Metallurgical Study And Performance Evaluating Of Integrated Steel Moldboard Blades In Wearing Dry Sand - Steel Wheels Test

RohollahMohammad Sanabadi Aziz[1]
Researcher
Jihad Institute of Engineering
Mashhad, Iran
rohollahmohammad@yahoo.com

***Abstract*— one of the oldest instruments used for tillage is moldboard plow. The main tasks of the plow are cutting, removing and restoring the soil. Blade is the most important and needed of moldboard plow. In Iran, the lack of attention to build plow blades with a proper quality create the problems such as decrease of tillage depth and hardening the surface layer which lead to decrease productivity. The blades made of poor quality material causes severe wear blades and decrease their useful life that also imposed an enormous cost to the agricultural. This study is surveying four imported moldboard plow blades and comparison with two domestic ones, introduction the proper blade in side of wear resistance and compared with the local production as the most important gained results.**

Keywords— Cutting blade, Moldboard plow, wear.

Introduction

Self-sufficiency and independence in strategic agricultural products such as wheat, rice and others are of the important government's goals. Agriculture takes account as one of the countries' development causes' and is a criterion of their independence. As a result, for reaching this aim, all determinative reasons should be considered.

Tools and agriculture machines are the main reasons in developing planting, cultivating and harvesting agricultural products' stages and the countries that use the proper and advanced machine and tools may produce supreme quality and higher harvest from their farms.

The instruments exerted in tillage of farms should have fine metallurgical properties such as toughness, hardness, wear resistance, high mechanical strength because of specific applications and soil difficult conditions and moldboard blade as the first part that is placed in contact with soil during plowing Should have an acceptable metallurgical properties such as hardness and high wear resistance and good toughness to prevent failure of the impacts of barriers and large rocks and the proper role of it cause acceptable depth of planting and have great effect on the plow performance later [2,5].

In Iran, because of the lack of attention to making plow blades with proper quality, problems are created such as tillage depth decreasing and hardening the surface layer of the ground that decrease the productivity of agricultural lands. The blades made of poor quality also because severe wear blades and their useful life decreasing that apply enormous cost to the agricultural sector. Soil has hard particles that can scratch the surface of the steel and make it wear. Wear is the most important limiting factor for the life of the cutting blades and other tillage tools [4].

According to declaration of technical management and quality control the former Agricultural Machinery Development Board, the useful life of each blades performed in 3 and 4 miner plows are about 30 to 40 hectares for internal and external which is depended on the plow set up, soil, tractor power and other variable factors. If it is assumed the all 13 million hectares of Iranian agricultural land are plowed yearly only once and with a common one-way three miner plows in Iran equipped with an Iranian plow blades, blades consumption number is about 1114300 yearly by considering the average life of a blade of 35 hectares. Since the price of Iranian blades depends on the shape, size, weight, and so on, often are about 30 to 70 thousand Rials with an average of 50 thousand Rials. So, the annual cost of the plow blade wear in Iran is estimated about 56 Milliard Rials. If blade construction technology can be reached with a 20% raise in life span by performing a project, the annual costs caused by wear blades decrease about 10 Milliard Rails with the exploitation and implementation in industry. In addition, the plow blade should have at least acceptable conditions for strength to withstand the stresses and pressure applied the operation [5].

1. MATERIALS AND METHODS

Wear is a surface which is caused by the relative motion of the piece surface respect to one or more materials been in contact with the piece surface and makes plastic deformation and materials' move on the surface or near piece surface and later to separate materials from the surface and the gradual destruction of the piece. The part should have high hardness to deal with this.

All soils have different context and are changing from the fine sandy soils to the sticky and heavy clay ones. In addition, some soils have rocks when impacts to plow and blade causes severe trauma that raise the failure chance of the plows and blades. But, the soil passes on the blade and moldboard causes severe wear of these parts. Plow manufacturers should use raw materials for construction of blade and moldboard that are proportional with the soil where they perform in to reach enough life span. Raw materials used in the manufacture of blade plow can be divided into four groups as cast iron, the integrated steels, three-layer steels and steels with a hard coating layer [2, 5].

