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Use of Multiple Linear Regression Technology in Controlling the Technical Specifications of Industrial Products: Predicting the Mechanical Specifications of the Products of the Longitudinal Rolling Factory of the LISCo

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A B S T R A C T

The main objective of this study is to arrive at the formulation of a model through which to predict the mechanical specifications of the products of the longitudinal rolling mill of the Libyan Iron and Steel Company (LISCo), using the multiple linear regression method, and in a simple, accurate manner through which the quality of the products can be controlled within the specifications approved by the LISCo Given the proportions of the added chemicals As a conclusion, the mechanical specifications of the products were predicted from yield stress, tensile strength and elongation ratio, and the error rate in predicting these mechanical specifications was very close to zero.This research also contributes to introducing the LISCo to the importance of prediction models for mechanical properties, which work to reduce the rate of uncertainty, especially with the development of forecasting methods that allow improving the degree of accuracy and help in making sound decisions.

إستخدام تقنية الانحدارالخطي المتعدد في التحكم في المواصفات الفنية للمنتجات الصناعية (التنبؤبالمواصفات الميكانيكية لمنتجات مصنع الدرفلة الطولية بالشركة الليبية للحديد والصلب)

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الكلمات المفتاحية:
الانحدارالخطي
الشركة الليبية للحديد والصلب
منتجات صناعية
توقعات

الملخص

سعينا من خلال هذه الدراسة للوصول إلى صياغة نموذج يمكن من خلاله التنبؤ بالمواصفات الميكانيكية، لمنتجات مصنع الدرفلة الطولية بالشركة الليبية للحديد والصلب، باستخدام طريقة الانحدار الخطي المتعدد، وبأسلوب بسيط، ودقيق يمكن من خلاله ضبط جودة المنتجات في حدود المواصفات المعتمدة لدى الشركة الليبية للحديد والصلب، بمعلومية نسب المواد الكيميائية المضافة حيث تم التنبؤ بالمواصفات الميكانيكية للمنتجات من اجهاد خضوع وقوة شد ونسبة الاستطالة وكانت نسبة الخطأ في التنبؤ بهذه المواصفات الميكانيكية قريبة جداً لصفر. كما يسهم هذا البحث في تعريف الشركة الليبية للحديد والصلب بأهمية نماذج التنبؤ بالخواص الميكانيكية، التي تعمل على التخفيض من نسبة عدم التأكد، خاصة مع تطور أساليب التنبؤ التي تسمح بتحسين درجة الدقة، وتساعد في اتخاذ القرارات السليمة.

1. Introduction:

The industrial and technological development depends largely on the progress in the field of products and their quality, and as a result of this great industrial development that the world witnessed in all fields, the need arose to know the mechanical properties of materials

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with multiple industrial uses so that these characteristics have high quality specifications in terms of resistance to pressure, durability, and submission Tensile, resistance, and mechanical properties in general, in order to predict them, and for their adoption in various industrial applications. The mechanical properties can be divided into the following [3]:

Yield Stress: Yield stress is known as the yield point, a point on the stress-strain curve] [3]. Yield strength is a property related to critical materials, which is exploited by many basic techniques of working materials to reshape materials by pressure (such as: forming, rolling, pressing, bending, and hydraulic shaping) to separate materials by cutting (such as using a machine) or shearing, and to connect elements rigidly to fasteners, the yield load is taken It is the load applied to the center of a spring loaded to straighten its plates [2].

Tensile Strength: It is a measure of how much stress you dance, dances the right way, which then crashes or loses, crashes or outruns, without crashing and can be calculated by the following equation:

$$\sigma = \frac{F}{A}$$

Where:

σ: tensile strength, unit of measurement (newtons/square meter) (N/m^2).

F: the amount of force, the force that pulls the ends of the metal together, the unit of measure (newtons) (N).

A: The cross-sectional area of the metal, unit of measure (square meters) (m^2).

Elongation Ratio: It is a measure of the ductility of a material and is defined from the following equation [3]:

$$\varepsilon = \frac{\Delta L}{Lo} = \frac{L - Lo}{Lo}$$

Where:

ε: elongation ratio.

ΔL: the increase in length.

Lo: is the original length.

L: is the final length.

Prediction/ Forecasting:

Forecasting is the mainstay for the internal planning of the company's policy decisions, as most of the administrative decisions in the facility depend on forecasting directly or indirectly. [4].

Reasons for the rapid spread of the use of forecasting:

Forecasting is based on a number of factors, the most important of which are [4]:

- Continuous progress in models and methods of forecasting.
- Increasing the volume and complexity of the administration's work, which made it more difficult to deal efficiently with decision-making without relying on models that facilitated unraveling the ambiguities of the future.
- The administration has become completely convinced at the present time of the advantages resulting from the use of forecasting, and its feasibility in completing planning processes.

Forecasting Requirements:

Forecasting depends on a set of requirements, the most important of which are [5]:

- Interest in and familiarity with various past historical records related to the demand forecasting process.
- List the factors that affect the sales volume in the past, such as income, advertising, commodity quality and price.
- Develop a visualization of the future activity of sales.
- Review and correct predictions and evaluation for future feedback.
- Determining the dependent demand and the independent demand.
- Attention and full knowledge of competing and alternative goods and their development.
- Taking into account the life cycle of the commodity, while forecasting sales, and at what stage of the cycle the commodity will be, where sales are at their peak in a phase of saturation and this phase is characterized by a degree of relative stability in sales, and in this phase it is necessary to seek the assistance of experts to create new benefits for the commodity, to increase the demand for it, otherwise the commodity will go into decline.

Steps To Prepare The Forecast:

Preparing the forecast is by following these steps [5]:

- **First Step:** Determining the purpose of the forecasting process, [5].

Step Two: Collecting historical data, whether on economic trends from government documents, and Figure (1) illustrates how to collect data [5].

Φ	Weight	Area of Crose - Section in Cm2									
mm	kg/m	1	2	3	4	5	6	7	8	9	1
5	0.154	0.196	0.393	0.589	0.785	0.982	1.18	1.37	1.57	1.77	1
6	0.222	0.283	0.566	0.848	1.13	1.41	1.70	1.98	2.26	2.54	2
7	0.302	0.385	0.770	1.15	1.54	1.93	2.31	2.69	3.08	3.46	3
8	0.395	0.503	1.01	0.51	2.01	2.51	3.02	3.52	4.02	4.52	5
10	0.617	0.785	1.57	2.36	3.14	3.93	4.71	5.50	6.28	7.07	7
12	0.888	1.13	2.26	3.39	4.52	5.65	6.79	7.92	9.05	1.02	11
13	1.04	1.33	2.66	3.98	5.31	6.64	7.96	9.29	10.6	11.9	13
14	1.21	1.54	3.08	4.62	6.16	7.70	4.24	10.8	12.3	13.9	1
16	1.58	2.01	4.02	6.03	8.04	10.1	12.1	14.1	16.1	18.1	2
18	2.00	2.54	5.09	7.63	10.2	12.7	15.3	17.8	20.4	22.9	2
19	2.23	2.835	5.67	8.50	11.30	14.2	17.0	19.9	22.7	25.5	2
20	2.47	3.14	6.28	9.42	12.6	15.7	18.8	22.0	25.1	28.3	3
22	2.98	3.80	7.60	11.4	15.2	19.0	22.8	26.6	30.4	34.2	3
24	3.55	4.52	9.04	13.6	18.1	22.6	27.0	31.7	36.2	40.7	4
25	3.85	4.91	9.82	14.7	19.6	24.5	29.5	34.4	39.3	44.2	4
26	4.17	5.31	10.6	13.9	21.2	26.5	31.9	37.2	42.5	47.0	5
28	3.83	6.16	12.3	18.5	24.6	30.8	37.0	43.1	49.3	55.4	6
30	5.55	7.07	14.1	21.2	28.3	35.3	42.4	49.5	56.6	63.6	7
32	6.31	8.04	16.1	24.1	32.2	40.2	48.3	56.3	64.3	72.4	8
34	7.13	9.08	18.20	27.2	36.3	45.4	54.5	53.6	72.6	81.7	9
36	7.99	10.2	20.4	30.6	40.8	50.7	61.2	71.4	81.6	91.8	1
38	8.9	11.3	22.6	33.9	45.2	56.5	67.8	79.1	90.4	102	1

Figure (1) Data Collection Form [5]

- **Step Three:** Displaying historical data on a graph as in Figure (2), to determine the extent to which there is a certain pattern of data trend [4].

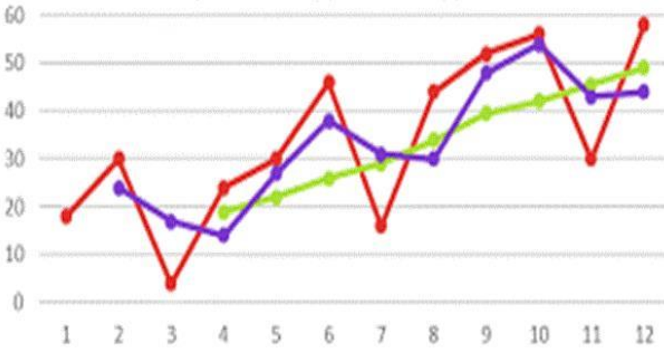

Figure (2) Specific Data Cycle [4]

- **Step Four:** Choosing a forecasting model. There are three main methods of forecasting: time-series models, causal models, and qualitative models. In general, we find that time-series models use historical data for the thing to be predicted to predict future demand values. These models depend on the study of the previous behavior of factors over time and we conclude including what will be in the future, and causal models are used for data on independent variables to develop predictions for dependent variables [5].
- **Step Five:** Conducting experiments that show the correctness of the methods that were used to predict the real values that appeared during the past period, and the method that produces the smallest average error is usually used, and you use it to predict the coming period. There are common measures to measure the error shown in Figure 3, which are the bias error and the average Absolute deviation and relative error, and when the number of the sample is 30 or more, we can judge that the distribution of samples is a normal distribution, and the distribution represents the estimate of the standard deviation of the community [5].

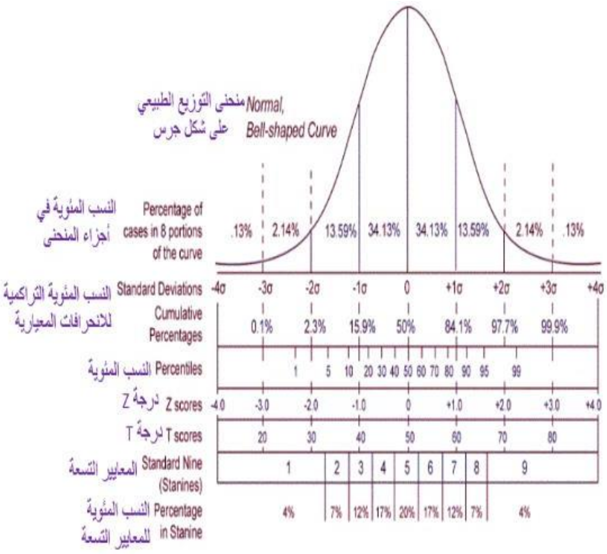

Figure 3 Error Measures [5]

- **Step Six:** The forecast method is used to predict the values of the dependent variables after their occurrence during the forecast period. It is noted here that statistical methods can be applied to create a reliable level of analysis.
- **Seventh Step:** Incorporating the effect of information on internal and external factors.
- **Step Eight:** Follow up on the results of applying the forecast method by recording the actual performance and observing the forecast error.

Forecasting Methods and Models:

1. Quantitative Methods:

Quantitative forecasting methods depend on the use of past data to predict the future, and this is consistent with the popular saying, [6].

A. Time Series Analysis:

The main objective of time series analysis is to identify the changes of the time series and to deconstruct this series in order to make an accurate forecast.

B. Regression and Correlation Analysis Models:

Regression analysis is one of the basic statistical methods in predicting the behavior of economic phenomena in the long run. [6].

1. Simple Regression Analysis Models:

The relationship between the dependent variable and the independent variable is linear, and the regression Equation is as follows and as shown in the Figure (4).

$$Y=a + bx + \mu$$

Y: the dependent variable.
X: the independent variable.
μ: the amount of error.
a,b: coefficients.

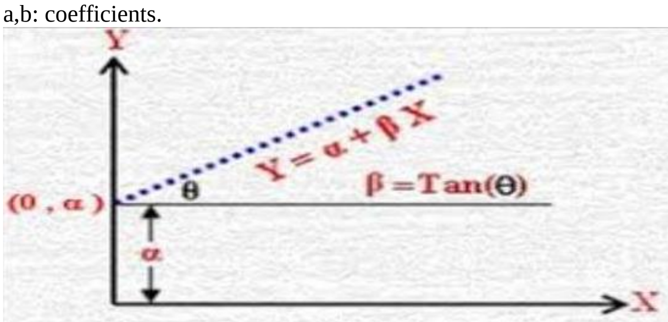

Figure (4) Simple Regression Analysis [6]

2. Simple Time Gap Regression Models:

It often occurs in economic life in the time mismatch between cause and effect, such as the slowing down of the effect of new equipment on the quantity of production, and this issue is called the time delay of the effect of one phenomenon on another, and when taking into account the amount of time units of slowdown, the simple regression model with time gap gives In the following form [7]:

$$\hat{y}_1 = a + bx_{t-L}$$

Where:
Y: the dependent variable.
X: the independent variable.
L: the amount of time units of deceleration (the length of the time gap).
t: time.
a, b: coefficients.

3. Multiple Regression Analysis Models:

Multiple linear regression is one of the advanced statistical methods, which ensures the accuracy of inference in order to improve research results through optimal use of data in finding causal relationships between the phenomena of the research subject, as shown in Figure (5) [8].

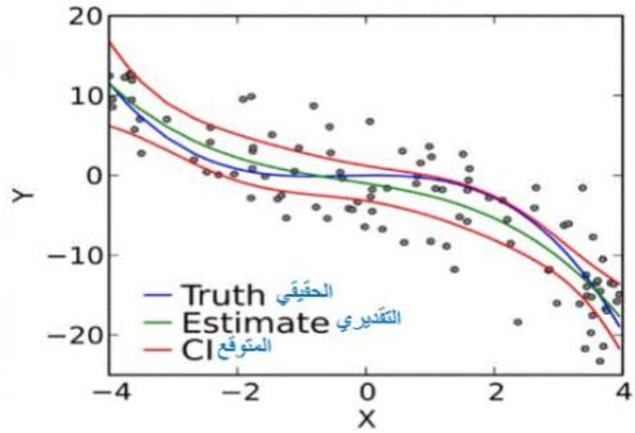

Figure (5) Multiple Regression Analysis [8]

The linear equation for multiple linear regression is [8]:

$$Y=a+B_1X_1+B_2X_2+\dots\dots$$

Whereas:
Y: dependent variable
a: constant value
B_1: the slope of the y regression on the first independent variable
B_2: the slope of the y-gradient on the second independent variable
X_1: the first independent variable
X_2: The second independent variable

Multiple linear regression can be used if the following conditions are met [8]:

- The relationship between the independent variables and the dependent variable must be linear.
- The data should be normally distributed for the independent variables and the dependent variable.
- The values of the dependent variable must be of at least ordinal level.

After obtaining the results of the multiple regression equation, we must show whether these coefficients are statistically acceptable. In order to judge the significance of the regression coefficients, we use the test (T) and the level of probability corresponding to it. It is known that the statistical program (SPSS), which is the program of the statistical and social package, and the language (R) which is a software work environment for computer statistics that allows making statistical applications on the one hand and building statistical programs on the other hand. They will automatically extract a T-test and its corresponding probability level. It will also obtain statistics used to know the overall significance of the model and from it (R), (R2). The first (R) is the simple correlation coefficient, which measures the strength of the relationship between two or more variables, while (R2) is called the coefficient of determination, which is used to find out the explanatory power of the estimated model (estimated equation) in the case of simple linear regression (one independent variable with one dependent variable). [7].

2. Qualitative Methods:

It is a set of objective methods that are used to make a forecast of demand when historical data on demand is not available, and which depends on methods that invest the wisdom and experience possessed by management [9]

1.2 Problem of Study:

The LISCo is considered one of the largest industrial companies in Libya, and due to its high production costs in order to guarantee the quality of its products, which forced it to conduct many checks and mechanical tests for its products, starting with the casting process in the furnace factories, and ending with testing the mechanical specifications of its final products, and that In order to control the quality of its products according to international standards.

1.3 Research Hypotheses:

- There is no relationship between the independent variables and the dependent variable.
- There is at least one relationship between the independent variables and the dependent variable.

1.4 Importance of the Study:

The importance of forecasting is prominent in the institution, and its importance increases according to the increase in the activity of the institution and the volume of sales and production operations in it, as the forecast situation affects the plan that is developed by the company's management to determine the volume of activity. In order to ensure the quality of product , the company perform mechanical tests which result in consuming time, materials, labour force, which is result in high costs., therefore this study was proposed to examine the possibility of using the prediction method to save the large sums spent on the tests conducted.

1.5 Objective of the Study:

We seek through this study to reach the formulation of a model through which the mechanical specifications of the products of the longitudinal rolling mill of the LISCo can be predicted using the multiple linear regression method, and in a simple and accurate manner through which the quality of the products can be controlled within the specifications approved by the LISCo.

