 hours in the first stage and cooled in the furnace
- Blades kept in 270 C for 2 hours in the second stage and cooled in the furnace

4. For the drill cultures made of 27 cast Chromium materials:

- Blades kept in 1000 C for 2 hours in the first stage and cooled in air
- Blades kept in 230 C in the second stage and cooled in air

The hardnesses of the tested drill culture blades which were manufactured as casted are given in Table 2 as before and after hardening processes.

The chemical analyses of these materials were performed by Ministry of Industry, Sincan Small and

Medium size Industrial Development Administration and the results are in Table 3.

During this research mechanical precision drilling machine which was developed by the Turkish Sugar Factories Corporation was used.

The above mentioned sowing machine has five rows and working width of the machine is 225 cm. The distance between rows is 45 cm; the distance in the rows is 8 cm. The sowing depth can be adjusted between 0 - 7 cm for every 0,5 mm. The machine itself is 470 kg. The transmission system is the type that the action starts from the central transport pattern. In this research, working speed was chosen as 4 - 5 km per hour and sowing depth as 2 - 3 mm range. The appearance of the drill culture is given in Figure 1.

Table 2. Hardness of cast drill cultures

Material type	Before hardening (HRC)	After hardening (HRC)
Ni-hard 4/1-2	43 - 47	53 - 56
27 Chromium	48 - 52	55 - 60

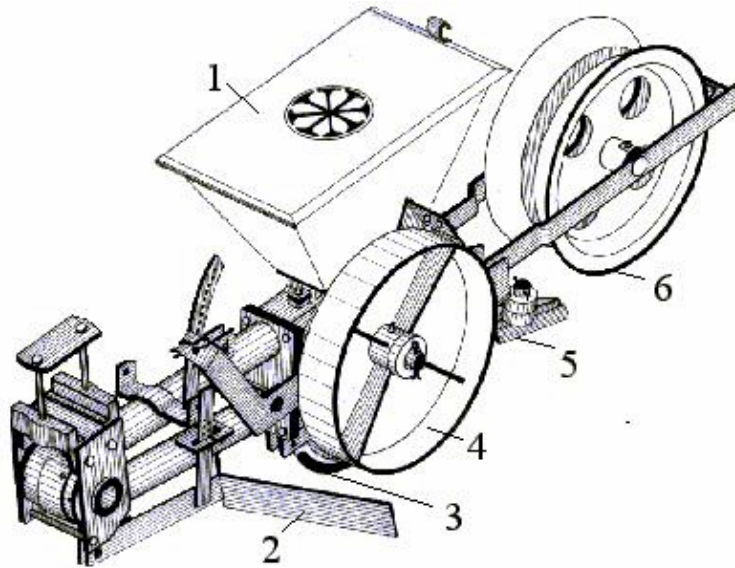


Figure 1. Schematic view of a unit of the precision drilling machine (1. Seed reservoir, 2. Front sweeper and compressor, 3. Drill culture, 4. Depth wheel, 5. Closer, 6. Compression wheel)

Table 3. Chemical analysis results of drill culture blade materials (%)

	C	Si	Mn	P	S	Cr	Mo	Ni	Fe
Ni-hard 4/1	3,390	1,260	0,806	0,024	0,015	10,200	0,202	6,580	Rest
Ni-hard 4/2	3,310	1,830	0,666	0,018	0,030	9,020	0,135	5,780	Rest
27 Chromium	3,110	0,420	0,802	0,009	0,012	27,508	1,201	0,410	Rest
C 1050 (C 45)	0,460	0,223	0,878	0,018	0,025	0,072	0,030	0,115	Rest

Results and Discussion

Amount of Wear on Materials

Appearances of unworn and worn drill cultures used in this research are given in Figure 2. In Table 4 and Figure 3, material of drill culture, initial and last weights of the cultures, total amount of wear, and amount of wear per area and per km of 40 drill cultures tested in this research are shown.

In this research, the biggest amount of wear is found to be on C 1050 (C45) material as 0,759 g/km. The lowest wear amount is obtained from 27 Chromium material and the result is 0,248 g/km. If the real wear amounts are evaluated, it is seen that C 1050 (C45) material appears to

have three times greater value of wear than of 27 Chromium material. There is no statistically significant difference on wear amount of 27 Chromium, Ni-hard (1 and 2) and filling welded Citadur 600. However the difference between 27 Chromium, Ni-hard (1 and 2) and C 1050 (C45), Citadur 600 and C 1050 (C45) were significant according to variance analyses and Least Significant Difference (L.S.D.) method ($p < 0,01$, $p < 0,05$ respectively).