1.1. RAW MATERIALS SELECTION

Using cast iron has no technical and justification and is not recommended because it is fragile, especially in dealing with large stones and because of the limits of casting technique than other manufacturing methods. Although a three-layer steels are suggested in heavy-sticky soil lands, but they cannot be offered in the Iranian territory which are mostly dry, alkaline salt and young with a high percentage of coarse sand and gravel. Using the hard-coated steels are not recommended for most agricultural soils and only use for the most abrasive conditions, including sharp sandy and sticky mud-rock soils because of a costly and no economic justification for public use and is recommended as a complementary approach in special mentioned cases. The application of integrated steels are counseled to the economical and cheap raw materials and top choices of using different alloy steels.

1.2. The criteria for selection of proper materials in the blades

An integrated steel group was selected to their traits like cheapness and economy, the higher right to choose in using different Alloy steels, and the more general use in the blade's make. Then, by buying four samples of the integrated steel plow blades which their use is common in Iran and by farmers, the stages were carried out such as cutting, test samples' construction and test experimentations as wear, hardness, chemical decomposition to find out the alloy composition, metallographic and impact experiments, microscopic structure determination and grain size. The proper blade was introduced and chosen by comparing the test results.

Plow blade should have high wear resistance to reach enough lifetime or have few wear during performing conditions from one side, and on the other hand it must have proper influence resistance to failure in dealing with obstacles and rocky. Since Iran's arable land is geologically young, rocky rate is high; as a result, the influence resistance and wear resistance is of special importance.

Because of, the main criteria to select a blade having a long life are materials that have many wear and influence resistance as much as possible simultaneously. But since all metallic materials especially steel, wear and influence resistance are dependent on material hardness and as raising in hardness makes wear resistance higher while influence resistance decrease, in practice, the material selection is not possible with high resistances simultaneously, and only a better choice of these two qualities is possible. At the end, about mentioned contents about the blade material selection in this project, better selection of wear and influence resistance properties were performed and based on the results of wear and impact experiments on four prepared samples of blade, the which had greatest wear and influence resistance was selected as the model and criteria to choose the best made sample.

1.3. Dry sand wear standard test - Rubber wheels

Wear test of rubber wheel – dry sand based on the standard of ASTM G65 is recommended to look at the consumable material wear in the maker of items such as the plow blade which are under wear of scrape type in low stress. This test method includes laboratory examinations to find out the wear resistance of metallic materials against scratches using apparatus of dry sand - rubber wheel. Laboratory reached results by performing this test is to help ranking different materials for scratch wear resistance under named conditions. The test results reported as volume decreasing cubic millimeters helping a certain work method, the substances with less volume decrease have greater wear resistance than others.

Wear test of dry sand - rubber wheels are composed of five proposed methods as follows and according to the wear resistance or the thickness of the material test samples.

Method A: This way that is an intensified and time-consuming one; various metallic materials on a massive scale of the volume decrease and the materials are ranked from few wear resistance to the high. This method is specifically suitable to rank materials from medium too much high wear resistance.

Method B: this method is short-term of the method A and may be used to rank materials with high wear resistance, but is specifically suitable for the ranking the materials with the average and low wear resistance and must be performed if volume decreasing is greater than 100 cubic mL in method A volume.

Method C: This type is the short-term of method A that is used for thin coating.

Method D: In this way, the applied load is lower than that of method A and is useful for ranking the materials with low wear resistance. It is also carried out to rank species of special materials that have a volume decreasing close to each other in method A.

Method E: This type is the short-term approach than the method B, and used to the rankings of medium or low wear resistance.

Because of the rubber wheel rotational speed about 10 ± 200 rpm and the diameter of 6.228 mm (9 inches) in a new and not worn condition, the linear wear distance and approximate time test would be counted.