1.6 Study Methodology:

In order to achieve the objective of the study, the process of collecting data and information was relied on the following:

- Collecting data, recording, and observations through field visits.
- Applying demand forecasting using multiple linear regression method.
- Analyze the results that realize the aim of the study and my lead to further studies in the area.

2. The LISCo:

The LISCo in Libya is considered a relatively new industry. It is considered one of the largest industrial companies in Libya. It contains 10 production factories and 5 basic facilities. In addition to workshops, warehouses and laboratories, the company also has a wire drawing plant in Tripoli, where the annual design capacity of the company's factories is estimated at (1.32 million tons) of liquid steel and (1.1 million tons) of sponge iron, which has been increased to 1.7 million tons of liquid steel and (1.75 million tons) of hot-moulded sponge iron, [1].

2.1 Production Units:

The company includes the following production units [1]:

- Direct reduction factory (3 units).
- Steel factory (2,1).
- Rolling for bars and skewers factory (4 lines).
- Light and medium sectors rolling factory.
- Hot rolling factory.
- Cold rolling factory.
- Galvanizing line.
- Paint line.

2.2 Supporting Units:

The company includes many auxiliary units and facilities, the most important of which are [1]:

- Port and storage yard for pellets.
- Electricity and water desalination plant.
- An oxygen and compressed air factory.
- A lime factory.
- Central workshop.
- A training center.
- Quality control laboratories.
- A resort and a sea club.

In the context of the company's concern and its tireless quest to respond to the customer's demands, and to impose its position in the international markets among the international iron and steel companies, it has worked to adopt the International Quality Standard (ISO 9001/2000) system and formed a Quality Council for it, to ensure the effectiveness of its application, and to achieve the desired goals, which qualified The LISCo was awarded the 12th European International Quality Award in 1998. It also obtained the Certificate of Implementing the Total Quality System 9001/2000 (ISO) on March 25, 2002.

2.3. Factories:

2.3.1. New Bar Rolling Factory:

The factory includes one new line for the production of bars with a design capacity of (800 thousand tons) of steel reinforcement, sizes (8 mm to 40 mm), where the factory uses bars of size (130 mm-150 mm). It is worth mentioning that those who operated the factory are national cadres within a month June of the year 2017, and Figure (6) shows the Rolling Bars Factory [1].

Figure (6) Bar Rolling Production Factory [1]

2.3.2. Hot Strip Rolling Factory:

The annual design capacity of the factory is (580,000 tons) of hot rolled coils, which are shown in Figure (7), and the commercial operation income is on 05/10/1990.

Figure (7) Products of the Hot Strip Rolling Factory [1]

2.3.3. Cold Rolling Factory:

The commercial operation of the factory began on January 20, 1990, with an annual design production capacity of (140,000 tons) of cold-rolled coils, as shown in Figure (8).

Figure (8) Products of the Cold Strip Rolling Factory [1]

2.3. Mechanical Properties of the Material:

The concept of mechanical properties of a material is how it behaves when loaded, where the elasticity factor of a material affects the amount of deflection under load, and the strength of a material determines the stresses it can withstand before it breaks, where the ductility of a material also plays an important role in determining when a material breaks when it is loaded beyond the limits Their flexibility, and because every mechanical system is subjected to loads during operation, it is important to understand how the materials that make up those mechanical systems behave[2].

3. Study Status:

The importance of forecasting is due to the fact that the company's long-term existence depends on the existence of a continuous demand for its goods or services, and this demand is linked in some way to the general level of economic activity. All management activities must be planned in advance, as well as all management decisions must be anticipated in the light of forecasts future prospects for this activity.And we seek through this study to reach models through which to predict the mechanical specifications of the products of the longitudinal rolling mill of the LISCo, using the multiple regression method, and in a simple and accurate way through which the quality of the products can be adjusted according to the specifications approved by the LISCo, where we took 198 A sample from the LISCo, to prove the accuracy of the prediction results and compare them with the real results of each of the yield stress, tensile strength and elongation ratio. The stratified sample was selected which is groups (DRI reduced iron group, FeMn group, Ferro silicon group FeSi group, Calcium oxide Lime group, Calcium fluoride group DOL, Carbon group C, Silicon group Si, Manganese group Mn), due to the availability of 198 samples. With great accuracy, Figure (9) shows the samples used in preparing and testing the prediction model.

NO	DRI	FeMn	FeSi	Lime	Dol.	C	Si	Mn	Yield Effort	Tensile Strength	Elongation
1	0.93647	0.00745	0.00287	0.04363	0.00319	34	23	81	448	747	20
2	0.93779	0.00729	0.00281	0.04897	0.00313	31	19	75	429	668	17
3	0.66688	0.00729	0.00281	0.04168	0.00313	30	20	74	431	681	18
4	0.93579	0.00753	0.0029	0.0484	0.00323	32	21	70	450	673	21
5	0.95863	0.00729	0.00281	0.0521	0.00313	30	22	72	475	771	15
6	0.9244	0.00886	0.00342	0.05065	0.0038	30	19	80	384	619	20
7	0.93579	0.00753	0.0029	0.04302	0.00323	31	18	77	412	653	19
8	0.59473	0.04248	0.02294	0.08496	0	29	22	76	457	700	16
9	0.84966	0.00959	0.0037	0.05482	0	32	21	75	382	583	26
10	0.9289	0.00834	0.00322	0.05955	0.00357	29	23	79	452	732	16
11	0.75023	0.007	0.0027	0.05002	0.003	33	24	70	428	692	17
12	0.8651	0.00631	0.00243	0.03514	0.0027	30	26	74	442	717	20
13	0.94875	0.00722	0.00278	0.04125	0.00309	32	25	76	419	650	19
14	0.94087	0.00693	0.00267	0.04457	0.00297	35	18	74	442	712	22
15	0.69409	0.00715	0.00276	0.0347	0.00306	33	26	70	444	729	17
16	0.9329	0.00787	0.00303	0.0562	0.00337	34	23	72	394	651	20
17	0.890403	0.007695	0.002968	0.054963	0.003298	34	21	74	370	613	21
18	0.883461	0.009094	0.003508	0.045472	0.003898	32	19	68	412	622	21
19	0.916953	0.007294	0.002813	0.042722	0.003126	31	22	71	408	673	25

Figure (9-a) Samples Used In Preparing and Testing the Prediction Model.

20	0.94711	0.00745	0.00287	0.01383	0.00319	31	22	72	418	653	18
21	0.93906	0.00715	0.00276	0.01429	0.00306	32	21	75	437	697	17
22	0.91695	0.00729	0.00281	0.01563	0.00313	31	21	70	394	639	20
23	0.60376	0.01208	0.00466	0.05175	0.00518	29	21	86	433	655	26
24	0.98945	0.00761	0.00294	0.02936	0.00326	31	20	77	374	564	21
25	0.98957	0.00753	0.0029	0.03012	0.00323	35	25	75	410	658	20
26	0.65127	0.01018	0.00275	0.05495	0.00305	34	14	72	387	595	22
27	0.96618	0.02196	0.01186	0.24155	0.01318	37	18	66	379	593	21
28	0.9711	0.00819	0.00316	0.0585	0.00351	30	19	69	370	554	26
29	0.93779	0.00729	0.00281	0.04168	0.00313	35	21	74	388	609	20
30	0.93594	0.0113	0.00436	0.04841	0.00484	35	25	73	380	626	20
31	0.98802	0.00865	0.00333	0.0457	0.00371	25	11	66	365	546	24
32	0.98989	0.00729	0.00281	0.0521	0.00313	32	20	74	403	651	19
33	0.95683	0.00761	0.00294	0.05437	0.00326	29	18	81	399	597	18
34	0.98934	0.00769	0.00297	0.05496	0.0033	35	14	75	409	676	16
35	0.78927	0.01036	0.00266	0.04933	0.00296	34	19	77	376	608	21
36	0.739211	0.00761	0.003153	0.043483	0.003261	31	15	98	358	559	22
37	0.989583	0.007292	0.003125	0.041667	0.003125	43	15	73	401	633	21

Figure (9-b) Samples Used In Preparing and Testing the Prediction Model.

38	0.70409	0.00761	0.00285	0.04757	0.00285	26	23	62	444	627	16
39	0.98612	0.01053	0.00335	0.04787	0.00287	26	18	68	343	537	23
40	0.97166	0.02227	0.00607	0.08097	0.00607	25	18	75	393	573	24
41	0.34568	0.02963	0.00741	0.07407	0.00741	28	17	78	371	556	22
42	0.98644	0.00986	0.0037	0.04932	0.0037	24	12	98	406	660	19
43	0.70323	0.01125	0.00422	0.07032	0.00422	33	18	1,01	407	681	26
44	0.98806	0.00869	0.00326	0.04886	0.00326	35	16	87	400	626	20
45	0.68985	0.01054	0.00259	0.04791	0.00287	38	2	84	426	664	18
46	0.98872	0.00752	0.00376	0.05373	0.00322	31	24	72	350	542	23
47	0.98684	0.00987	0.00329	0.05482	0.00329	36	19	84	326	499	25
48	0.97959	0.01633	0.00408	0.06803	0.00408	33	17	109	366	565	22
49	0.95238	0.03741	0.0102	0.10204	0.0102	33	21	76	364	584	22
50	0.96691	0.00859	0.00301	0.05372	0.00322	24	26	74	348	537	22
51	0.98253	0.01365	0.00382	0.05459	0.00328	37	21	87	385	608	23
52	0.97986	0.01633	0.00381	0.05444	0.00327	33	18	91	397	598	20
53	0.98793	0.00878	0.00329	0.05488	0.00329	29	13	90	411	626	23

Figure (9-c) Samples Used In Preparing and Testing the Prediction Model.

54	0.98446	0.01244	0.00311	0.05181	0.00311	32	24	79	405	636	19
55	0.98446	0.01244	0.00311	0.05181	0.00311	38	22	78	392	630	20
56	0.98691	0.01007	0.00302	0.05035	0.00302	40	18	80	384	619	20
57	0.9838	0.01273	0.00347	0.05787	0.00347	38	17	89	413	679	25
58	0.98542	0.01106	0.00352	0.06033	0.00302	29	14	88	397	633	20
59	0.98571	0.01084	0.00345	0.04929	0.00296	36	20	82	376	591	27
60	0.98196	0.01494	0.0031	0.05337	0.0032	33	12	89	355	632	25
61	0.98214	0.01488	0.00298	0.05952	0.00298	28	17	97	329	500	25
62	0.86735	0.00714	0.00306	0.05612	0.00306	35	20	101	424	637	20
63	0.76684	0.01244	0.00311	0.05181	0.00311	38	21	81	429	629	19
64	0.9768	0.01954	0.00366	0.06105	0.00366	33	18	91	390	631	20
65	0.97622	0.02003	0.00375	0.06258	0.00375	33	18	81	409	645	24
66	0.98874	0.00783	0.00343	0.04895	0.00294	35	29	83	417	652	18
67	0.98307	0.01365	0.00328	0.05461	0.00328	28	21	80	381	566	22
68	0.9781	0.01752	0.00438	0.05839	0.00438	32	11	110	380	578	22
69	0.78254	0.00906	0.00247	0.04119	0.00247	35	21	97	407	610	20
70	0.768443	0.01332	0.003074	0.05123	0.003074	35	18	92	422	650	19
71	0.795229	0.012922	0.002982	0.049702	0.002982	34	21	89	413	627	19

Figure (9-d) Samples Used In Preparing and Testing the Prediction Model.

72	0.72131	0.01311	0.00328	0.05464	0.00328	31	20	89	399	594	21
73	0.9865	0.01038	0.00312	0.05192	0.00312	33	16	96	429	680	19
74	0.63102	0.01283	0.00321	0.05348	0.00321	24	19	72	415	628	20
75	0.73892	0.01182	0.00296	0.04926	0.00296	33	13	96	411	629	20
76	0.98305	0.01356	0.00339	0.0678	0.00339	34	22	110	438	730	17
77	0.73988	0.01387	0.00347	0.0578	0.00347	33	17	92	415	696	19
78	0.65502	0.01419	0.00328	0.06004	0	31	14	86	359	545	22
79	0.72821	0.01231	0.00308	0.05128	0.00308	30	111	100	429	663	20
80	0.55894	0.01118	0.00305	0.05081	0.00305	36	19	94	413	655	19
81	0.98912	0.00791	0.00297	0.04946	0.00297	33	17	92	413	633	20
82	0.9894	0.00757	0.00303	0.04139	0	29	19	79	401	643	19
83	0.98958	0.00729	0.00313	0.04167	0.00313	38	19	85	407	635	19
84	0.7448	0.01095	0.00329	0.04381	0.00329	32	12	66	433	668	19
85	0.76004	0.00869	0.00326	0.04343	0.00326	33	25	79	386	566	22
86	0.98649	0.01085	0.00266	0.04932	0	30	20	83	412	611	19
87	0.86482	0.03186	0.01229	0.22758	0.01365	27	21	87	364	557	23
88	0.989337	0.007695	0.002968	0.054963	0.003298	31	22	81	383	657	20
89	0.989678	0.007449	0.002873	0.053208	0.003193	28	24	84	494	535	20

Figure (9-e) Samples Used In Preparing and Testing the Prediction Model.

90	0.98533	0.01178	0.00289	0.04284	0.00321	34	21	81	380	603	20
91	0.98979	0.00737	0.00284	0.04212	0.00316	35	18	76	425	738	18
92	0.98468	0.01204	0.00328	0.04376	0.00328	33	20	92	413	657	21
93	0.93458	0.0113	0.00277	0.05135	0.00308	36	18	78	384	601	20
94	0.98548	0.01166	0.00286	0.05298	0.00318	30	25	81	386	586	20
95	0.98501	0.01178	0.00321	0.05353	0.00321	33	15	83	376	599	21
96	0.70855	0.00729	0.00281	0.0521	0.00313	32	23	81	400	702	19
97	0.98979	0.00729	0.00292	0.05209	0.00313	32	19	76	369	623	21
98	0.9009	0.07207	0.02703	0.22523	0.02703	36	22	82	400	602	19
99	0.98413	0.0127	0.00317	0.05291	0.00317	36	17	85	374	578	26
100	0.98462	0.01231	0.00308	0.05231	0.00308	34	20	77	418	645	19
101	0.9867	0.00998	0.00333	0.05543	0.00333	31	22	87	431	673	21
102	0.64835	0.00926	0.00278	0.05249	0.00309	34	25	80	372	580	21
103	0.97297	0.01892	0.00811	0.08108	0.00811	31	17	70	425	650	17
104	0.97872	0.01702	0.00426	0.07092	0.00426	22	17	64	390	542	26
105	0.7095	0.00799	0.0027	0.04997	0.003	29	22	92	419	654	19
106	0.969012	0.008075	0.002725	0.040375	0.003028	31	20	77	430	678	20
107	0.941453	0.006865	0.002648	0.049034	0.002942	31	21	77	414	641	19

Figure (9-f) Samples Used In Preparing and Testing the Prediction Model.

108	0.9901	0.007	0.0029	0.05001	0.003	33	21	84	391	677	20
109	0.98989	0.00729	0.00281	0.0521	0.00313	41	20	90	395	644	20
110	0.95734	0.00832	0.00312	0.05203	0.00312	32	21	70	410	698	19
111	0.93642	0.01387	0.00347	0.0578	0.00347	30	20	84	385	605	23
112	0.94767	0.00737	0.00284	0.04738	0.00316	39	32	90	401	661	19
113	0.95863	0.00729	0.00281	0.04168	0.00313	36	20	83	427	690	20
114	0.97337	0.00946	0.00365	0.05543	0.00406	31	22	76	399	612	20
115	0.70179	0.0089	0.00267	0.04151	0.00297	33	23	77	382	606	20
116	0.98662	0.01075	0.00264	0.03907	0.00293	33	24	78	380	539	26
117	0.98427	0.01284	0.00289	0.0214	0.00321	32	18	84	385	530	25
118	0.70104	0.01753	0.00394	0.07302	0.00438	31	23	82	387	596	20
119	0.98609	0.01096	0.00296	0.05478	0.00329	29	22	88	439	678	18
120	0.98548	0.01166	0.00286	0.05298	0.00318	32	17	70	314	636	22
121	0.98593	0.0113	0.00277	0.05135	0.00308	32	21	83	421	653	18
122	0.72731	0.01096	0.00269	0.03985	0.00299	31	16	90	409	636	21
123	0.98052	0.0159	0.00358	0.06625	0.00398	24	24	81	398	658	21
124	0.985793	0.011598	0.002609	0.048323	0.002899	36	18	75	466	776	15

Figure (9-g) Samples Used In Preparing and Testing the Prediction Model.