Soil Texture versus Wear Amount Relation

The soil texture and organic material amounts where the experiment was carried out are given in Table 1. The amount of wear for determined textures are shown in Table 5 and Figure 4.



Figure 2. Appearances of unworn (a) and worn (b) drill cultures used in this research. (1. C 1050 (C45), 2. 27 chromium (G-X 300 CrMo), 3-4. Ni-hard 4/1 and 2 (G-X 300 CrNiSi), 5. Citadur 600 B)

Table 4. Measurement values of the tested drill cultures

Drill culture material	Initial weight (g)	Last weight (g)	Difference	Average Wear amount (g/km)	Average Wear amount (g/ha)	Real (actual) wear amount
27 Chromium	829,660	823,530	6,130	0,248 a	0,551 a	100
Ni-hard(1)	827,420	818,810	8,610	0,357 a	0,794 a	144
Ni-hard(2)	848,570	838,420	10,150	0,399 a	0,887 a	161

C 1050	774,310	753,760	20,560	0,759 b	1,686 b	306
Citadur 600 B	714,090	702,070	12,020	0,470 ab	1,045 ab	190

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Table 5. Amount of wear on materials according to soil texture (g/km)

Texture	Material type				
	27 Chromium	Ni-hard 1	Ni-hard 2	C 1050	Citadur 600 B
Clay	0,174	0,303	0,335	0,549	0,388
Sandy clayey loam	0,109	0,126	0,243	0,850	0,320
Clayey loam	0,393	0,507	0,536	1,007	0,630

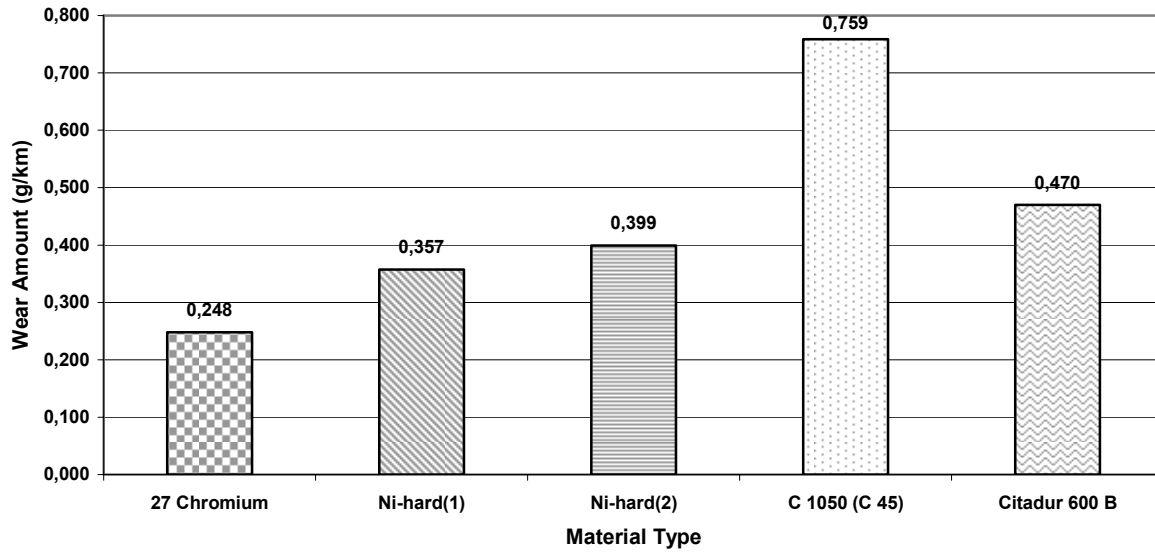


Figure 3. Wear amount of drill cultures manufactured from different materials (g/km)