Table 1. Wear test data in different methods

Method Type	Force Applied To The Test Sample (N)	Speed of Rubber Wheels (rpm)	Linear Wear Distance (m)	Rough Time Test (min)
A	130	6000	4309	30
B	130	2000	1436	10
C	130	100	71.8	0.5
D	45	6000	4309	30
E	130	1000	718	5

Rubber wheels are a steel disc with worn cooked of butyl chloride rubber, have a primary diameter of 6/228 mm (9 inches) at the new method which operation makes wear and diameter decreasing. Rubber wheel has a diameter of 9/215 mm (5/8 inch) which can be usable, and then a new rubber worn should be cooked on the steel disc from approved materials. By rubber wheel diameter decreasing, its speed should be regulated in which the traveled linear distance equal to the linear wear distance as presented in Table 1 or the created volume decreasing using the used wheel is adjusted and corrected to that of the created volume decrease of the new wheel. Wear test of dry sand - rubber wheel includes a standard sample of sand fine particles with a controlled size and composition. The abrasive materials come between the surface of the test sample and a wheel during rotation with a worn made of butyl chloride rubber with some hardness. Sample test is pressed with a certain force applied by a sinker and lever against the rubber wheels during rotation and abrasive material flow causes the wear surface of the sample with controlled and speed. The speed of rubber wheels is in such a way the surface is moving against the sand flow.

Fig. 1. Design and development a wear test of dry sand - rubber wheel

Hardness measurement of rubber wheel should be read at least 4 times in the environment and was carried out in intervals of 90 degrees from each other according to ASTM D2240 test method and a pointer number reading should be done with 5 seconds interval to stabilize the pointer. Abrasive materials should be rounded quartz sand grains with AFS 50/70. Sand with grading is controlled with grading analysis using laboratory made by the ASTM E11 standard.

Table 2. Sand grading analysis of AFS 50/70

The percentage of remaining on the sieve	Hole size sieve (Micron)	Sieve Number
0	425	40
Up to 5%	300	50
Up to 95%	212	70
0	150	100

3.3 Wear test

Wear test blades' specimens was cutting, milling and grinding based on G65 ASTM standard. Specimens' nominal dimensions include: length of 76 mm, width of 25 mm and thickness from 2.9 to 7.8 mm according to the available limit and the exact and measured dimensions by digital caliper is mentioned in Table 3. Determination of several samples with the size of 100 g were performed by a shaker equipped with the screens of mesh numbers of 40, 70, 50, 100 for 3 min, which results are presented in Table 4. This table shows the results of three trials and the average grain size also the average and corrected value of gradation as a total of one hundred percent. Because of differences in grading of the samples, tests' repetition and the report of average a grading are needed in a few experiments.

Table 3. The dimensions of the blades' wear test

Sample	Dimensions (mm)		
	Length (l)	Width (w)	Thickness (t)
A	76.1	25	2.9
B	75.85	24.95	3.9
C	75.75	25	2.95
D	75.95	25	7.8

Table 4. Grading analysis of sand (%)

Screen number	Test number			The average value of gradation	The mean value and corrected grain
	1	2	3		
40	0.18	0.06	0.13	0.13	0.13
50	1.42	1.31	1.33	1.33	1.33
70	28.56	30.59	28.42	28.42	28.45
100	59.83	57.43	59.91	59.91	59.98
Under the screen	9.88	10.45	10.09	10.09	10.1
Total	99.87	99.84	99.93	99.88	100

According to the moisture content that is less than 0.5 percent, there is no need to dry consumed sand before experiment. The mentioned measurement was done in hot and dry seasons. If wear tests are carried out in rainfall seasons, it is proper that this is being performed again because of the humidity of the environment and air can make rise in the moisture content the sand. In all performed tests, the samples are rinsed before and after the test with industrial alcohol, water and detergents, distilled water and medical alcohol, respectively. After drying with a laboratory dryer, they will be weighted using a laboratory scale with a sensitivity of 0.0001 grams, then sand volume decreasing and weight loss will be measured. Also, to cutout the created error arising from the wear of rubber wheel and its diameter loss which is led to decrease the linear distance of wear, before running any test, the rubber wheel diameter should be measured using a digital caliper in two vertical diameters and its average value is used to calculate the adjusted volume loss (AVL). In whole tests, the force applied to the test sample is equal to 130 Newton (13.25 kg) which is adjusted using potentiometer by placing a Sinker of 4.5 kg at locating the weights.