125	0.98285	0.0142	0.00295	0.0546	0.00328	30	19	80	396	622	21
126	0.98375	0.01326	0.00298	0.05527	0.00332	37	20	75	438	683	18
127	0.98437	0.0123	0.00332	0.03691	0.00369	26	25	75	428	629	18
128	0.64891	0.00946	0.00365	0.05408	0.00406	34	22	100	374	633	23
129	0.98578	0.01141	0.0028	0.05188	0.00311	30	22	78	376	582	24
130	0.7124	0.01171	0.00263	0.04879	0.00293	34	24	75	380	638	20
131	0.98619	0.01127	0.00254	0.04696	0.00282	31	18	76	339	548	24
132	0.97168	0.02082	0.0075	0.05552	0.00833	33	21	76	416	672	19
133	0.98708	0.01018	0.00275	0.05088	0.00305	30	19	79	419	637	20
134	0.98414	0.01274	0.00313	0.01737	0.00347	33	20	73	431	695	18
135	0.99456	0.00262	0.00283	0.04188	0.00314	37	26	80	465	734	16
136	0.98361	0.01311	0.00328	0.05464	0.00328	31	23	69	441	671	20
137	0.98754	0.00959	0.00288	0.03835	0.00288	31	21	77	386	619	24
138	0.98731	0.00976	0.00293	0.0434	0.00325	34	23	74	353	5599	25
139	0.98578	0.01141	0.0028	0.0467	0.00311	29	19	94	416	703	19
140	0.98414	0.01274	0.00313	0.04631	0.00347	31	15	79	401	680	19
141	0.9861	0.010693	0.003208	0.047523	0.003564	28	21	74	397	684	20
142	0.987459	0.009875	0.002666	0.042461	0.002962	30	19	73	419	636	21
143	0.983788	0.012471	0.003741	0.055425	0.004157	28	21	86	408	634	19

Figure (9-i) Samples Used In Preparing and Testing the Prediction Model.

144	0.99039	0.00693	0.00267	0.0416	0.00297	31	20	76	409	635	19
145	0.98989	0.00729	0.00281	0.04168	0.00313	31	20	74	355	561	22
146	0.98989	0.00729	0.00281	0.04481	0.00313	30	21	82	435	688	20
147	0.67518	0.01039	0.0028	0.06232	0.00312	33	19	73	381	663	20
148	0.98267	0.01251	0.00482	0.07147	0.00536	31	21	88	392	635	20
149	0.98614	0.01	0.00386	0.05717	0.00429	29	21	81	403	617	19
150	0.98845	0.00834	0.00322	0.05955	0.00357	36	20	114	386	595	25
151	0.97787	0.01716	0.00463	0.06862	0.00515	31	21	82	393	529	20
152	0.98746	0.00987	0.00267	0.0395	0.00296	32	27	72	390	607	27
153	0.9901	0.00715	0.00276	0.05104	0.00306	34	24	74	405	624	24
154	0.9891	0.00787	0.00303	0.0562	0.00337	32	22	72	394	614	20
155	0.70479	0.00796	0.00307	0.01819	0.00341	33	23	82	431	670	18
156	0.75556	0.00745	0.00287	0.01703	0.00319	34	16	82	437	686	20
157	0.5735	0.01096	0.00228	0.05482	0.00253	30	22	76	374	602	21
158	0.98501	0.01204	0.00296	0.06129	0.00328	31	19	77	381	603	20
159	0.95664	0.00936	0.00281	0.04159	0.00312	29	22	81	432	642	18
160	0.761118	0.007611	0.002936	0.039143	0.003262	34	23	86	461	743	17
161	0.309634	0.008336	0.003215	0.053591	0	32	19	23	409	643	20

Figure (9-j) Samples Used In Preparing and Testing the Prediction Model.

162	0.98517	0.01191	0.00292	0.06496	0.00325	30	22	92	362	581	22
163	0.66688	0.00753	0.0029	0.05378	0.00323	29	18	87	394	627	23
164	0.60024	0.00934	0.0036	0.04402	0.004	24	17	76	400	615	19
165	0.85885	0.00707	0.00273	0.04042	0.00303	30	22	75	430	686	18
166	0.96905	0.00729	0.00281	0.04168	0.00313	37	23	75	438	667	19
167	0.96771	0.00761	0.00294	0.04349	0.00326	32	25	79	468	755	16
168	0.93677	0	0.06323	0.23419	0.07026	32	15	80	479	717	15
169	0.98787	0.00875	0.00338	0.06252	0.00375	29	20	77	456	778	17
170	0.9903	0.007	0.0027	0.03601	0.003	34	23	71	417	687	19
171	0.9891	0.00787	0.00303	0.03934	0.00337	27	19	72	410	663	19
172	0.98934	0.00769	0.00297	0.04397	0.0033	26	22	75	455	707	17
173	0.73551	0.00686	0.00265	0.03923	0.00294	28	23	72	513	778	16
174	0.97761	0.00796	0.00307	0.04547	0.00341	33	24	77	462	666	16
175	0.9901	0.00715	0.00276	0.05104	0.00306	30	21	73	459	698	17
176	0.98979	0.00722	0.00278	0.05155	0.00309	32	23	73	433	656	20
177	0.986	0.01	0.004	0.05716	0.00429	28	17	68	420	691	20
178	0.988602	0.008141	0.003257	0.046522	0.003489	30	17	74	448	697	17
179	0.97914	0.0149	0.00596	0.085143	0.006386	28	19	92	364	553	22

Figure (9-k) Samples used in preparing and testing the prediction model.

180	0.98383	0.01167	0.0045	0.0667	0.005	34	20	82	419	634	19
181	0.98934	0.00769	0.00297	0.05496	0.0033	32	20	73	397	681	22
182	0.99069	0.00788	0.00143	0.05629	0.00338	23	18	64	479	762	17
183	0.6462	0.01346	0.00377	0.05385	0.00404	34	15	103	374	639	22
184	0.97349	0.02071	0.0058	0.06214	0.00621	32	23	97	425	661	19
185	0.98698	0.01018	0.00285	0.0407	0.00305	29	20	83	426	660	19
186	0.9901	0.00715	0.00276	0.04083	0.00306	24	17	80	414	673	21
187	0.43538	0.00956	0.00287	0.06371	0.00319	29	14	82	435	706	18
188	0.79581	0.01007	0.00272	0.04029	0.00302	29	21	76	443	747	18
189	0.66698	0.01112	0.00429	0.06352	0.00476	33	27	83	433	727	17
190	0.93306	0.00976	0.00293	0.0434	0.00325	39	21	87	423	672	19
191	0.77837	0.00841	0.00284	0.04207	0.00316	30	17	73	402	605	19
192	0.98979	0.00737	0.00284	0.04212	0.00316	33	20	77	433	726	18
193	0.98968	0.00745	0.00287	0.04257	0.00319	30	24	81	444	606	17
194	0.98796	0.00926	0.00278	0.04116	0.00309	30	22	72	437	703	18
195	0.7475	0.00769	0.00297	0.04397	0.0033	30	17	82	448	744	17
196	0	0.025955	0.010011	0.185391	0.011123	31	27	88	378	610	21
197	0	0.721649	0.278351	5.154639	0.309278	28	19	81	337	534	23
198	0	0.031862	0.012289	0.227583	0.013655	30	16	76	433	787	18

Figure (9-m) Samples used in preparing and testing the prediction model.

3.1. Forecasting Models:

To use the prediction equation for multiple linear regression analysis, it is necessary to know whether the independent variables have an effect on the dependent variable or not, and for this we calculated the correlation rate R, which shows if there is a relationship between the independent variables and the successive variable.

3.1.1. Yield Effort Prediction Model:

After confirming the existence of a correlation, we can use the prediction equation to analyze the multiple linear regression, and Figure (10) shows the results of the multiple linear regression analysis and the statistical analysis of the yield effort prediction model.

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.571961474
R Square	0.327139928
Adjusted R Squ	0.164022335
Standard Erro	28.44561608
Observations	42

ANOVA

	df	SS	MS	F	Significance F
Regression	8	12982.35331	1622.794164	2.00554656	0.076770244
Residual	33	26702.05145	809.1530742		
Total	41	39684.40476			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 99.0%	Upper 99.0%
Intercept	413.0300401	97.59253102	4.232189039	0.000173268	214.4765428	611.583537	146.2826546	679.777426
DRI	-38.68576338	39.88987724	-0.969814049	0.339194071	-119.8423288	42.4708021	-147.7158331	70.3443063
FeMn	-4000.538448	2339.779756	-1.709792743	0.096692853	-8760.856155	759.779259	-10395.8038	2394.72691
FeSi	8428.08049	4766.385483	1.768233082	0.08626677	-1269.203688	18125.3647	-4599.769618	21455.9306
Lime	-151.801289	308.5587445	-0.491968845	0.625998264	-779.5687749	475.966197	-995.1776982	691.57512
Dol.	434.4523967	4617.001681	0.094098384	0.925600033	-8958.908152	9827.81295	-12185.09046	13053.9952
C	-0.933405579	1.390097842	-0.671467541	0.506596284	-3.761580904	1.89476975	-4.732927542	2.86611638
Si	3.31249016	1.397465834	2.370355024	0.023768047	0.469324544	6.15565578	-0.507170562	7.13215088
Mn	0.07144496	0.699204222	0.102180391	0.919231873	-1.351096725	1.49398665	-1.839673607	1.98256353

Figure (10) Results of the multiple linear regression analysis with the yield stress prediction model

Through Figure (11), it is necessary to know whether there is a relationship between the independent variables (chemicals) and the dependent variable (submission stress), by means of the correlation coefficient R where its value was 0.57 and this confirms the existence of a strong correlation between the independent variables and the dependent variable, while R2 The coefficient of determination indicates the influence of the independent variables on the dependent variable, where its value was 0.32, and this indicates the strength of the effect. As for Adjusted (R2), the corrected coefficient of determination is the same as R2, but they differ from each other that Adjusted (R2) increases only when adding an independent variable that has an effect on the dependent variable and after knowing that there is a relationship, we test the hypothesis by tabular F test where if F The tabular F selects the null hypothesis H0: there is no relationship between the independent variables and the dependent variable. And if the tabular F > F selects the hypothesis H1: there is at least one relationship between the independent variables and the dependent variable, and this test is considered a comprehensive test, so we conduct another test to find out which of the independent variables have an effect on the dependent variable individually by T and P test -Value, where if the value of T > 2, then this independent variable has an effect on the dependent variable, and if T < 2, then this variable has no effect, and as for the P-Value test, if P-Value > 0.05, this variable has no effect on the dependent variable However, if P-Value < 0.05, this independent variable has an effect on the dependent variable.

3.1.2. Results of the Yield Effort Prediction Model:

These results are 42 samples obtained from the yield stress prediction model and were compared with the real stress as shown in Figure (11), where it was found that the mean error is close to zero.

RESIDUAL OUTPUT / PROBABILITY OUTPUT

Observatior	Predicted Yield Effort	Residuals	Standard Residuals	Percentile	Yield Effort
1	416.2195936	31.78040638	1.245314545	1.19047619	343
2	404.5664133	24.4335867	0.957429573	3.571428571	358
3	420.3287639	10.67123606	0.418152157	5.952380952	365
4	409.9324544	40.06754556	1.570045916	8.333333333	370
5	413.9422218	61.05777818	2.392547733	10.71428571	370
6	405.2354826	-21.23548256	-0.83211193	13.0952381	371
7	402.2449036	9.75509642	0.382253245	15.47619048	374
8	451.7519345	5.248065488	0.205645334	17.85714286	376
9	409.6985878	-27.69858777	-1.08536857	20.23809524	379
10	418.1207323	33.87926768	1.32755838	22.61904762	380
11	426.1674171	1.832582887	0.071809721	25	382
12	434.0828911	7.917108946	0.310231745	27.38095238	384
13	424.3704952	-5.370495164	-0.210442738	29.76190476	387
14	398.2020512	43.79794878	1.716221687	32.14285714	388
15	437.2076277	6.79237233	0.266158965	34.52380952	393
16	413.5710005	-19.57100052	-0.766889237	36.9047619	394
17	409.0179048	-39.01790483	-1.528915766	39.28571429	394
18	404.7516705	7.248329539	0.284025638	41.66666667	399

Figure (11-a) results of the yield stress prediction model and its comparison with the real stress.

RESIDUAL OUTPUT / PROBABILITY OUTPUT

Observatior	Predicted Yield Effort	Residuals	Standard Residuals	Percentile	Yield Effort
19	415.9733639	-7.973363917	-0.312436095	44.04761905	401
20	419.1758176	-1.175817582	-0.046074387	46.42857143	403
21	415.5577758	21.44222422	0.840213098	48.80952381	406
22	416.7019989	-22.70199889	-0.889577341	51.19047619	408
23	423.6505009	9.349499107	0.366359923	53.57142857	409
24	408.822292	-34.82229201	-1.364510768	55.95238095	410
25	421.4346299	-11.43462993	-0.448065729	58.33333333	412
26	383.049877	3.950122953	0.154785483	60.71428571	412
27	386.6047265	-7.604726501	-0.297991045	63.0952381	418
28	401.831541	-31.83154104	-1.247318255	65.47619048	419
29	408.4935568	-20.49355675	-0.803039583	67.85714286	428
30	418.4670446	-38.46704464	-1.507330322	70.23809524	429
31	380.8169657	-15.81696566	-0.619787461	72.61904762	431
32	404.3840122	-1.384012244	-0.05423249	75	433
33	401.8155363	-2.815536324	-0.110326731	77.38095238	437
34	381.1411868	27.85881318	1.091646999	79.76190476	442
35	394.0055618	-18.00556185	-0.705547556	82.14285714	442
36	403.1300403	-45.13004032	-1.768419665	84.52380952	444

Figure (11-b) results of the yield stress prediction model and its comparison with the real stress.

RESIDUAL OUTPUT / PROBABILITY OUTPUT

Observatior	Predicted Yield Effort	Residuals	Standard Residuals	Percentile	Yield Effort
37	381.7134167	19.28658325	0.755744353	86.9047619	444
38	429.7644283	14.23557167	0.557820572	89.28571429	448
39	395.1874333	-52.1874333	-2.044963458	91.66666667	450
40	369.5373217	23.46267825	0.919384546	94.04761905	452
41	371.2762463	-0.27624633	-0.010824707	96.42857143	457
42	385.0525795	20.94742053	0.820824226	98.80952381	475
Total Error		-3.41061E-12			
Average Error 17117		-8.12049E-14			

Average Stepping Effort of The Sample = 407, 547619

Figure (11-c) results of the yield stress prediction model and its comparison with the real stress.

Through Figure (11), after performing the prediction process for 42 samples, the total prediction for the yield effort was 17117, and the average error was -8.12049E-14, which is very close to zero, which indicates the accuracy of the prediction. As for the negative sign, this indicates that the prediction is greater than the real one. We subtract this value from all predictions until we get an average error equal to zero, and the average error is the result of subtracting the prediction from the real one, adding all the values of the subtraction process and dividing it by the number of samples (42 samples). Prediction was performed for only 42 samples because Microsoft Office Excel did not accept more than this size.

3.1.3. Tensile Strength Prediction Model:

After confirming the existence of a correlation, we can use the prediction equation to analyze the multiple linear regression, and Figure (12) shows the results of the multiple linear regression analysis of the tensile strength prediction model.

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.997128759
R Square	0.994265762
Adjusted R Square	0.963673418
Standard Error	54.22239823
Observations	42

ANOVA

	df	SS	MS	F	ignificance F
Regression	8	17332575.67	2166571.959	736.9120758	6.57E-35
Residual	34	99962.32797	2940.06847		
Total	42	17432538			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	ower 99.0%	Jpper 99.0%
Intercept	0	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
DRI	64.0203302	63.82620404	1.003041481	0.3229264	-65.69012	193.7307829	-110.123	238.1634
FeMn	-2212.043288	3952.269399	-0.5596894	0.579360193	-10244.02	5819.934498	-12995.4	8571.306
FeSi	6357.878607	8495.264275	0.748402687	0.459363378	-10906.58	23622.33279	-16820.6	29536.31
Lime	-119.6940869	584.7570177	-0.204690296	0.839034554	-1308.063	1068.675152	-1715.14	1475.754
Dol.	-1232.957154	8756.876433	-0.140798738	0.888859825	-19029.07	16563.1569	-25125.2	22659.26
C	4.216962061	2.289888732	1.841557628	0.074277936	-0.436652	8.870575864	-2.03076	10.46468
Si	10.05367571	2.294171246	4.382269079	0.00010691	5.391359	14.71599263	3.794272	16.31308
Mn	3.469175392	0.920950068	3.766952749	0.000628095	1.59758	5.340771111	0.95646	5.98189

Figure (12) results of the multiple linear regression analysis of the tensile strength prediction model.

Through the results, it must be known whether there is a relationship between the independent variables (chemicals) and the dependent variable (tensile strength), through the correlation coefficient R, where its value was 0.997, and this confirms the existence of a strong correlation between the independent variables and the dependent variable. As for the R2 coefficient of determination, it indicates the effect of the independent variables on the dependent variable, where its value was 0.0994, and this indicates the strength of the effect, and the Adjusted (R2) coefficient of determination is the same as the meaning of R2, but they differ from each other that Adjusted (R2) increases only when adding an independent variable It has an effect on the dependent variable and after knowing that there is a relationship, we test the hypothesis by using the F tabular test where if F < F tabular selects the null hypothesis H0: there is no relationship between the independent variables and the dependent variable. And if the tabular F > F selects the hypothesis H1: there is at least one relationship between the independent variables and the dependent variable, and this test is considered a comprehensive test, so we conduct another test to find out which of the independent variables have an effect on the dependent variable individually by T and P test -Value, where if the value of T > 2, then this independent variable has an effect on the dependent variable, but if T < 2, then this variable has no effect, and as for the P-Value test, if P-Value > 0.05, this variable has no effect on the dependent variable, If the P-Value < 0.05, this independent variable has an effect on the dependent variable.

3.1.4. Results of the Tensile Strength Prediction Model:

These results are 42 samples obtained from the tensile strength prediction model and were compared to the real tensile strength as shown in Figure (13), where it was found that the mean error is close to zero.