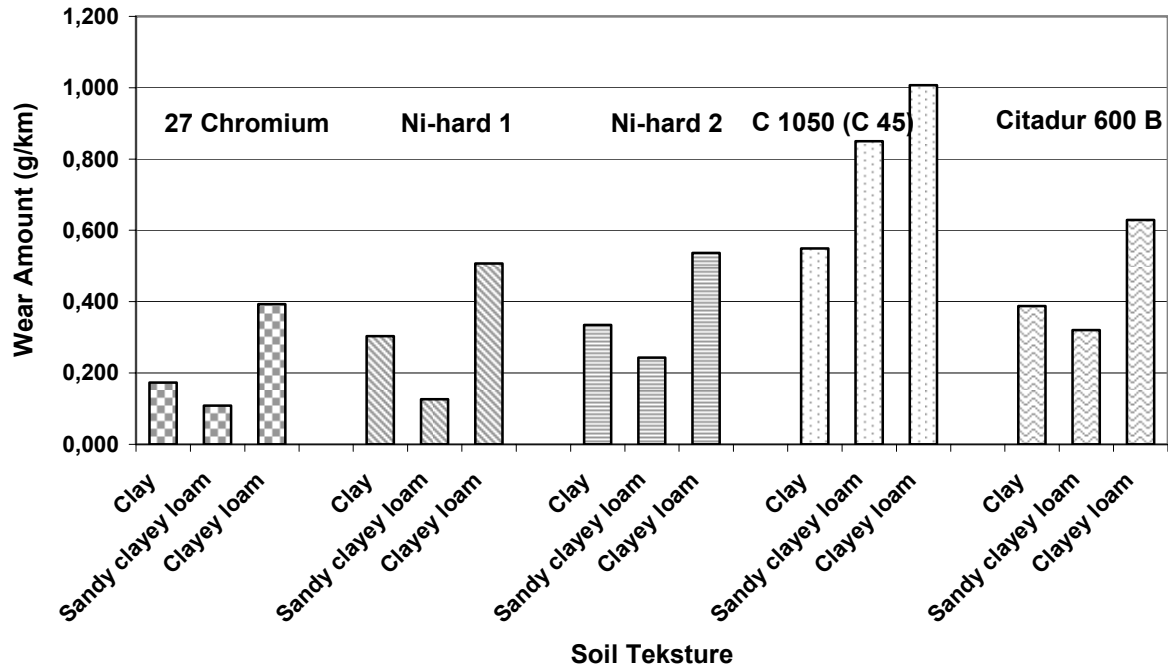


Figure 4. Amount of wear on materials according to soil texture

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The evaluation of the results according to soil texture are 227,8 ha for clayey loam soil, 204,6 ha for clayey soil and 71,8 ha for sandy clayey loam soil. As the expected result: 27 Chromium, Ni-hard (1 and 2) and Citadur 600 B materials showed increasing amount of wear in parallel to the increasing sowing amount, although C 1050 (C45) material was less used in sandy clayey loam soil but showed more wear.

Conclusion

Because the reason that each tested material was used in a different sowing machine, results were evaluated according to each sowing machine. As can be seen from the studies on Table 4, Table 5 and Figure 3, Figure 4 wear amounts on drill cultures made of 27 Chromium material are generally less than the wear amounts on Ni-hard 4 (1-2), material filled with Citadur 600B hard filling electrode and drill cultures manufactured from C 1050 material.

According to the results obtained from this experiment, it could be stated that the total wear on the drill cultures of a machine is an indication of resistance to wear of the material used in manufacturing the drill culture blade.

According to the this, if the wear amount on 27 Chromium material is accepted as a basis and if that amount is assumed to be 100, then the wear amount of Ni-hard 4 (1) corresponds to 144, Ni-hard 4 (2) to 161, materials filled with Citadur 600B to 190 and material made of wrought iron C 1050 to 306. In other words; Ni-hard 4 (1) shows a wear amount of 44 %, Ni-hard 4 (2) 61

%, materials filled with Citadur 600B 90 % and wrought iron C 1050 material average 306 %.

In the evaluation on the basis of the average wear amounts of drill cultures used in the same sowing machine and with drill culture blades made of cast 27 Chromium material, the difference between average wear amounts of cast 27 Chromium material and wrought iron C 1050 material is found to be statistically important ($p < 0,01$).

According to the statistical evaluation of the results, it is possible to state that the drill culture blades made of cast 27 Chromium has 206 % long life than the blades made of wrought iron and heat treatment applied C 1050 material (Table 4). According to this result, in the case of manufacturing drill culture blades from cast 27 Chromium material will increase the life of drill cultures at least one times. Reduction of wear of drill cultures will increase sowing quality and remove the expenses of workmanship changing the drill cultures and filling electrode work ship during/after the sowing.

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