1.3.1. Short-term wear test

Wear tests' running cause wear and the diameter rubber wheel losses. After its diameter decreasing to 8.5 inch (9/219 mm), rubber worn baking is needed again. To control and limit the wear on rubber wheel and because of the limits in available rubber wheels number, it was first preferred that samples' was done using method B which is a short-term approach. The measured rubber wheel average diameter was 227.6 mm (8.96 inches) before the start of the short-term tests and its measurement after running any test shows limit changes in the diameter. So after performing the four tests for 4 blade samples, its average diameter decreases merely to 227.4 millimeters and therefore, the average of diameter decreasing is equal to 0.05 mm for each test.

Fig. 2. Rubber Wheel diameter measured by a digital caliper

To run the mentioned tests, the counters and controller of RMP are adjusted to 2000 rpm, then the valve switching of sand flow are opened by placing the sample in the holder and tighten the clamps. The devices is turn on after securing the curtain flow sand and immediately release the lever to place the test sample in contact with rubber wheel. After the performing in controlled rpm, rubber wheel speed is automatically stopped and the test samples are released from the contact of rubber wheel using rising and locking the lever arm, then switching valve is shouted down of sand flow and opened the samples from the clamp to carry out the steps of washing, drying and weighting. It should be mentioned that according to the plow blade models are all steel alloys, in change of weight decreasing of volume loss, the amount a density of 8.7 grams for each cubic centimeter have considered.

1.3.2. Long-term wear test

The results of wear short-term test for both methods of B and D are close to each other, as adjusted volume loss is got 181.15 and 180.84 cubic millimeter, respectively. To have a higher resolution of results, it is preferred the long-term test (Method A) is also carried out. So, the counters and controller of RMP are adjusted to 6000 rpm, and because of the limits of the sample numbers, the tested samples in short-term approach would be used again from the opposite side for the long-term test. So, their primary weight for the long-term tests are the final weight in the short-term tests.

1.4. Hardness test

Hardness was measured from the highest face of samples (76×25) in two coordinate axes X and Y towards width and length of the samples, respectively. In these measurements, the center of the face was considered as the origin with the coordinate of (0, 0) and hardness was evaluated at intervals of 5 mm from each other. Hardness was first performed by Rockwell C procedure. But, because of the both reasons of grading limit and divisions in the Rockwell C scale which is leading to a decrease in measurement accuracy, the need of using other hardness methods for the blade No. D and according to the lack of coverage of the soft metal material hardness in Rockwell C, Vickers approach were preferred to repeat hardness measuring. The blade samples' hardness range changes that are equal to the minimum to maximum measured hardness and is measured the average hardness. Also, using a change table for the hardness of Vickers - Brinell - Rockwell and tensile strength [6], the hardness range of A, B and C samples could be measured as the high hardness level with Rockwell C method and for the sample of D could be measured low hardness according to the Rockwell B method. The average tensile strength of blades could also be estimated with the average hardness. Samples blades of D, C, B, A is cut crossly and the cutting surfaces is flattened by grinding. Then, hardness measuring was performed in longitudinal direction and along the centerline of sections and in the transverse direction and in the wide cross-section using both methods of Vickers and Rockwell C at intervals of about 5 mm from each other. Fig. 3 shows the scheme of the Krat-kramer hardness measuring during hardness measuring of the samples and Fig.4 shows a picture of the cut-off sections of the blades.

Fig. 3. The Krat-kramer hardness measuring during hardness measuring of the samples

Fig. 4. The cut-off sections of the blades

Impact test and determination of impact strength

The sampling, developing of Charpy impact test's specimens and running the impact test were carried out on the available plow blades. Since setting up samples with finish of 10×10×55 mm was not possible because of limiting the available plow blades' thickness, the sample with the size of 6.7×10×55 mm was build according to ASTM A370 standard. Fig.5 shows the impact test.

Fig. 5. The impact test

1.5. Metallographic and microscopic determination

The polishing stage was done to detect the microscopic structure of blades after cutting and metallographic sample preparation using cutter disc device, then the samples were etched by using a special solution. Etching solution used for whole samples is Nital solution (Nitric acid in alcohol).