RESIDUAL OUTPUT

Observation	Predicted قوة الشد	Residuals	Standard Residuals
1	708.1988264	38.80117357	0.795337254
2	634.0081868	33.99181317	0.696756125
3	619.9045078	61.09549221	1.252320911
4	640.8586352	32.14136484	0.658826074
5	650.5047386	120.4952614	2.469883294
6	645.6264589	-26.62645891	-0.545782841
7	631.4085979	21.59140206	0.442575439
8	686.913766	13.08623401	0.268238521
9	656.3976541	-73.39765409	-1.504487708
10	677.5308601	54.46913993	1.116495513
11	663.3158914	28.68410864	0.587960057
12	693.9831872	23.01681284	0.471793171
13	703.6638175	-53.66381748	-1.099988205
14	638.1818323	73.81816773	1.513107297
15	681.6208495	47.37915054	0.971166592
16	675.1227637	-24.12276372	-0.49446269
17	659.4309267	-46.43092666	-0.951730124
18	610.3628864	11.63711355	0.238534794
19	649.7066605	23.29333951	0.477461349
20	658.5194648	-5.519464804	-0.113136681

Figure (13-a) Results of the tensile strength prediction model and their comparison with the real tensile strength.

RESIDUAL OUTPUT

Observation	Predicted قوة الشد	Residuals	Standard Residuals
21	662.6081195	34.39188054	0.704956612
22	639.4265376	-0.426537592	-0.008743066
23	660.7476296	-5.747629617	-0.117813549
24	656.5640492	-92.56404919	-1.897355929
25	716.7018275	-58.70182751	-1.20325614
26	560.2204891	34.77951092	0.712902167
27	609.4748475	-16.4748475	-0.337697517
28	609.7101182	-55.71011821	-1.141932792
29	668.3872533	-59.38725332	-1.217305835
30	703.0552519	-77.05525189	-1.57946028
31	500.2729844	45.72701557	0.937301521
32	647.7709228	3.229077211	0.066188859
33	636.8178465	-39.81784651	-0.816176775
34	603.0751032	72.92489683	1.494797242
35	636.5196068	-28.51960678	-0.584588137

Figure (13-b) Results of the tensile strength prediction model and their comparison with the real tensile strength.

RESIDUAL OUTPUT

Observation	Predicted قوة الشد	Residuals	Standard Residuals
36	662.8197844	-103.8197844	-2.128073321
37	643.6364033	-10.63640333	-0.218022473
38	593.1373675	33.86263247	0.69410821
39	578.3803834	-41.38038338	-0.848205286
40	580.9595089	-7.959508881	-0.163152126
41	545.2677191	10.73228094	0.21998775
42	616.2162295	43.78377048	0.897469344
	Total Error =	34.96950514	
	Average Error =	0.832607265	
	26917.03049		

Average Tensile Strength = 640. 881678

Figure (13-c) Results of the tensile strength prediction model and their comparison with the real tensile strength.

In Figure (13), after performing the prediction process for 42 samples, the average error was 0.832, which is very close to zero, which indicates the accuracy of the prediction.

3.1.5. Elongation Ratio Prediction Model:

After confirming that there is a correlation, we can use the prediction equation to analyze the multiple linear regression, and Figure (14) shows the results of the multiple linear regression analysis and the statistical analysis of the elongation ratio prediction model.

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.990863478
R Square	0.981810431
Adjusted R Square	0.948653755
Standard Error	3.049099815
Observations	42

ANOVA

	df	SS	MS	F	Significance F
Regression	8	17061.9017	2132.737709	229.400397	1.19452E-26
Residual	34	316.098329	9.297009684		
Total	42	17378			

	Coefficients	Standard Erro	t Stat	P-value	Lower 95%	Upper 95%	Lower 99.0%	Upper 99.0%
Intercept	0	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
DRI	5.900916963	3.5891527	1.644097495	0.10937265	-1.393118903	13.195	-3.89171	15.693541
FeMn	592.145152	222.248818	2.664334318	0.01170958	140.4812126	1043.81	-14.2373	1198.52757
FeSi	-1194.12097	477.716028	-2.499646022	0.01742108	-2164.956746	-223.285	-2497.52	109.276751
Lime	30.94194816	32.8827675	0.940977616	0.35335428	-35.88387556	97.7678	-58.7752	120.659106
Dol.	-318.9235379	492.427321	-0.647656058	0.52155702	-1319.656258	681.809	-1662.46	1024.61239
C	0.173799475	0.12876781	1.349712161	0.18602689	-0.087888194	0.43549	-0.17753	0.52512883
Si	0.000371942	0.12900863	0.002883079	0.99771649	-0.261805131	0.26255	-0.35161	0.35235835
Mn	0.10268001	0.05178798	1.982699512	0.05552774	-0.002565836	0.20793	-0.03862	0.24397805

Figure (14) results of the multiple linear regression analysis of the elongation ratio prediction model.

Through the results, it must be known whether there is a relationship between the independent variables (chemicals) and the dependent variable (elongation ratio), by means of the correlation coefficient R whose value was 0.998 and this confirms the existence of a strong correlation between the independent variables and the dependent variable, while R2 The coefficient of determination indicates the effect of the independent variables on the dependent variable, where its value was 0.981, and this indicates the strength of the effect. As for Adjusted (R2), the corrected coefficient of determination is the same as R2, but they differ from each other that Adjusted (R2) increases only when adding an independent variable that has an effect on the dependent variable and after knowing that there is a relationship, we test the hypothesis by tabular F test where if F The tabular F selects the null hypothesis H0: there is no relationship between the independent variables and the dependent variable. If the tabular F > F selects the hypothesis H1: there is at least one relationship between the independent variables and the dependent variable, and this test is considered a comprehensive test, so we conduct another test to find out which of the independent variables have an effect on the dependent variable individually by T and P test -Value, where if the value of T > 2, then this independent variable has an effect on the dependent variable, but if T < 2, then this variable has no effect, and as for the P-Value test, if P-Value > 0.05, this variable has no effect on the dependent variable, If the P-Value < 0.05, this independent variable has an effect on the dependent variable.

3.1.6. Results of the Elongation Ratio Prediction Model:

These results are 42 samples obtained from the equation for predicting the elongation ratio and were compared with the true relative elongation ratio as shown in Figure (15), where it was found that the mean error is close to zero.

RESIDUAL OUTPUT

Observation	Predicted الاستطالة%	Residuals	Standard Residuals
1	21.0726868	-1.072686796	-0.391008753
2	20.10764223	-3.10764223	-1.132777357
3	18.00718119	-0.007181194	-0.002617642
4	19.73806845	1.261931554	0.459991011
5	19.84661656	-4.846616564	-1.766656873
6	20.41210911	-0.412109111	-0.150219309
7	20.11550498	-1.115504977	-0.406616556
8	16.75249696	-0.752496962	-0.274295256
9	21.2423502	4.757649798	1.734227291
10	20.44155049	-4.441550493	-1.619004846
11	18.87059557	-1.870595574	-0.681857226
12	18.98196027	1.018039727	0.371089162
13	20.21238904	-1.212389043	-0.4419321
14	20.58348869	1.416511307	0.516337408
15	18.06562174	-1.065621742	-0.388433446
16	20.51422383	-0.514223827	-0.187441496
17	20.43073524	0.569264758	0.207504655
18	19.12450461	1.875495386	0.683643274
19	19.38161619	5.618383813	2.047976407
20	18.76762279	-0.767622793	-0.279808824

Figure (15-a) results of the prediction model for the elongation rate and its comparison with the real elongation rate.

RESIDUAL OUTPUT

Observation	Predicted الاستطالة%	Residuals	Standard Residuals
21	19.21726595	-2.217265954	-0.808223239
22	18.44029118	1.559708821	0.568534827
23	18.98059515	7.01940485	2.558667404
24	20.00962497	0.99037503	0.361005008
25	20.52592265	-0.525922648	-0.191705873
26	20.62189811	1.378101893	0.502336661
27	21.03074562	-0.03074562	-0.011207192
28	19.80448282	6.195517177	2.258349274
29	20.4752151	-0.475215105	-0.173222292
30	20.55082091	-0.550820905	-0.200781623
31	18.32579155	5.674208448	2.068325236
32	20.58329295	-1.58329295	-0.577131559
33	20.65331924	-2.653319236	-0.96717052
34	21.28841077	-5.288410766	-1.927696797
35	22.01564244	-1.015642442	-0.37021532
36	20.86484841	1.135151587	0.413778009
37	21.69275521	-0.692755207	-0.252518583
38	16.70872873	-0.70872873	-0.258341147
39	20.12662535	2.873374647	1.047383675
40	24.28867697	-0.288676972	-0.105226636
41	23.55087287	-1.550872872	-0.565314004
42	21.82946211	-2.829462109	-1.031376965

Total Error = 1.745745974
Average Error = 0.04156538
844.254254
Average Elongation Ratio = 20. 10129176

Figure (15-b) results of the prediction model for the elongation rate and its comparison with the real elongation rate.

In Figure (15), after performing the prediction process for 42 samples, the mean error was 0.041, which is very close to zero, which indicates the accuracy of the prediction.

3.2. Testing the Yield Effort Prediction Model:

Testing the prediction model and calculating the mean error in predicting yield stress, and these results are shown in Figure (16) for all 198 samples obtained from the prediction model.

NO	DRI	FeMn	FeSi	Lime	Dol.	C	Si	Mn	Yield Effort	Tensile Strength	Elongation	Expected Yield Effort	Error
1	0.93647	0.00745	0.00287	0.04363	0.00319	34	23	81	448	747	20	416.2195936	31.78041
2	0.93779	0.00729	0.00281	0.04897	0.00313	31	19	75	429	668	17	404.5664133	24.43359
3	0.66688	0.00729	0.00281	0.04168	0.00313	30	20	74	431	681	18	420.3287639	10.67124
4	0.93579	0.00753	0.0029	0.0484	0.00323	32	21	70	450	673	21	409.9324544	40.06755
5	0.95863	0.00729	0.00281	0.0521	0.00313	30	22	72	475	771	15	413.9422218	61.05778
6	0.9244	0.00886	0.00342	0.05065	0.0038	30	19	80	384	619	20	405.2354826	-21.23548
7	0.93579	0.00753	0.0029	0.04302	0.00323	31	18	77	412	653	19	402.2449036	9.755096
8	0.59473	0.04248	0.02294	0.08496	0	29	22	76	457	700	16	451.7519345	5.248065
9	0.84966	0.00959	0.0037	0.05482	0	32	21	75	382	583	26	409.6985878	-27.69859
10	0.9289	0.00834	0.00322	0.05955	0.00357	29	23	79	452	732	16	418.1207323	33.87927
11	0.75023	0.007	0.0027	0.05002	0.003	33	24	70	428	692	17	426.1674171	1.832583
12	0.8651	0.00631	0.00243	0.03514	0.0027	30	26	74	442	717	20	434.0828911	7.917109
13	0.94875	0.00722	0.00278	0.04125	0.00309	32	25	76	419	650	19	424.3704952	-5.370495
14	0.94087	0.00693	0.00267	0.04457	0.00297	35	18	74	442	712	22	398.2020512	43.79795
15	0.69409	0.00715	0.00276	0.0347	0.00306	33	26	70	444	729	17	437.2076277	6.792372
16	0.9329	0.00787	0.00303	0.0562	0.00337	34	23	72	394	651	20	413.5710005	-19.571
17	0.8904	0.00769	0.00297	0.05496	0.0033	34	21	74	370	613	21	409.0179048	-39.0179
18	0.8835	0.0091	0.0035	0.0455	0.0039	32	19	68	412	622	21	404.7516705	7.24833
19	0.917	0.0073	0.0028	0.0427	0.0031	31	22	71	408	673	25	415.9733639	-7.973364
20	0.9471	0.0074	0.0029	0.0138	0.0032	31	22	72	418	653	18	419.1758176	-1.175818
21	0.9391	0.0071	0.0028	0.0143	0.0031	32	21	75	437	697	17	415.5577758	21.44222

Figure (16-a) Testing the prediction model and calculating the mean error in prediction of yield stress.

22	0.91695	0.00729	0.00281	0.01563	0.00313	31	21	70	394	639	20	416.7019989	-22.702
23	0.60376	0.01208	0.00466	0.05175	0.00518	29	21	86	433	655	26	423.6505009	9.349499
24	0.98945	0.00761	0.00294	0.02936	0.00326	31	20	77	374	564	21	408.822292	-34.82229
25	0.98957	0.00753	0.0029	0.03012	0.00323	35	25	75	410	658	20	421.4346299	-11.43463
26	0.65127	0.01018	0.00275	0.05495	0.00305	34	14	72	387	595	22	383.049877	3.950123
27	0.96618	0.02196	0.01186	0.24155	0.01318	37	18	66	379	593	21	386.6047265	-7.604727
28	0.9711	0.00819	0.00316	0.0585	0.00351	30	19	69	370	564	26	401.831541	-31.83154
29	0.93779	0.00729	0.00281	0.04168	0.00313	35	21	74	388	609	20	408.4935568	-20.49356
30	0.93594	0.0113	0.00436	0.04841	0.00484	35	25	73	380	626	20	418.4670446	-38.46704
31	0.98802	0.00865	0.00333	0.0457	0.00371	25	11	66	365	546	24	380.8169657	-15.81697
32	0.98989	0.00729	0.00281	0.0521	0.00313	32	20	74	403	651	19	404.3840122	-1.384012
33	0.95683	0.00761	0.00294	0.05437	0.00326	29	18	81	399	597	18	401.8155363	-2.815536
34	0.98934	0.00769	0.00297	0.05496	0.0033	35	14	75	409	676	16	381.1411868	27.85881
35	0.78927	0.01036	0.00266	0.04933	0.00296	34	19	77	376	608	21	394.0055618	-18.00556
36	0.73921	0.00761	0.00315	0.04348	0.00326	31	15	98	358	559	22	403.1300403	-45.13004
37	0.98958	0.00729	0.00313	0.04167	0.00313	43	15	73	401	633	21	381.7134167	19.28658
38	0.70409	0.00761	0.00285	0.04757	0.00285	26	23	62	444	627	16	429.7644283	14.23557
39	0.9861	0.0105	0.0034	0.0479	0.0029	26	18	68	343	537	23	395.1874333	-52.18743
40	0.9717	0.0223	0.0061	0.081	0.0061	25	18	75	393	573	24	369.5373217	23.46268
41	0.3457	0.0296	0.0074	0.0741	0.0074	28	17	78	371	556	22	371.2762463	-0.276246
42	0.9864	0.0099	0.0037	0.0493	0.0037	24	12	98	406	660	19	385.0525795	20.94742

Figure (16-b) Testing the prediction model and calculating the mean error in prediction of yield stress.

43	0.70323	0.01125	0.00422	0.07032	0.00422	33	18	1.01	407	681	26	396.4258267	10.57417
44	0.98806	0.00869	0.00326	0.04886	0.00326	35	16	87	400	626	20	388.0543451	11.94565
45	0.68985	0.01054	0.00259	0.04791	0.00287	38	2	84	426	664	18	337.1156404	88.88436
46	0.98872	0.00752	0.00376	0.05373	0.00322	31	24	72	350	542	23	425.3389162	-75.33892
47	0.98684	0.00987	0.00329	0.05482	0.00329	36	19	84	326	499	25	391.5410206	-65.54102
48	0.97959	0.01633	0.00408	0.06803	0.00408	33	17	109	366	565	22	368.9633033	-2.963303
49	0.95238	0.03741	0.0102	0.10204	0.0102	33	21	76	364	584	22	345.6402538	18.35975
50	0.96691	0.00859	0.00301	0.05372	0.00322	24	26	74	348	537	22	428.8496288	-80.84963
51	0.98253	0.01365	0.00382	0.05459	0.00328	37	21	87	385	608	23	387.0096552	-2.009655
52	0.97986	0.01633	0.00381	0.05444	0.00327	33	18	91	397	598	20	370.3858817	26.61412
53	0.98793	0.00878	0.00329	0.05488	0.00329	29	13	90	411	626	23	382.9575822	28.04242
54	0.98446	0.01244	0.00311	0.05181	0.00311	32	24	79	405	636	19	400.1594826	4.840517
55	0.98446	0.01244	0.00311	0.05181	0.00311	38	22	78	392	630	20	387.8626238	4.137376
56	0.98691	0.01007	0.00302	0.05035	0.00302	40	18	80	384	619	20	381.6989916	2.301008
57	0.9838	0.01273	0.00347	0.05787	0.00347	38	17	89	413	679	25	373.2277572	39.77224
58	0.98542	0.01106	0.00352	0.06033	0.00302	29	14	88	397	633	20	378.0658215	18.93418
59	0.98571	0.01084	0.00345	0.04929	0.00296	36	20	82	376	591	27	392.905752	-16.90575
60	0.982	0.0149	0.0031	0.0534	0.0032	33	12	89	355	632	25	349.9460077	5.053992
61	0.9821	0.0149	0.003	0.0595	0.003	28	17	97	329	500	25	369.9512044	-40.9512
62	0.8673	0.0071	0.0031	0.0561	0.0031	35	20	101	424	637	20	410.3080786	13.69192
63	0.7668	0.0124	0.0031	0.0518	0.0031	38	21	81	429	629	19	393.1831321	35.81687

Figure (16-c) Testing the prediction model and calculating the mean error in prediction of yield stress.

64	0.9768	0.01954	0.00366	0.06105	0.00366	33	18	91	390	631	20	355.607094	34.39291
65	0.97622	0.02003	0.00375	0.06258	0.00375	33	18	81	409	645	24	353.5394251	55.46057
66	0.98874	0.00783	0.00343	0.04895	0.00294	35	29	83	417	652	18	435.4950821	-18.49508
67	0.98307	0.01365	0.00328	0.05461	0.00328	28	21	80	381	566	22	390.2704622	-9.270462
68	0.9781	0.01752	0.00438	0.05839	0.00438	32	11	110	380	578	22	349.4860475	30.51395
69	0.78254	0.00906	0.00247	0.04119	0.00247	35	21	97	407	610	20	405.9802648	1.019735
70	0.76844	0.01332	0.00307	0.05123	0.00307	35	18	92	422	650	19	383.0096408	38.99036
71	0.79523	0.01292	0.00298	0.0497	0.00298	34	21	89	413	627	19	393.6385286	19.36147
72	0.72131	0.01311	0.00328	0.05464	0.00328	31	20	89	399	594	21	397.0946412	1.905359
73	0.9865	0.01038	0.00312	0.05192	0.00312	33	16	96	429	680	19	382.1076836	46.89232
74	0.63102	0.01283	0.00321	0.05348	0.00321	24	19	72	415	628	20	403.2727285	11.72727
75	0.73892	0.01182	0.00296	0.04926	0.00296	33	13	96	411	629	20	374.982981	36.01702
76	0.98305	0.01356	0.00339	0.0678	0.00339	34	22	110	438	730	17	389.5041895	48.49581
77	0.73988	0.01387	0.00347	0.0578	0.00347	33	17	92	415	696	19	382.9536005	32.0464
78	0.65502	0.01419	0.00328	0.06004	0	31	14	86	359	545	22	372.9855531	-13.98555
79	0.72821	0.01231	0.00308	0.05128	0.00308	30	111	100	429	663	20	701.9348595	-272.9349
80	0.55894	0.01118	0.00305	0.05081	0.00305	36	19	94	413	655	19	402.0424093	10.95759
81	0.9891	0.0079	0.003	0.0495	0.003	33	17	92	413	633	20	393.9828195	19.01718
82	0.9894	0.0076	0.003	0.0414	0	29	19	79	401	643	19	405.2184647	-4.218465
83	0.9896	0.0073	0.0031	0.0417	0.0031	38	19	85	407	635	19	400.4877448	6.512255
84	0.7448	0.011	0.0033	0.0438	0.0033	32	12	66	433	668	19	377.4662271	55.53377

Figure (16-d) Testing the prediction model and calculating the mean error in prediction of yield stress.

85	0.76004	0.00869	0.00326	0.04343	0.00326	33	25	79	386	566	22	428.8069773	-42.80698
86	0.98649	0.01085	0.00266	0.04932	0	30	20	83	412	611	19	390.5942768	21.40572
87	0.86482	0.03186	0.01229	0.22758	0.01365	27	21	87	364	557	23	377.6481785	-13.64818
88	0.98934	0.00769	0.00297	0.05496	0.0033	31	22	81	383	657	20	411.8034002	-28.8034
89	0.98968	0.00745	0.00287	0.05321	0.00319	28	24	84	494	535	20	421.8345612	72.16544
90	0.98533	0.01178	0.00289	0.04284	0.00321	34	21	81	380	603	20	390.6591127	-10.65911
91	0.98979	0.00737	0.00284	0.04212	0.00316	35	18	76	425	738	18	396.5776793	28.42232
92	0.98468	0.01204	0.00328	0.04376	0.00328	33	20	92	413	657	21	391.2565631	21.74344
93	0.93458	0.0113	0.00277	0.05135	0.00308	36	18	78	384	601	20	380.1894576	3.810542
94	0.98548	0.01166	0.00286	0.05298	0.00318	30	25	81	386	586	20	406.3233932	-20.32339
95	0.98501	0.01178	0.00321	0.05353	0.00321	33	15	83	376	599	21	372.9634722	3.036528
96	0.70855	0.00729	0.00281	0.0521	0.00313	32	23	81	400	702	19	425.7053696	-25.70537
97	0.98979	0.00729	0.00292	0.05209	0.00313	32	19	76	369	623	21	402.0977621	-33.09776
98	0.9009	0.07207	0.02703	0.22523	0.02703	36	22	82	400	602	19	340.3200114	59.67999
99	0.98413	0.0127	0.00317	0.05291	0.00317	36	17	85	374	578	26	373.0436125	0.956387
100	0.98462	0.01231	0.00308	0.05231	0.00308	34	20	77	418	645	19	385.0462783	32.95372
101	0.9867	0.00998	0.00333	0.05543	0.00333	31	22	87	431	673	21	406.1587524	24.84125
102	0.6483	0.0093	0.0028	0.0525	0.0031	34	25	80	372	580	21	424.4793327	-52.47933
103	0.973	0.0189	0.0081	0.0811	0.0081	31	17	70	425	650	17	391.6320445	33.36796
104	0.9787	0.017	0.0043	0.0709	0.0043	22	17	64	390	542	26	374.3698511	15.63015
105	0.7095	0.008	0.0027	0.05	0.003	29	22	92	419	654	19	422.4369891	-3.436989

Figure (16-e) Testing the prediction model and calculating the mean error in prediction of yield stress.

رقم	DRI	FeMn	FeSi	Lime	Dol.	C	Si	Mn	جهد الخضوع	قوة الشد	الاستطالة%	جهد الخضوع المتوقع	خطاء التوقع
106	0.96901	0.00808	0.00273	0.04038	0.00303	31	20	77	430	678	20	404.2098025	25.7902
107	0.94145	0.00686	0.00265	0.04903	0.00294	31	21	77	414	641	19	411.4253639	2.574636
108	0.9901	0.007	0.0029	0.05001	0.003	33	21	84	391	677	20	409.638562	-18.63856
109	0.98989	0.00729	0.00281	0.0521	0.00313	41	20	90	395	644	20	397.1264814	-2.126481
110	0.95734	0.00832	0.00312	0.05203	0.00312	32	21	70	410	698	19	407.1546003	2.8454
111	0.93642	0.01387	0.00347	0.0578	0.00347	30	20	84	385	605	23	387.5167457	-2.516746
112	0.94767	0.00737	0.00284	0.04738	0.00316	39	32	90	401	661	19	441.049331	-40.04933
113	0.95863	0.00729	0.00281	0.04168	0.00313	36	20	83	427	690	20	404.0844603	22.91554
114	0.97337	0.00946	0.00365	0.05543	0.00406	31	22	76	399	612	20	410.9968815	-11.99688
115	0.70179	0.0089	0.00267	0.04151	0.00297	33	23	77	382	606	20	418.6575007	-36.6575
116	0.98662	0.01075	0.00264	0.03907	0.00293	33	24	78	380	539	26	403.7156577	-23.71566
117	0.98427	0.01284	0.00289	0.0214	0.00321	32	18	84	385	530	25	381.8414871	3.158513
118	0.70104	0.01753	0.00394	0.07302	0.00438	31	23	82	387	596	20	392.9599768	-5.959977
119	0.98609	0.01096	0.00296	0.05478	0.00329	29	22	88	439	678	18	401.1882326	37.81177
120	0.98548	0.01166	0.00286	0.05298	0.00318	32	17	70	314	636	22	377.1707662	-63.17077
121	0.98593	0.0113	0.00277	0.05135	0.00308	32	21	83	421	653	18	392.2312411	28.76876
122	0.72731	0.01096	0.00269	0.03985	0.00299	31	16	90	409	636	21	389.4649686	19.53503
123	0.9805	0.0159	0.0036	0.0663	0.004	24	24	81	398	658	21	396.1949367	1.805063
124	0.9858	0.0116	0.0026	0.0483	0.0029	36	18	75	466	776	15	375.7947745	90.20523
125	0.9829	0.0142	0.0029	0.0546	0.0033	30	19	80	396	622	21	376.8487669	19.15123
126	0.9838	0.0133	0.003	0.0553	0.0033	37	20	75	438	683	18	377.1855728	60.81443

Figure (16-f) Testing the prediction model and calculating the mean error in prediction of yield stress.

127	0.98437	0.0123	0.00332	0.03691	0.00369	26	25	75	428	629	18	413.6260311	14.37397
128	0.64891	0.00946	0.00365	0.05408	0.00406	34	22	100	374	633	23	422.6683865	-48.66839
129	0.98578	0.01141	0.0028	0.05188	0.00311	30	22	78	376	582	24	396.7655073	-20.76551
130	0.7124	0.01171	0.00263	0.04879	0.00293	34	24	75	380	638	20	407.8153524	-27.81535
131	0.98619	0.01127	0.00254	0.04696	0.00282	31	18	76	339	548	24	381.3765863	-42.37659
132	0.97168	0.02082	0.0075	0.05552	0.00833	33	21	76	416	672	19	394.6964271	21.30357
133	0.98708	0.01018	0.00275	0.05088	0.00305	30	19	79	419	637	20	391.4729126	27.52709
134	0.98414	0.01274	0.00313	0.01737	0.00347	33	20	73	431	695	18	389.8899233	41.11008
135	0.99456	0.00262	0.00283	0.04188	0.00314	37	26	80	465	734	16	440.2195313	24.78047
136	0.98361	0.01311	0.00328	0.05464	0.00328	31	23	69	441	671	20	395.456127	45.54387
137	0.98754	0.00959	0.00288	0.03835	0.00288	31	21	77	386	619	24	402.2681148	-16.26811
138	0.98731	0.00976	0.00293	0.0434	0.00325	34	23	74	353	5599	25	405.0254027	-52.0254
139	0.98578	0.01141	0.0028	0.0467	0.00311	29	19	94	416	703	19	389.692158	26.30784
140	0.98414	0.01274	0.00313	0.04631	0.00347	31	15	79	401	680	19	371.2290294	29.77097
141	0.9861	0.01069	0.00321	0.04752	0.00356	28	21	74	397	684	20	402.1895421	-5.189542
142	0.98746	0.00987	0.00267	0.04246	0.00296	30	19	73	419	636	21	392.7882232	26.21178
143	0.98379	0.01247	0.00374	0.05542	0.00416	28	21	86	408	634	19	399.5769747	8.423025
144	0.9904	0.0069	0.0027	0.0416	0.003	31	20	76	409	635	19	407.2388668	1.761133
145	0.9899	0.0073	0.0028	0.0417	0.0031	31	20	74	355	561	22	406.8991756	-51.89918
146	0.9899	0.0073	0.0028	0.0448	0.0031	30	21	82	435	688	20	411.2421037	23.7579
147	0.6752	0.0104	0.0028	0.0623	0.0031	33	19	73	381	663	20	398.2354075	-17.23541

Figure (16-f) Testing the prediction model and calculating the mean error in prediction of yield stress.

148	0.98267	0.01251	0.00482	0.07147	0.00536	31	21	88	392	635	20	404.0321499	-12.03215
149	0.98614	0.01	0.00386	0.05717	0.00429	29	21	81	403	617	19	408.8455243	-5.845524
150	0.98845	0.00834	0.00322	0.05955	0.00357	36	20	114	386	595	25	401.8464497	-15.84645
151	0.97787	0.01716	0.00463	0.06862	0.00515	31	21	82	393	529	20	383.9119763	9.088024
152	0.98746	0.00987	0.00267	0.0395	0.00296	32	27	72	390	607	27	417.7995811	-27.79958
153	0.9901	0.00715	0.00276	0.05104	0.00306	34	24	74	405	624	24	416.0045408	-11.00454
154	0.9891	0.00787	0.00303	0.0562	0.00337	32	22	72	394	614	20	409.9512312	-15.95123
155	0.70479	0.00796	0.00307	0.01819	0.00341	33	23	82	431	670	18	429.7632555	1.236744
156	0.75556	0.00745	0.00287	0.01703	0.00319	34	16	82	437	686	20	404.1407597	32.85924
157	0.5735	0.01096	0.00228	0.05482	0.00253	30	22	76	374	602	21	409.2536774	-35.25368
158	0.98501	0.01204	0.00296	0.06129	0.00328	31	19	77	381	603	20	383.2928018	-2.292802
159	0.95664	0.00936	0.00281	0.04159	0.00312	29	22	81	432	642	18	408.8794981	23.1205
160	0.76112	0.00761	0.00294	0.03914	0.00326	34	23	86	461	743	17	423.9503798	37.04962
161	0.30963	0.00834	0.00322	0.05359	0	32	19	23	409	643	20	421.3782548	-12.37825
162	0.98517	0.01191	0.00292	0.06496	0.00325	30	22	92	362	581	22	394.9087739	-32.90877
163	0.66688	0.00753	0.0029	0.05378	0.00323	29	18	87	394	627	23	413.5961202	-19.59612
164	0.60024	0.00934	0.0036	0.04402	0.004	24	17	76	400	615	19	417.206216	-17.20622
165	0.8588	0.0071	0.0027	0.0404	0.003	30	22	75	430	686	18	419.9150193	10.08498
166	0.9691	0.0073	0.0028	0.0417	0.0031	37	23	75	438	667	19	412.1138629	25.88614
167	0.9677	0.0076	0.0029	0.0435	0.0033	32	25	79	468	755	16	423.2897784	44.71022
168	0.9368	0	0.0632	0.2342	0.0703	32	15	80	479	717	15	930.2204766	-451.2205

Figure (16-g) Testing the prediction model and calculating the mean error in prediction of yield stress.

169	0.98787	0.00875	0.00338	0.06252	0.00375	29	20	77	456	778	17	405.0720882	50.92791
170	0.9903	0.007	0.0027	0.03601	0.003	34	23	71	417	687	19	414.8314527	2.168547
171	0.9891	0.00787	0.00303	0.03934	0.00337	27	19	72	410	663	19	407.2401	2.7599
172	0.98934	0.00769	0.00297	0.04397	0.0033	26	22	75	455	707	17	417.7104545	37.28955
173	0.73551	0.00686	0.00265	0.03923	0.00294	28	23	72	513	778	16	429.9490812	83.05092
174	0.97761	0.00796	0.00307	0.04547	0.00341	33	24	77	462	666	16	418.0228131	43.97719
175	0.9901	0.00715	0.00276	0.05104	0.00306	30	21	73	459	698	17	409.7292477	49.27075
176	0.98979	0.00722	0.00278	0.05155	0.00309	32	23	73	433	656	20	414.3803016	18.6197
177	0.986	0.01	0.004	0.05716	0.00429	28	17	68	420	691	20	396.8120375	23.18796
178	0.9886	0.00814	0.00326	0.04652	0.00349	30	17	74	448	697	17	397.7125745	50.28743
179	0.97914	0.0149	0.00596	0.08514	0.00639	28	19	92	364	553	22	398.9990387	-34.99904
180	0.98383	0.01167	0.0045	0.0667	0.005	34	20	82	419	634	19	398.639748	20.36025
181	0.98934	0.00769	0.00297	0.05496	0.0033	32	20	73	397	681	22	403.6734546	-6.673455
182	0.99069	0.00788	0.00143	0.05629	0.00338	23	18	64	479	762	17	390.8797683	88.12023
183	0.6462	0.01346	0.00377	0.05385	0.00404	34	15	103	374	639	22	384.8339449	-10.83394
184	0.97349	0.02071	0.0058	0.06214	0.00621	32	23	97	425	661	19	387.9028763	37.09712
185	0.98698	0.01018	0.00285	0.0407	0.00305	29	20	83	426	660	19	398.4130483	27.58695
186	0.9901	0.0071	0.0028	0.0408	0.0031	24	17	80	414	673	21	404.1293024	9.870698
187	0.4354	0.0096	0.0029	0.0637	0.0032	29	14	82	435	706	18	398.9943386	36.00566
188	0.7958	0.0101	0.0027	0.0403	0.003	29	21	76	443	747	18	407.9867174	35.01328
189	0.667	0.0111	0.0043	0.0635	0.0048	33	27	83	433	727	17	435.8850129	-2.885013

190	0.93306	0.00976	0.00293	0.0434	0.00325	39	21	87	423	672	19	396.7607883	26.23921
191	0.77837	0.00841	0.00284	0.04207	0.00316	30	17	73	402	605	19	401.6996346	0.300365
192	0.98979	0.00737	0.00284	0.04212	0.00316	33	20	77	433	726	18	405.1409158	27.85908
193	0.98968	0.00745	0.00287	0.04257	0.00319	30	24	81	444	606	17	421.3688381	22.63116
194	0.98796	0.00926	0.00278	0.04116	0.00309	30	22	72	437	703	18	406.2842606	30.71574
195	0.7475	0.00769	0.00297	0.04397	0.0033	30	17	82	448	744	17	407.2701825	40.72982
196	0	0.02595	0.01001	0.18539	0.01112	31	27	88	378	610	21	437.0503779	-59.05038
197	0	0.03186	0.01229	0.22758	0.01365	30	16	76	433	787	18	390.9556703	42.04433
									Average Prediction Error = 2.928656				

Figure (16-i) Testing the prediction model and calculating the mean error in prediction of yield stress.

From Figure (16) the prediction process for yield stress was carried out for 197 samples and the average error was very small 2.928656 compared to the sample size 197 and the mean error sign was positive and this indicates that the real value is greater than the prediction value, so we increased the mean error to the prediction to get On average error equal to zero.