1.6. Farm Blade Test

Performing the Farm blade test and evaluation of the blades' efficiency and performance of blades from different sides such as the wear value, no failure and impact tolerance in dealing with obstacles and rocks and over the entire length of their lives merely is possible by comparison of two or more blades. Since arable soils have a high diversity of tissues, the size and available few rocks, soil moisture content, the value of soil density and compaction and other specifications, and many of these features have a significant impact on the results of the farm test, it is needed to sample, measure and report soil characteristics of the farm before starting the test and plowing the farm. In this scheme, after selecting a farm as large as 40 acres, the primary and secondary sampling and measuring soil properties that affect the results of the farm test are performed, then, in a common test, two internal made blades in the project with two blades bought (A) are mounted on a one-way 4 miner moldboard plow and farm experiments are carried out with the selected plowing. Before installing the blades on the plow miner, cleanup operations include oxide removal, decolorization and washing are done and weighting would be reached after marking. After testing, the blades would be removed from the plow and washed and weighted again and the blade weight loss is measured and compared with each other. In installing blades on plows to remove the effects of its installation location on the different plows, constructed blades, M, and selected ones, A, are mounted on the consecutive plows decussately and the chosen farm has divided into four sections and displacement of rotating blades are operated.

Fig. 6. Used Plow (GAK-P-12/4)

Fig. 7. One of the blades mounted on plow miner

Before running the test and after the blades' installation, plow regulation should be finished which include lateral and longitudinal level, adjusting work tilling width and adjusting work tilling depth up to 30 cm.

5. Results and discussions

Table 5 and 6 show results and information about Short-term and long-term wear test of the plow blade samples, respectively.

Table 5. Results and information about short-term wear test of the plow blade samples

Sample	Primary weight (gr)	Final weight (gr)	Weight loss (gr)	Sand flow rate (gr.min^{-1})	Rubber wheel average diameter (mm)	Volume loss (mm^3)	Justified volume loss (mm^3)
A	43.8042	42.6075	1.1967	375	227.60	153.42	154.09
B	58.4113	57.0048	1.4065	370	227.55	180.32	181.15
C	44.4073	43.3162	1.0911	382	227.50	139.88	140.56
D	117.5510	116.1475	1.4035	380	227.45	179.93	180.84
The method B: Rubber wheel speed is 2000 rounds and the applied force is 130 N on the sample							

Table 6. Results and information about long-term wear test of the plow blade samples

sample	Primary weight (gr)	Final weight (gr)	Weight loss (gr)	Sand flow rate (gr.min^{-1})	Rubber wheel average diameter (mm)	Volume loss (mm^3)	Justified volume loss (mm^3)
A	42.6075	39.6448	2.96 27	378	227.4 0	379.83	381.83
B	57.0048	53.5245	3.48 03	372	227.3 4	446.19	448.66
C	43.3162	40.5858	2.73 04	375	227.3 0	350.05	352.05
D	116.1475	112.8214	3.32 61	390	227.2 5	426.42	428.95
The method A: Rubber wheel speed is 6000 rounds and the applied force is 130 N on the sample							

Table 7. Results of hardness measuring test of blades' wear test

Axis	Point coordinates (x, y)	The hardness of the Blades' wear samples of Vickers (H.V)			
		A	B	C	D
X	(-2,0)	560	445	320	260
	(-1,0)	585	505	355	254
	(0,0)	565	495	345	270
	(1,0)	585	445	325	248
	(2,0)	485	415	310	254

Y	(0,-7)	530	500	435	238
	(0,-6)	585	465	370	228
	(0,-5)	555	425	355	216
	(0,-4)	560	500	310	232
	(0,-3)	545	415	280	254
	(0,-2)	675	485	395	240
	(0,-1)	555	480	325	265
	(0,0)	565	495	345	270
	(0,1)	615	495	370	250
	(0,2)	675	470	350	254
	(0,3)	600	435	345	252
	(0,4)	600	485	360	254
	(0,5)	490	510	325	256
	(0,6)	555	470	310	252
	(0,7)	600	465	285	252

Table 8. Changes in hardness, average hardness and blades' tensile strength

Blade samples		**A**	**B**	**C**	**D**
Changes in Hardness	Vickers (H.V)	485-675	415-510	280-395	216-270
	Rockwell C (H.R.C)	48-59	42.2-49.8	29.2-40.3	-
	Rockwell B (H.R.**B**)	-	-	-	94.2-102
Average Hardness	Vickers (H.V)	547	470	341	250
	Rockwell C (H.R.C)	53.8	46.9	34.5	22.2
Tensile Strength	(N/mm^2)	1896	1520	1098	800

Section hardness results show that samples often have a certain hardness profile as the center piece has less hardness while surface have higher hardness. This phenomenon is because of the hardness properties of steel alloys used in the manufacture of parts.