3.3 Testing the Tensile Strength Prediction Model:

Test the prediction model and calculate the average error in predicting the tensile strength, and these results are shown in Figure (17) for all 198 samples obtained from the prediction model.

NO	DRI	FeMn	FeSi	Lime	Dol.	C	Si	Mn	Yield Effort	Tensile Strength	Elongation	Expected Yield Effort	Error
1	0.93647	0.00745	0.00287	0.04363	0.00319	34	23	81	448	747	20	[illegible]	[illegible]80117
2	0.93779	0.00729	0.00281	0.04897	0.00313	31	19	75	429	668	17	634.0081868	33.99181
3	0.66688	0.00729	0.00281	0.04168	0.00313	30	20	74	431	681	18	619.9045078	61.09549
4	0.93579	0.00753	0.0029	0.0484	0.00323	32	21	70	450	673	21	640.8586352	32.14136
5	0.95863	0.00729	0.00281	0.0521	0.00313	30	22	72	475	771	15	650.5047386	120.4953
6	0.9244	0.00886	0.00342	0.05065	0.0038	30	19	80	384	619	20	645.6264589	-26.62646
7	0.93579	0.00753	0.0029	0.04302	0.00323	31	18	77	412	653	19	631.4085979	21.5914
8	0.59473	0.04248	0.02294	0.08496	0	29	22	76	457	700	16	686.913766	13.08623
9	0.84966	0.00959	0.0037	0.05482	0	32	21	75	382	583	26	656.3976541	-73.39765
10	0.9289	0.00834	0.00322	0.05955	0.00357	29	23	79	452	732	16	677.5308601	54.46914
11	0.75023	0.007	0.0027	0.05002	0.003	33	24	70	428	692	17	663.3158914	28.68411
12	0.8651	0.00631	0.00243	0.03514	0.0027	30	26	74	442	717	20	693.9831872	23.01681
13	0.94875	0.00722	0.00278	0.04125	0.00309	32	25	76	419	650	19	703.6638175	-53.66382
14	0.94087	0.00693	0.00267	0.04457	0.00297	35	18	74	442	712	22	638.1818323	73.81817
15	0.69409	0.00715	0.00276	0.0347	0.00306	33	26	70	444	729	17	681.6208495	47.37915
16	0.9329	0.00787	0.00303	0.0562	0.00337	34	23	72	394	651	20	675.1227637	-24.12276
17	0.8904	0.00769	0.00297	0.05496	0.0033	34	21	74	370	613	21	659.4309267	-46.43093
18	0.8835	0.0091	0.0035	0.0455	0.0039	32	19	68	412	622	21	610.3628864	11.63711
19	0.917	0.0073	0.0028	0.0427	0.0031	31	22	71	408	673	25	649.7066605	23.29334
20	0.9471	0.0074	0.0029	0.0138	0.0032	31	22	72	418	653	18	658.5194648	-5.519465
21	0.9391	0.0071	0.0028	0.0143	0.0031	32	21	75	437	697	17	662.6081195	34.39188

Figure (17-a) Testing the prediction model and calculating the mean error in predicting the tensile strength.

22	0.91695	0.00729	0.00281	0.01563	0.00313	31	21	70	394	639	20	639.4265376	-0.426538
23	0.60376	0.01208	0.00466	0.05175	0.00518	29	21	86	433	655	26	660.7476296	-5.74763
24	0.98945	0.00761	0.00294	0.02936	0.00326	31	20	77	374	564	21	656.5640492	-92.56405
25	0.98957	0.00753	0.0029	0.03012	0.00323	35	25	75	410	658	20	716.7018275	-58.70183
26	0.65127	0.01018	0.00275	0.05495	0.00305	34	14	72	387	595	22	560.2204891	34.77951
27	0.96618	0.02196	0.01186	0.24155	0.01318	37	18	66	379	593	21	609.4748475	-16.47485
28	0.9711	0.00819	0.00316	0.0585	0.00351	30	19	69	370	554	26	609.7101182	-55.71012
29	0.93779	0.00729	0.00281	0.04168	0.00313	35	21	74	388	609	20	668.3872533	-59.38725
30	0.93594	0.0113	0.00436	0.04841	0.00484	35	25	73	380	626	20	703.0552519	-77.05525
31	0.98802	0.00865	0.00333	0.0457	0.00371	25	11	66	365	546	24	500.2729844	45.72702
32	0.98989	0.00729	0.00281	0.0521	0.00313	32	20	74	403	651	19	647.7709228	3.229077
33	0.95683	0.00761	0.00294	0.05437	0.00326	29	18	81	399	597	18	636.8178465	-39.81785
34	0.98934	0.00769	0.00297	0.05496	0.0033	35	14	75	409	676	16	603.0751032	72.9249
35	0.78927	0.01036	0.00266	0.04933	0.00296	34	19	77	376	608	21	636.5196068	-28.51961
36	0.73921	0.00761	0.00315	0.04348	0.00326	31	15	98	358	559	22	662.8197844	-103.8198
37	0.98958	0.00729	0.00313	0.04167	0.00313	43	15	73	401	633	21	643.6364033	-10.6364
38	0.70409	0.00761	0.00285	0.04757	0.00285	26	23	62	444	627	16	593.1373675	33.86263
39	0.9861	0.0105	0.0034	0.0479	0.0029	26	18	68	343	537	23	578.3803834	-41.38038
40	0.9717	0.0223	0.0061	0.081	0.0061	25	18	75	393	573	24	580.9595089	-7.959509
41	0.3457	0.0296	0.0074	0.0741	0.0074	28	17	78	371	556	22	545.2677191	10.73228
42	0.9864	0.0099	0.0037	0.0493	0.0037	24	12	98	406	660	19	616.2162295	43.78377

Figure (17-b) Testing the prediction model and calculating the mean error in predicting the tensile strength.

22	0.91695	0.00729	0.00281	0.01563	0.00313	31	21	70	394	639	20	639.4265376	-0.426538
23	0.60376	0.01208	0.00466	0.05175	0.00518	29	21	86	433	655	26	660.7476296	-5.74763
24	0.98945	0.00761	0.00294	0.02936	0.00326	31	20	77	374	564	21	656.5640492	-92.56405
25	0.98957	0.00753	0.0029	0.03012	0.00323	35	25	75	410	658	20	716.7018275	-58.70183
26	0.65127	0.01018	0.00275	0.05495	0.00305	34	14	72	387	595	22	560.2204891	34.77951
27	0.96618	0.02196	0.01186	0.24155	0.01318	37	18	66	379	593	21	609.4748475	-16.47485
28	0.9711	0.00819	0.00316	0.0585	0.00351	30	19	69	370	554	26	609.7101182	-55.71012
29	0.93779	0.00729	0.00281	0.04168	0.00313	35	21	74	388	609	20	668.3872533	-59.38725
30	0.93594	0.0113	0.00436	0.04841	0.00484	35	25	73	380	626	20	703.0552519	-77.05525
31	0.98802	0.00865	0.00333	0.0457	0.00371	25	11	66	365	546	24	500.2729844	45.72702
32	0.98989	0.00729	0.00281	0.0521	0.00313	32	20	74	403	651	19	647.7709228	3.229077
33	0.95683	0.00761	0.00294	0.05437	0.00326	29	18	81	399	597	18	636.8178465	-39.81785
34	0.98934	0.00769	0.00297	0.05496	0.0033	35	14	75	409	676	16	603.0751032	72.9249
35	0.78927	0.01036	0.00266	0.04933	0.00296	34	19	77	376	608	21	636.5196068	-28.51961
36	0.73921	0.00761	0.00315	0.04348	0.00326	31	15	98	358	559	22	662.8197844	-103.8198
37	0.98958	0.00729	0.00313	0.04167	0.00313	43	15	73	401	633	21	643.6364033	-10.6364
38	0.70409	0.00761	0.00285	0.04757	0.00285	26	23	62	444	627	16	593.1373675	33.86263
39	0.9861	0.0105	0.0034	0.0479	0.0029	26	18	68	343	537	23	578.3803834	-41.38038
40	0.9717	0.0223	0.0061	0.081	0.0061	25	18	75	393	573	24	580.9595089	-7.959509
41	0.3457	0.0296	0.0074	0.0741	0.0074	28	17	78	371	556	22	545.2677191	10.73228
42	0.9864	0.0099	0.0037	0.0493	0.0037	24	12	98	406	660	19	616.2162295	43.78377

Figure (17-c) Testing the prediction model and calculating the mean error in predicting the tensile strength.

43	0.70323	0.01125	0.00422	0.07032	0.00422	33	18	1.01	407	681	26	356.9685668	324.0314
44	0.98806	0.00869	0.00326	0.04886	0.00326	35	16	87	400	626	20	665.1574795	-39.15748
45	0.68985	0.01054	0.00259	0.04791	0.00287	38	2	84	426	664	18	499.7830106	164.217
46	0.98872	0.00752	0.00376	0.05373	0.00322	31	24	72	350	542	23	681.959527	-139.9595
47	0.98684	0.00987	0.00329	0.05482	0.00329	36	19	84	326	499	25	685.885907	-186.8859
48	0.97959	0.01633	0.00408	0.06803	0.00408	33	17	109	366	565	22	727.5867451	-162.5867
49	0.95238	0.03741	0.0102	0.10204	0.0102	33	21	76	364	584	22	632.233921	-48.23392
50	0.96691	0.00859	0.00301	0.05372	0.00322	24	26	74	348	537	22	670.9336215	-133.9336
51	0.98253	0.01365	0.00382	0.05459	0.00328	37	21	87	385	608	23	715.4105513	-107.4106
52	0.97986	0.01633	0.00381	0.05444	0.00327	33	18	91	397	598	20	676.1111788	-78.11118
53	0.98793	0.00878	0.00329	0.05488	0.00329	29	13	90	411	626	23	619.3450093	6.654991
54	0.98446	0.01244	0.00311	0.05181	0.00311	32	24	79	405	636	19	695.5444127	-59.54441
55	0.98446	0.01244	0.00311	0.05181	0.00311	38	22	78	392	630	20	697.2696582	-67.26966
56	0.98691	0.01007	0.00302	0.05035	0.00302	40	18	80	384	619	20	677.540762	-58.54076
57	0.9838	0.01273	0.00347	0.05787	0.00347	38	17	89	413	679	25	685.6021559	-6.602156
58	0.98542	0.01106	0.00352	0.06033	0.00302	29	14	88	397	633	20	618.3856016	14.6144
59	0.98571	0.01084	0.00345	0.04929	0.00296	36	20	82	376	591	27	688.8664896	-97.86649
60	0.982	0.0149	0.0031	0.0534	0.0032	33	12	89	355	632	25	607.7155203	24.28448
61	0.9821	0.0149	0.003	0.0595	0.003	28	17	97	329	500	25	663.5853314	-163.5853
62	0.8673	0.0071	0.0031	0.0561	0.0031	35	20	101	424	637	20	747.752439	-110.7524
63	0.7668	0.0124	0.0031	0.0518	0.0031	38	21	81	429	629	19	683.6916234	-54.69162

Figure (17-d) Testing the prediction model and calculating the mean error in predicting the tensile strength.

64	0.9768	0.01954	0.00366	0.06105	0.00366	33	18	91	390	631	20	666.6067465	-35.60675
65	0.97622	0.02003	0.00375	0.06258	0.00375	33	18	81	409	645	24	631.0830913	13.91691
66	0.98874	0.00783	0.00343	0.04895	0.00294	35	29	83	417	652	18	785.3719884	-133.372
67	0.98307	0.01365	0.00328	0.05461	0.00328	28	21	80	381	566	22	649.7266736	-83.72667
68	0.9781	0.01752	0.00438	0.05839	0.00438	32	11	110	380	578	22	666.4652895	-88.46529
69	0.78254	0.00906	0.00247	0.04119	0.00247	35	21	97	407	610	20	733.0207413	-123.0207
70	0.76844	0.01332	0.00307	0.05123	0.00307	35	18	92	422	650	19	677.0771933	-27.07719
71	0.79523	0.01292	0.00298	0.0497	0.00298	34	21	89	413	627	19	694.9203126	-67.92031
72	0.72131	0.01311	0.00328	0.05464	0.00328	31	20	89	399	594	21	667.9865038	-73.9865
73	0.9865	0.01038	0.00312	0.05192	0.00312	33	16	96	429	680	19	682.9959919	-2.995992
74	0.63102	0.01283	0.00321	0.05348	0.00321	24	19	72	415	628	20	564.0583962	63.9416
75	0.73892	0.01182	0.00296	0.04926	0.00296	33	13	96	411	629	20	633.3030874	-4.303087
76	0.98305	0.01356	0.00339	0.0678	0.00339	34	22	110	438	730	17	788.3660632	-58.36606
77	0.73988	0.01387	0.00347	0.0578	0.00347	33	17	92	415	696	19	656.7722693	39.22773
78	0.65502	0.01419	0.00328	0.06004	0	31	14	86	359	545	22	594.0033288	-49.00333
79	0.72821	0.01231	0.00308	0.05128	0.00308	30	111	100	429	663	20	1618.410021	-955.41
80	0.55894	0.01118	0.00305	0.05081	0.00305	36	19	94	413	655	19	689.5312985	-34.5313
81	0.9891	0.0079	0.003	0.0495	0.003	33	17	92	413	633	20	684.3442287	-51.34423
82	0.9894	0.0076	0.003	0.0414	0	29	19	79	401	643	19	648.2708671	-5.270867
83	0.9896	0.0073	0.0031	0.0417	0.0031	38	19	85	407	635	19	704.3964006	-69.3964
84	0.7448	0.011	0.0033	0.0438	0.0033	32	12	66	433	668	19	519.6021884	148.3978

Figure (17-e) Testing the prediction model and calculating the mean error in predicting the tensile strength.

85	0.76004	0.00869	0.00326	0.04343	0.00326	33	25	79	386	566	22	705.5055693	-139.5056
86	0.98649	0.01085	0.00266	0.04932	0	30	20	83	412	611	19	665.7058631	-54.70586
87	0.86482	0.03186	0.01229	0.22758	0.01365	27	21	87	364	557	23	645.7486052	-88.74861
88	0.98934	0.00769	0.00297	0.05496	0.0033	31	22	81	383	657	20	687.451713	-30.45171
89	0.98968	0.00745	0.00287	0.05321	0.00319	28	24	84	494	535	20	705.6183067	-170.6183
90	0.98533	0.01178	0.00289	0.04284	0.00321	34	21	81	380	603	20	681.8237663	-78.82377
91	0.98979	0.00737	0.00284	0.04212	0.00316	35	18	76	425	738	18	648.4185386	89.58146
92	0.98468	0.01204	0.00328	0.04376	0.00328	33	20	92	413	657	21	707.3982976	-50.3983
93	0.93458	0.0113	0.00277	0.05135	0.00308	36	18	78	384	601	20	645.8996634	-44.89966
94	0.98548	0.01166	0.00286	0.05298	0.00318	30	25	81	386	586	20	704.0898705	-118.0899
95	0.98501	0.01178	0.00321	0.05353	0.00321	33	15	83	376	599	21	624.9688477	-25.96885
96	0.70855	0.00729	0.00281	0.0521	0.00313	32	23	81	400	702	19	684.2048313	17.79517
97	0.98979	0.00729	0.00292	0.05209	0.00313	32	19	76	369	623	21	645.3122808	-22.31228
98	0.9009	0.07207	0.02703	0.22523	0.02703	36	22	76	400	602	19	667.2665748	-65.26657
99	0.98413	0.0127	0.00317	0.05291	0.00317	36	17	85	374	578	26	662.454297	-84.4543
100	0.98462	0.01231	0.00308	0.05231	0.00308	34	20	77	418	645	19	656.895051	-11.89505
101	0.9867	0.00998	0.00333	0.05543	0.00333	31	22	87	431	673	21	705.2324479	-32.23245
102	0.6483	0.0093	0.0028	0.0525	0.0031	34	25	80	372	580	21	700.8493419	-120.8493
103	0.973	0.0189	0.0081	0.0811	0.0081	31	17	70	425	650	17	596.7696631	53.23034
104	0.9787	0.017	0.0043	0.0709	0.0043	22	17	64	390	542	26	524.0385065	17.96149
105	0.7095	0.008	0.0027	0.05	0.003	29	22	92	419	654	19	697.8530348	-43.85303

Figure (17-f) Testing the prediction model and calculating the mean error in predicting the tensile strength.

106	0.96901	0.00808	0.00273	0.04638	0.00303	31	20	77	430	678	20	651.8609478	26.13905
107	0.94145	0.00686	0.00265	0.04903	0.00294	31	21	77	414	641	19	661.4046543	-20.40465
108	0.9901	0.007	0.0029	0.05001	0.003	33	21	84	391	677	20	698.3534326	-21.35343
109	0.98989	0.00729	0.00281	0.0521	0.00313	41	20	90	395	644	20	741.2303876	-97.23039
110	0.95734	0.00832	0.00312	0.05203	0.00312	32	21	70	410	698	19	641.5578491	56.44215
111	0.93642	0.01387	0.00347	0.0578	0.00347	30	20	74	385	605	23	659.1110374	-54.11104
112	0.94767	0.00737	0.00284	0.04738	0.00316	39	32	90	401	661	19	851.2796901	-190.2797
113	0.98863	0.00729	0.00281	0.04168	0.00313	36	20	83	427	690	20	695.107292	-5.107292
114	0.97337	0.00946	0.00365	0.05543	0.00406	31	22	76	399	612	20	668.5182954	-56.5183
115	0.70179	0.0089	0.00267	0.04151	0.00297	33	23	77	382	606	20	671.1140475	-65.11405
116	0.98662	0.01075	0.00264	0.03907	0.00293	33	24	78	380	539	26	698.9167479	-159.9167
117	0.98427	0.01284	0.00289	0.0214	0.00321	32	18	84	375	530	25	653.7813308	-123.7813
118	0.70104	0.01753	0.00394	0.07302	0.00438	31	23	82	387	596	20	663.4736931	-67.47369
119	0.98609	0.01096	0.00296	0.05478	0.00329	29	22	88	439	678	18	695.8518629	-17.85186
120	0.98548	0.01166	0.00286	0.05298	0.00318	32	17	70	314	636	22	593.9334596	42.06654
121	0.98593	0.0113	0.00277	0.05135	0.00308	32	21	83	421	653	18	679.8261964	-26.8262
122	0.72731	0.01096	0.00269	0.03985	0.00299	31	16	90	409	636	21	634.7778433	1.222157
123	0.9805	0.0159	0.0036	0.0663	0.004	24	24	81	398	658	21	661.0143757	-3.014376
124	0.9858	0.0116	0.0026	0.0483	0.0029	36	18	75	466	776	15	637.6531836	138.3468
125	0.9829	0.0142	0.0029	0.0546	0.0033	30	19	80	396	622	21	634.7530571	-12.75306
126	0.9838	0.0133	0.003	0.0553	0.0033	37	20	75	438	683	18	659.1995898	23.80041

Figure (17-g) Testing the prediction model and calculating the mean error in predicting the tensile strength.

127	0.98437	0.0123	0.00332	0.03691	0.00369	26	25	75	428	629	18	669.1252991	-40.1253
128	0.64891	0.00946	0.00365	0.05408	0.00406	34	22	100	374	633	23	743.819434	-110.8194
129	0.98578	0.01141	0.0028	0.05188	0.00311	30	22	78	376	582	24	663.9111658	-81.91116
130	0.7124	0.01171	0.00263	0.04879	0.00293	34	24	75	380	638	20	671.8590522	-33.85905
131	0.98619	0.01127	0.00254	0.04696	0.00282	31	18	76	339	548	24	620.5822683	-72.58227
132	0.97168	0.02082	0.0075	0.05552	0.00833	33	21	76	416	672	19	660.8357446	11.16426
133	0.98708	0.01018	0.00275	0.05088	0.00305	30	19	79	419	637	20	639.8910875	-2.891088
134	0.98414	0.01274	0.00313	0.01737	0.00347	33	20	73	431	695	18	641.8294755	53.17052
135	0.99456	0.00262	0.00283	0.04188	0.00314	37	26	80	465	734	16	761.9262527	-27.92625
136	0.98361	0.01311	0.00328	0.05464	0.00328	31	23	69	441	671	20	645.5562409	25.44376
137	0.98754	0.00959	0.00288	0.03835	0.00288	31	21	77	386	619	24	661.1439564	-42.14396
138	0.98731	0.00976	0.00293	0.0434	0.00325	34	23	74	353	5599	25	682.3552367	4916.645
139	0.98578	0.01141	0.0028	0.0467	0.00311	29	19	94	416	703	19	685.660987	17.33901
140	0.98414	0.01274	0.00313	0.04631	0.00347	31	15	75	416	680	19	600.4776516	79.52235
141	0.9861	0.01069	0.00321	0.04752	0.00356	28	21	74	397	684	20	635.7109627	48.28904
142	0.98746	0.00987	0.00267	0.04246	0.00296	30	19	73	419	636	20	620.3691551	15.63084
143	0.98379	0.01247	0.00374	0.05542	0.00416	28	21	86	408	634	19	674.9749085	-40.97491
144	0.9904	0.0069	0.0027	0.0416	0.003	31	20	76	409	635	19	651.8855838	-16.88558
145	0.9899	0.0073	0.0028	0.0417	0.0031	30	20	74	355	561	22	644.8011639	-83.80116
146	0.9899	0.0073	0.0028	0.0448	0.0031	30	21	82	435	688	20	678.0171197	9.98288
147	0.6752	0.0104	0.0028	0.0623	0.0031	33	19	73	381	663	20	610.206722	52.79328

Figure (17-i) Testing the prediction model and calculating the mean error in predicting the tensile strength.

148	0.98267	0.01251	0.00482	0.07147	0.00536	31	21	88	392	635	20	697.8935588	-62.89356
149	0.98614	0.01	0.00386	0.05717	0.00429	29	21	81	403	617	19	667.8299886	-50.82999
150	0.98845	0.00834	0.00322	0.05955	0.00357	36	20	114	395	595	25	802.1218015	-207.1218
151	0.97787	0.01716	0.00463	0.06862	0.00515	31	21	82	393	529	20	665.8704169	-136.8704
152	0.98746	0.00987	0.00267	0.0395	0.00296	32	27	72	390	607	27	706.1178887	-99.11789
153	0.9901	0.00715	0.00276	0.05104	0.00306	34	24	74	405	624	29	696.6029669	-72.60297
154	0.9891	0.00787	0.00303	0.0562	0.00337	32	22	72	394	614	20	660.2330244	-46.23302
155	0.70479	0.00796	0.00307	0.01819	0.00341	33	23	82	431	670	18	695.517572	-25.51757
156	0.75556	0.00745	0.00287	0.01703	0.00319	34	16	82	437	686	20	632.8948003	53.1052
157	0.5735	0.01096	0.00228	0.05482	0.00253	30	22	76	374	602	21	628.6065217	-26.60652
158	0.98501	0.01204	0.00296	0.06129	0.00328	31	19	77	381	603	20	632.7053218	-29.70532
159	0.95664	0.00936	0.00281	0.04159	0.00312	29	22	81	432	642	18	674.0434943	-32.04439
160	0.76112	0.00761	0.00294	0.03914	0.00326	34	23	86	461	743	17	714.8091357	28.19086
161	0.30963	0.00834	0.00322	0.05359	0	32	19	23	409	643	20	421.1651402	221.8349
162	0.98517	0.01191	0.00292	0.06496	0.00325	30	22	92	362	581	22	710.3872401	-129.3872
163	0.66688	0.00753	0.0029	0.05378	0.00323	29	18	87	394	627	23	639.1636597	-12.16366
164	0.60024	0.00934	0.0036	0.04402	0.004	24	17	79	400	615	19	566.2455492	48.75445
165	0.8588	0.0071	0.0027	0.0404	0.003	30	22	75	430	686	18	655.9860106	30.01399
166	0.9691	0.0073	0.0028	0.0417	0.0031	37	23	75	438	667	19	702.398965	-35.39896
167	0.9677	0.0076	0.0029	0.0435	0.0033	32	25	79	468	755	16	714.9036591	40.09634
168	0.9368	0	0.0632	0.2342	0.0703	32	15	80	479	717	15	910.6185599	-193.6186

Figure (17-k) Testing the prediction model and calculating the mean error in predicting the tensile strength.

169	0.98787	0.00875	0.00338	0.06252	0.00375	29	20	77	456	778	17	643.7299513	134.27
170	0.9903	0.007	0.0027	0.03601	0.003	34	23	71	417	687	19	677.9940633	9.005937
171	0.9891	0.00787	0.00303	0.03934	0.00337	27	19	72	410	663	19	611.0051832	51.99482
172	0.98934	0.00769	0.00297	0.04397	0.0033	26	22	75	455	707	17	646.8676037	60.1324
173	0.73551	0.00686	0.00265	0.03923	0.00294	28	23	72	513	778	16	639.5045253	138.4955
174	0.97761	0.00796	0.00307	0.04547	0.00341	33	24	77	462	666	16	702.4259177	-36.42592
175	0.9901	0.00715	0.00276	0.05104	0.00306	30	21	73	459	698	17	646.1049161	51.89508
176	0.98979	0.00722	0.00278	0.05155	0.00309	32	23	73	433	656	20	674.544061	-18.54406
177	0.986	0.01	0.004	0.05716	0.00429	28	17	68	420	691	20	579.1999397	111.8001
178	0.9886	0.00814	0.00326	0.04652	0.00349	30	17	74	448	697	17	610.2561721	86.74383
179	0.97914	0.0149	0.00596	0.08514	0.00639	28	19	92	364	553	22	677.8129226	-124.8129
180	0.98383	0.01167	0.0045	0.0667	0.005	34	20	82	419	634	19	680.5606407	-46.56064
181	0.98934	0.00769	0.00297	0.05496	0.0033	32	20	73	397	681	22	643.8079205	37.19208
182	0.99069	0.00788	0.00143	0.05629	0.00338	23	18	64	479	762	17	544.1643585	217.8356
183	0.6462	0.01346	0.00377	0.05385	0.00404	34	15	103	374	639	22	675.6382396	-36.63824
184	0.97349	0.02071	0.0058	0.06214	0.00621	32	23	97	425	661	19	740.9671423	-79.96714
185	0.98698	0.01018	0.00285	0.0407	0.00305	29	20	83	426	660	19	661.4643918	-1.464392
186	0.9901	0.0071	0.0028	0.0408	0.0031	24	17	80	414	673	21	606.0944108	66.90559
187	0.4354	0.0096	0.0029	0.0637	0.0032	29	14	82	435	706	18	560.9230918	145.0769
188	0.7958	0.0101	0.0027	0.0403	0.003	29	21	76	443	747	18	634.4847658	112.5152
189	0.667	0.0111	0.0043	0.0635	0.0048	33	27	83	433	727	17	730.4449011	-3.444901

Figure (17-m) Testing the prediction model and calculating the mean error in predicting the tensile strength.

190	0.93306	0.00976	0.00293	0.0434	0.00325	39	21	87	423	672	19	724.9590273	-52.95903
191	0.77837	0.00841	0.00284	0.04207	0.00316	30	17	73	402	605	19	591.018618	13.98138
192	0.98979	0.00737	0.00284	0.04212	0.00316	33	20	77	433	726	18	663.5611413	62.43886
193	0.98968	0.00745	0.00287	0.04257	0.00319	30	24	81	444	606	17	704.9184526	-98.91845
194	0.98796	0.00926	0.00278	0.04116	0.00309	30	22	72	437	703	18	649.1640521	53.83595
195	0.7475	0.00769	0.00297	0.04397	0.0033	30	17	82	448	744	17	622.2687546	121.7312
196	0	0.02595	0.01001	0.18539	0.01112	31	27	88	378	610	21	677.7939577	-67.79396
197	0	0.03186	0.01229	0.22758	0.01365	30	16	76	433	787	18	514.6043996	272.3956
									Average Prediction Error 4.750072				

Figure (17-n) Testing the prediction model and calculating the mean error in predicting the tensile strength.

From Figure (17) the tensile strength prediction process was performed for 197 samples and the mean error was very small 2.928656 compared to the sample size 197 and the mean error sign was positive and this indicates that the real value is greater than the prediction value, so we increased the mean error to the prediction to get On average error equal to zero.

3.4. Testing the Elongation Ratio Prediction Model:

Test the prediction model and calculate the average error in the prediction of the elongation ratio, and these results are shown in Figure (18) for all 198 samples obtained from the prediction model.

NO	DRI	FeMn	FeSi	Lime	Dol.	C	Si	Mn	Yield Effort	Tensile Strength	Elongation	Expected Yield Effort	Error
1	0.93647	0.00745	0.00287	0.04363	0.00319	34	23	81	448	747	20	21.0726868	-1.072687
2	0.93779	0.00729	0.00281	0.04897	0.00313	31	19	75	429	668	17	20.10764223	-3.107642
3	0.66688	0.00729	0.00281	0.04168	0.00313	30	20	74	431	681	18	18.00718119	-0.007181
4	0.93579	0.00753	0.0029	0.0484	0.00323	32	21	70	450	673	21	19.73806845	1.261932
5	0.95863	0.00729	0.00281	0.0521	0.00313	30	22	72	475	771	15	19.84661656	-4.846617
6	0.9244	0.00886	0.00342	0.05065	0.0038	30	19	80	384	619	20	20.41210911	-0.412109
7	0.93579	0.00753	0.0029	0.04302	0.00323	31	18	77	412	653	19	20.11550498	-1.115505
8	0.59473	0.04248	0.02294	0.08496	0	29	22	76	457	700	16	16.75249696	-0.752497
9	0.84966	0.00959	0.0037	0.05482	0	32	21	75	382	583	26	21.2423502	4.75765
10	0.9289	0.00834	0.00322	0.05955	0.00357	29	23	79	452	732	16	20.44155049	-4.44155
11	0.75023	0.007	0.0027	0.05002	0.003	33	24	70	428	692	17	18.87059557	-1.870596
12	0.8651	0.00631	0.00243	0.03514	0.0027	30	26	74	442	717	20	18.98196027	1.01804
13	0.94875	0.00722	0.00278	0.04125	0.00309	32	25	76	419	650	19	20.21238904	-1.212389
14	0.94087	0.00693	0.00267	0.04457	0.00297	35	18	74	442	712	22	20.58348869	1.416511
15	0.69409	0.00715	0.00276	0.0347	0.00306	33	26	70	444	729	17	18.06562174	-1.065622
16	0.9329	0.00787	0.00303	0.0562	0.00337	34	23	72	394	651	20	20.51422383	-0.514224
17	0.8904	0.00769	0.00297	0.05496	0.0033	34	21	74	370	613	21	20.43073524	0.569265
18	0.8835	0.0091	0.0035	0.0455	0.0039	32	19	68	412	622	21	19.12450461	1.875495
19	0.917	0.0073	0.0028	0.0427	0.0031	31	22	71	408	673	25	19.38161619	5.618384
20	0.9471	0.0074	0.0029	0.0138	0.0032	31	22	72	418	653	18	18.76762279	-0.767623
21	0.9391	0.0071	0.0028	0.0143	0.0031	32	21	75	437	697	17	19.21726595	-2.217266

Figure (18-a) Testing the prediction model and calculating the mean error in predicting the elongation ratio.

22	0.91695	0.00729	0.00281	0.01563	0.00313	31	21	70	394	639	20	18.44029118	1.559709
23	0.60376	0.01208	0.00466	0.05175	0.00518	29	21	86	433	655	26	18.98059515	7.019405
24	0.98945	0.00761	0.00294	0.02936	0.00326	31	20	77	374	564	21	20.00962497	0.990375
25	0.98957	0.00753	0.0029	0.03012	0.00323	35	25	75	410	658	20	20.52592265	-0.525923
26	0.65127	0.01018	0.00275	0.05495	0.00305	34	14	72	387	595	22	20.62189811	1.378102
27	0.96618	0.02196	0.01186	0.24155	0.01318	37	18	66	379	593	21	21.03074562	-0.030746
28	0.9711	0.00819	0.00316	0.0585	0.00351	30	19	69	370	554	26	19.80448282	6.195517
29	0.93779	0.00729	0.00281	0.04168	0.00313	35	21	74	388	609	20	20.4752151	-0.475215
30	0.93594	0.0113	0.00436	0.04841	0.00484	35	25	73	380	626	20	20.55082091	-0.550821
31	0.98802	0.00865	0.00333	0.0457	0.00371	25	11	66	365	546	24	18.32579155	5.674208
32	0.98989	0.00729	0.00281	0.0521	0.00313	32	20	74	403	651	19	20.58329295	-1.583293
33	0.95683	0.00761	0.00294	0.05437	0.00326	29	18	81	399	597	18	20.65331924	-2.653319
34	0.98934	0.00769	0.00297	0.05496	0.0033	35	14	75	409	676	16	21.28841077	-5.288411
35	0.78927	0.01036	0.00266	0.04933	0.00296	34	19	77	376	608	21	22.01564244	-1.015642
36	0.73921	0.00761	0.00315	0.04348	0.00326	31	15	98	358	559	22	20.86484841	1.135152
37	0.98958	0.00729	0.00313	0.04167	0.00313	43	15	73	401	633	21	21.69275521	-0.692755
38	0.70409	0.00761	0.00285	0.04757	0.00285	26	23	62	444	627	16	16.70872873	-0.708729
39	0.9861	0.0105	0.0034	0.0479	0.0029	26	18	68	343	537	23	20.12662535	2.873375
40	0.9717	0.0223	0.0061	0.081	0.0061	25	18	75	393	573	24	24.28867697	-0.288677
41	0.3457	0.0296	0.0074	0.0741	0.0074	28	17	78	371	556	22	23.55087287	-1.550873
42	0.9864	0.0099	0.0037	0.0493	0.0037	24	12	98	406	660	19	21.82946211	-2.829462

Figure (18-b) Testing the prediction model and calculating the mean error in predicting the elongation ratio.