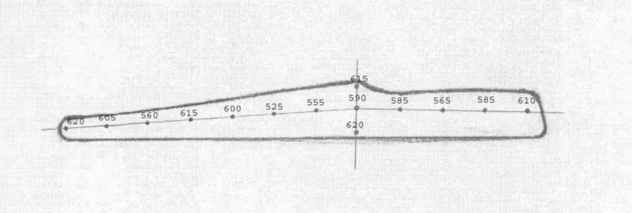

Fig.8. Hardness changes at the cross-section the blade A according to Vickers.

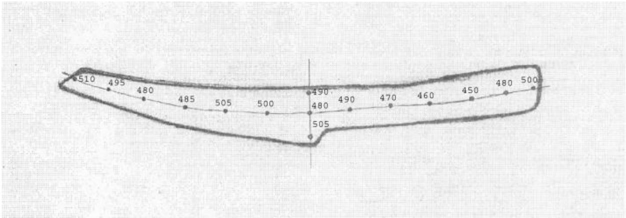

Fig.9. Hardness changes at the cross-section the blade B according to Vickers.

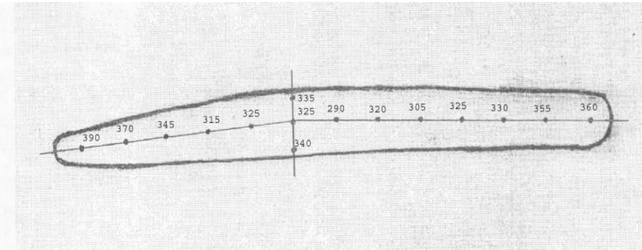

Fig.10. Hardness changes at the cross-section the blade C according to Vickers.

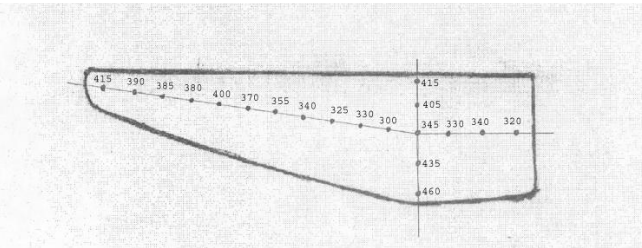

Fig.11. Hardness changes at the cross-section the blade D according to Vickers.

The results of the impact test samples of plow blade are provided in Table.9 and it could be seen that the blade of D has the highest influence resistance while the blade C has the lowest one.

Table 9. Blades' impact strength

Sample	**Impact Strength (J)**
A	8.9
B	7.6
C	5.1
D	14

6. Conclusion

While speed of rubber wheel in long-term wear test is 3 times higher than the short-term, test results show the created wear value with the justified volume loss in long-term experiment and for various blades is in about 2.37 to 2.5 times than the short-term ones. So, raising in rubber wheel speed about three times lead no same raise in samples' wear. This is because of the contact the rubber test sample and raises the contact surface with time passing, and a further wear of the sample.

Comparing the adjusted volume loss (AVL) in long-term and short-term tests shows a higher resolution in a long time results. So, the blades B and D got 448.66 and 428.95, respectively, which represents about 5% more wear in blade B than blade D. But, the short-term wear test results only represents about 0.17% of the difference in the two mentioned samples' wear. So, long-term test results have the higher reliability potential. Fig.12 shows the picture of wear test samples from left to right before and after the short-term and long-term tests, respectively. It also could be seen that the length, width and depth of the wear effect in long-term tests rose toward the short-term ones.

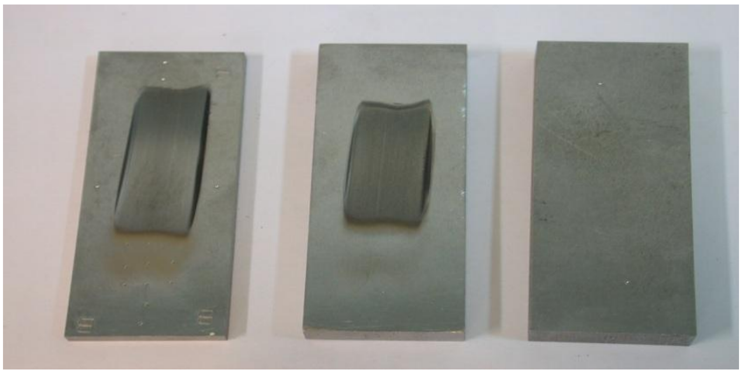

Fig.12. The blade wear samples before and after test running

Table 10. The comparison between different experiments of blade samples

Blade sample	Wear (mm^3)	Average hardness (Rockwell C)	Impact strength (J)	Microscopic structure	No. grain size
A	381.83	53.8	8.9	Tempered Martensite	10.3
B	448.66	46.9	7.6	Tempered Martensite	9.2
C	352.05	34.5	5.1	Perlite	10.3
D	428.95	22.2	14	Perlite & Ferrite	8

Surveying the experiments' results show that raising the samples' hardness from D to A, and without considering microscopic structure do not cause decrease in the wear value and the microscopic structure plays a decisive role in the wear value and influence resistance. For instance, despite the specimen, C has an average hardness less than the samples A and B because of the perlite microscopic structure shows the minimum wear value or the most wear strength. This sample has also the least influence resistance. But the comparison between the samples A and B with the tempered marten site microscopic structure show that the hardness raises in sample A rather than B cause decreasing in its value and this raising could an important role in wear decrease. The sample D with the microscopic structure of perlite and ferrite shows the maximum influence resistance by comparison the specimens' results and the ferrite phase leads to sharp rise in influence resistance compared with the sample C with 100% microscopic structure of perlite, but the wear value far enhance in this sample on the other.

Table 11. A comparison of wear level and influence resistance of the samples' blade

Sample	Wear value (mm^3)	Influence resistance (J)	Wear value ratio to that value in the blade C	Blades' Influence resistance ratio to that value in head of the blade D
A	381.83	8.9	1.084	0.636
B	448.66	7.6	1.274	0.543
C	352.05	5.1	1	0.364
D	428.95	14	1.218	1

Table 11 shows the blade C and A could be the first choice for wear resistance with the lowest wear and the second one of about 8.4% wear, respectively. This is while the head of blade D with 21.8 % and B with 27.4% more wear rather than blade C could not be the proper choice from this side. But, although the blade C has the lowest wear or the highest wear resistance, its influence resistance has least so its amount is only equal to 36.4% of the blade D value thus it is not a good choice in this respect. The blade A that is the second blade with wear resistance is in the end considered and suggested as the best selection in both respects of influence and wear resistance according to the higher influence resistance rather than blade C. To verify the accuracy of the mentioned estimation after the farm test, washing and weighting blades operating reinstalling of them is prepared and continued plowing in the other farm next to the selected farm which the blades had enough performance about 80 hectares. Therefore, it could be concluded the life span of the blades mounted on a plow is equal to each blade life of the plow multiplied by the number tilling and the longevity of the blades could be raised by applying more tilling or replaced after plowing a greater area.

References

[1] Khrushchev, M. Principles of abrasive wear. Wear, Vol 28, 1974. Pp: 69-88.

[2] Mansouri Rad, D. Tractor and agricultural machinery. 1st Edition. Vol.1. Bo Ali Sina University Publication. 1989.

[3] Rabinowicz, E. Friction and wear of materials. 2nd edn. John Wiley and Sons, U.S.A. 1995. Pp: 315-328.

[4] Sari, N. Y .and M.Yilmaz. Investigation of abrasive and erosive wear behavior of surface hardening methods applied to AISI 1050 steel . Science Direct. Material and design. 2004.

[5] Shafiei, S.A. Tillage machinery. 1st edition. Center of University publication. 1995.

[6] V. Gast. Steel standards and tables (steel key), translated by Vlinedjad A. Tarrah publication. 1999.

[7] www.Bellota.com

[8] Yilmaz, B. Reduction of wear via hard facing of chisel plow share. Science Direct. Tribology International. Vol 39, 2006. Pp: 570-574.