43	0.70323	0.01125	0.00422	0.07032	0.00422	33	18	1.01	407	681	26	12.44998076	13.55002
44	0.98806	0.00869	0.00326	0.04886	0.00326	35	16	87	400	626	20	22.57936808	-2.579368
45	0.68985	0.01054	0.00259	0.04791	0.00287	38	2	84	426	664	18	23.01836118	-5.018361
46	0.98872	0.00752	0.00376	0.05373	0.00322	31	24	72	350	542	23	19.22144224	3.778558
47	0.98684	0.00987	0.00329	0.05482	0.00329	36	19	84	326	499	25	23.27503851	1.724961
48	0.97959	0.01633	0.00408	0.06803	0.00408	33	17	109	366	565	22	28.31119542	-6.311195
49	0.95238	0.03741	0.0102	0.10204	0.0102	33	21	76	364	584	22	29.03999786	-7.039998
50	0.96691	0.00859	0.00301	0.05372	0.00322	24	26	74	348	537	22	19.61620868	2.383719
51	0.98253	0.01365	0.00382	0.05459	0.00328	37	21	87	385	608	23	25.33175211	-2.331752
52	0.97986	0.01633	0.00381	0.05444	0.00327	33	18	91	397	598	20	26.63076635	-6.630766
53	0.98793	0.00878	0.00329	0.05488	0.00329	29	13	90	411	626	23	22.03150127	0.968499
54	0.98446	0.01244	0.00311	0.05181	0.00311	32	24	79	405	636	19	23.75433096	-4.754331
55	0.98446	0.01244	0.00311	0.05181	0.00311	38	22	78	392	630	20	24.69370392	-4.693704
56	0.98691	0.01007	0.00302	0.05035	0.00302	40	18	80	384	619	20	23.94680492	-3.946805
57	0.9838	0.01273	0.00347	0.05787	0.00347	38	17	89	413	679	25	25.63040451	-0.630405
58	0.98542	0.01106	0.00352	0.06033	0.00302	29	14	88	397	633	20	23.14791782	-3.147918
59	0.98571	0.01084	0.00345	0.04929	0.00296	36	20	82	376	591	27	23.3832583	3.616742
60	0.982	0.0149	0.0031	0.0534	0.0032	33	12	89	355	632	25	26.45511118	-1.455111
61	0.9821	0.0149	0.003	0.0595	0.003	28	17	97	329	500	25	26.77857054	-1.778571
62	0.8673	0.0071	0.0031	0.0561	0.0031	35	20	101	424	637	20	22.91362101	-2.913621
63	0.7668	0.0124	0.0031	0.0518	0.0031	38	21	81	429	629	19	23.71723463	-4.717235

Figure (18-c) Testing the prediction model and calculating the mean error in predicting the elongation ratio.

64	0.9768	0.01954	0.00366	0.06105	0.00366	33	18	81	390	631	20	28.76485953	-8.76486
65	0.97622	0.02003	0.00375	0.06258	0.00375	33	18	81	409	645	24	27.93275239	-3.932752
66	0.98874	0.00783	0.00343	0.04895	0.00294	35	29	83	417	652	18	21.57459426	-3.574594
67	0.98307	0.01365	0.00328	0.05461	0.00328	28	21	80	381	566	22	23.70640527	-1.706405
68	0.9781	0.01752	0.00438	0.05839	0.00438	32	11	110	380	578	22	28.18587802	-6.185878
69	0.78254	0.00906	0.00247	0.04119	0.00247	35	21	97	407	610	20	23.5692309	-3.569231
70	0.76844	0.01332	0.00307	0.05123	0.00307	35	18	92	422	650	19	24.89232214	-5.892322
71	0.79523	0.01292	0.00298	0.0497	0.00298	34	21	89	413	627	19	24.42587611	-5.425876
72	0.72131	0.01311	0.00328	0.05464	0.00328	31	20	89	399	594	21	23.28599584	-2.285996
73	0.9865	0.01038	0.00312	0.05192	0.00312	33	16	96	429	680	19	24.46184061	-5.461841
74	0.63102	0.01283	0.00321	0.05348	0.00321	24	19	72	415	628	20	19.69447356	0.305526
75	0.73892	0.01182	0.00296	0.04926	0.00296	33	13	96	411	629	20	24.01069441	-4.010694
76	0.98305	0.01356	0.00339	0.0678	0.00339	34	22	110	438	730	17	28.010949	-11.01095
77	0.73988	0.01387	0.00347	0.0578	0.00347	33	17	92	415	696	19	24.30999215	-5.309992
78	0.65502	0.01419	0.00328	0.06004	0	31	14	86	359	545	22	24.43949952	-2.4395
79	0.72821	0.01231	0.00308	0.05128	0.00308	30	111	100	429	663	20	24.03953419	-4.039534
80	0.55894	0.01118	0.00305	0.05081	0.00305	36	19	94	413	655	19	22.79286743	-3.792867
81	0.9891	0.0079	0.003	0.0495	0.003	33	17	92	413	633	20	22.75111734	-2.751117
82	0.9894	0.0076	0.003	0.0414	0	29	19	79	401	643	19	21.14508478	-2.145085
83	0.9896	0.0073	0.0031	0.0417	0.0031	38	19	85	407	635	19	22.05740572	-3.057406
84	0.7448	0.011	0.0033	0.0438	0.0033	32	12	66	433	668	19	19.60757062	-0.607571

Figure (18-d) Testing the prediction model and calculating the mean error in predicting the elongation ratio.

85	0.76004	0.00869	0.00326	0.04343	0.00326	33	25	79	386	566	22	19.90021039	2.09979
86	0.98649	0.01085	0.00266	0.04932	0	30	20	83	412	611	19	24.33623292	-5.336233
87	0.86482	0.03186	0.01229	0.22758	0.01365	27	21	87	364	557	23	25.61530745	-2.615307
88	0.98934	0.00769	0.00297	0.05496	0.0033	31	22	81	383	657	20	21.21226846	-1.212268
89	0.98968	0.00745	0.00287	0.05321	0.00319	28	24	84	459	535	20	20.94862796	-0.948628
90	0.98533	0.01178	0.00289	0.04284	0.00321	34	21	81	380	603	20	23.87230979	-3.87231
91	0.98979	0.00737	0.00284	0.04212	0.00316	35	18	76	425	738	18	20.99945266	-2.999453
92	0.98468	0.01204	0.00328	0.04376	0.00328	33	20	92	413	657	21	24.51429094	-3.514291
93	0.93458	0.0113	0.00277	0.05135	0.00308	36	18	78	384	601	20	23.77198414	-3.771984
94	0.98548	0.01166	0.00286	0.05298	0.00318	30	25	81	386	586	20	23.4668759	-3.466876
95	0.98501	0.01178	0.00321	0.05353	0.00321	33	15	83	376	599	21	23.8462765	-2.846276
96	0.70855	0.00729	0.00281	0.0521	0.00313	32	23	81	400	702	19	19.64307166	-0.643017
97	0.98979	0.00729	0.00292	0.05209	0.00313	32	19	76	369	623	21	20.66309485	0.336905
98	0.9009	0.07207	0.02703	0.22523	0.02703	36	22	82	400	602	19	28.75380658	-9.753807
99	0.98413	0.0127	0.00317	0.05291	0.00317	36	17	85	374	578	26	25.15128434	0.848716
100	0.98462	0.01231	0.00308	0.05231	0.00308	34	20	77	418	645	19	23.88403608	-4.884036
101	0.9867	0.00998	0.00333	0.05543	0.00333	31	22	87	431	673	21	22.74274858	-1.742749
102	0.6483	0.0093	0.0028	0.0525	0.0031	34	25	80	372	580	21	20.76458491	0.235415
103	0.973	0.0189	0.0081	0.0811	0.0081	31	17	70	425	650	17	19.76676447	-2.766764
104	0.9787	0.017	0.0043	0.0709	0.0043	22	17	64	390	542	26	22.01184122	3.988159
105	0.7095	0.008	0.0027	0.05	0.003	29	22	92	419	654	19	20.78353886	-1.783539

Figure (18-e) Testing the prediction model and calculating the mean error in predicting the elongation ratio.

106	0.96901	0.00808	0.00273	0.04038	0.00303	31	20	77	430	678	20	20.83042377	-0.830424
107	0.94145	0.00686	0.00265	0.04903	0.00294	31	21	77	414	641	19	20.33941389	-1.339414
108	0.9901	0.007	0.0029	0.05001	0.003	33	21	84	391	677	20	21.48332567	-1.483326
109	0.98989	0.00729	0.00281	0.0521	0.00313	41	20	90	395	644	20	23.79036839	-3.790368
110	0.95734	0.00832	0.00312	0.05203	0.00312	32	21	70	410	698	19	20.22210262	-1.222103
111	0.93642	0.01387	0.00347	0.0578	0.00347	30	20	84	385	605	23	24.12798725	-1.127987
112	0.94767	0.00737	0.00284	0.04738	0.00316	39	32	90	401	661	19	23.05174355	-4.051744
113	0.95863	0.00729	0.00281	0.04168	0.00313	36	20	83	427	690	20	21.69573693	-1.695737
114	0.97337	0.00946	0.00365	0.05543	0.00406	31	22	76	399	612	20	20.60994725	-0.609947
115	0.70179	0.0089	0.00247	0.04151	0.00297	33	23	77	382	606	20	21.21115808	-0.211158
116	0.98662	0.01075	0.00264	0.03907	0.00293	33	24	78	380	539	26	23.06301454	2.936985
117	0.98427	0.01284	0.00289	0.0214	0.00321	32	18	84	385	530	25	23.79276477	1.207235
118	0.70104	0.01753	0.00394	0.07302	0.00438	31	23	82	387	596	20	24.48410295	-4.484103
119	0.98609	0.01096	0.00296	0.05478	0.00329	29	22	88	439	678	18	23.505132	-5.505132
120	0.98548	0.01166	0.00286	0.05298	0.00318	32	17	70	314	636	22	22.6820192	-0.682019
121	0.98593	0.0113	0.00277	0.05135	0.00308	32	21	83	421	653	18	23.89431726	-5.894317
122	0.72731	0.01096	0.00269	0.03985	0.00299	31	16	87	409	636	21	22.48394116	-1.483941
123	0.9805	0.0159	0.0036	0.0663	0.004	24	24	81	398	658	21	24.20863058	-3.208631
124	0.9858	0.0116	0.0026	0.0483	0.0029	36	18	75	466	776	15	24.10352902	-9.103529
125	0.9829	0.0142	0.0029	0.0546	0.0033	30	19	80	396	622	21	24.76548629	-3.765486
126	0.9838	0.0133	0.003	0.0553	0.0033	37	20	75	438	683	18	24.88706716	-6.887067

Figure (18-f) Testing the prediction model and calculating the mean error in predicting the elongation ratio.

127	0.98437	0.0123	0.00332	0.03691	0.00369	26	25	75	428	629	18	21.32167372	-3.321674
128	0.64891	0.00946	0.00365	0.05408	0.00406	34	22	100	374	633	23	21.63924843	1.360752
129	0.98578	0.01141	0.0028	0.05188	0.00311	30	22	78	376	582	24	23.07417547	0.925825
130	0.7124	0.01171	0.00263	0.04879	0.00293	34	24	75	380	638	20	22.18709176	-2.187092
131	0.98619	0.01127	0.00254	0.04696	0.00282	31	18	76	339	548	24	23.21779393	0.782206
132	0.97168	0.02082	0.0075	0.05552	0.00833	33	21	76	416	672	19	21.72108664	-2.721087
133	0.98708	0.01018	0.00275	0.05088	0.00305	30	19	79	419	637	20	22.50295732	-2.502957
134	0.98414	0.01274	0.00313	0.01737	0.00347	33	20	73	431	695	18	22.28397354	-4.283974
135	0.99456	0.00262	0.00283	0.04188	0.00314	37	26	80	465	734	16	18.99197883	-2.991979
136	0.98361	0.01311	0.00328	0.05464	0.00328	31	23	69	441	671	20	22.78129296	-2.781293
137	0.98754	0.00959	0.00288	0.03835	0.00288	31	21	77	386	619	24	21.64130372	2.358696
138	0.98731	0.00976	0.00293	0.0434	0.00325	34	23	74	353	5599	25	21.93085795	3.069142
139	0.98578	0.01141	0.0028	0.0467	0.00311	29	19	94	416	703	19	24.38160309	-5.381603
140	0.98414	0.01274	0.00313	0.04631	0.00347	31	15	79	401	680	19	23.44621692	-4.446217
141	0.9861	0.01069	0.00321	0.04752	0.00356	28	21	74	397	684	20	21.12625112	-1.126251
142	0.98746	0.00987	0.00267	0.04246	0.00296	30	19	73	419	636	21	21.57615178	-0.576152
143	0.98379	0.01247	0.00374	0.05542	0.00416	28	21	86	408	634	19	22.8161334	-3.816133
144	0.9904	0.0069	0.0027	0.0416	0.003	31	20	76	409	635	19	20.29467201	-1.294672
145	0.9899	0.0073	0.0028	0.0417	0.0031	31	20	74	355	561	22	20.08708076	1.912919
146	0.9899	0.0073	0.0028	0.0448	0.0031	30	21	82	435	688	20	20.83181712	-0.831817
147	0.6752	0.0104	0.0028	0.0623	0.0031	33	19	73	381	663	20	20.95873768	-0.958738

Figure (18-g) Testing the prediction model and calculating the mean error in predicting the elongation ratio.

148	0.98267	0.01251	0.00482	0.07147	0.00536	31	21	88	392	635	20	22.37730121	-2.377301
149	0.98614	0.01	0.00386	0.05717	0.00429	29	21	81	403	617	19	20.90177707	-1.901777
150	0.98845	0.00834	0.00322	0.05955	0.00357	36	20	114	386	595	25	25.6022019	-0.602202
151	0.97787	0.01716	0.00463	0.06862	0.00515	31	21	82	393	529	20	24.69501719	-4.695017
152	0.98746	0.00987	0.00267	0.0395	0.00296	32	27	72	390	607	27	21.73238452	5.267615
153	0.9901	0.00715	0.00276	0.05104	0.00306	34	24	74	405	624	24	20.90145116	3.098549
154	0.9891	0.00787	0.00303	0.0562	0.00337	32	22	72	394	614	20	20.49787691	-0.497877
155	0.70479	0.00796	0.00307	0.01819	0.00341	33	23	82	431	670	18	18.84456498	-0.844565
156	0.75556	0.00745	0.00287	0.01703	0.00319	34	16	82	437	686	20	19.28204853	0.717951
157	0.5735	0.01096	0.00228	0.05482	0.00253	30	22	76	374	602	21	21.0724362	-0.072436
158	0.98501	0.01204	0.00296	0.06129	0.00328	31	19	77	381	603	20	23.5630849	-3.563085
159	0.95664	0.00936	0.00281	0.04159	0.00312	29	22	81	432	642	18	21.49161104	-3.491611
160	0.76112	0.00761	0.00294	0.03914	0.00326	34	23	86	461	743	17	20.41166322	-3.411663
161	0.30963	0.00834	0.00322	0.05359	0	32	19	23	409	643	20	12.51230239	7.487698
162	0.98517	0.01191	0.00292	0.06496	0.00325	30	22	92	362	581	22	25.01738091	-3.017381
163	0.66688	0.00753	0.0029	0.05378	0.00323	29	18	87	394	627	23	19.54074274	3.459257
164	0.60024	0.00934	0.0036	0.04402	0.004	24	17	76	400	615	19	16.83728798	2.162712
165	0.8588	0.0071	0.0027	0.0404	0.003	30	22	75	430	686	18	19.20545145	-1.205451
166	0.9691	0.0073	0.0028	0.0417	0.0031	37	23	75	438	667	19	21.11069925	-2.110699
167	0.9677	0.0076	0.0029	0.0435	0.0033	32	25	79	468	755	16	20.69968733	-4.699687
168	0.9368	0	0.0632	0.2342	0.0703	32	15	80	479	717	15	-71.35757204	86.35757

Figure (18-h) Testing the prediction model and calculating the mean error in predicting the elongation ratio.

169	0.98787	0.00875	0.00338	0.06252	0.00375	29	20	77	456	778	17	20.67305486	-3.673055
170	0.9903	0.007	0.0027	0.03601	0.003	34	23	71	417	687	19	20.13003091	-1.130031
171	0.9891	0.00787	0.00303	0.03934	0.00337	27	19	72	410	663	19	19.10609435	-0.106094
172	0.98934	0.00769	0.00297	0.04397	0.0033	26	22	75	455	707	17	19.38705749	-2.387057
173	0.73551	0.00686	0.00265	0.03923	0.00294	28	23	72	513	778	16	17.78666552	-1.786666
174	0.97761	0.00796	0.00307	0.04547	0.00341	33	24	77	462	666	16	20.78558578	-4.785586
175	0.9901	0.00715	0.00276	0.05104	0.00306	30	21	73	459	698	17	20.10245742	-3.102457
176	0.98979	0.00722	0.00278	0.05155	0.00309	32	23	73	433	656	20	20.46457904	-0.464579
177	0.986	0.01	0.004	0.05716	0.00429	28	17	68	420	691	20	19.21993525	0.780065
178	0.9886	0.00814	0.00326	0.04652	0.00349	30	17	74	448	697	17	19.91116592	-2.911166
179	0.97914	0.0149	0.00596	0.08514	0.00639	28	19	92	364	553	22	22.40176382	-0.401764
180	0.98383	0.01167	0.0045	0.0667	0.005	34	20	82	419	634	19	22.14584951	-3.14585
181	0.98934	0.00769	0.00297	0.05496	0.0033	32	20	73	397	681	22	20.56388397	1.436116
182	0.99069	0.00788	0.00143	0.05629	0.00338	23	18	64	479	762	17	20.04526497	-3.045265
183	0.6462	0.01346	0.00377	0.05385	0.00404	34	15	103	374	639	22	24.15270361	-2.152704
184	0.97349	0.02071	0.0058	0.06214	0.00621	32	23	97	425	661	19	26.55501935	-7.555019
185	0.98698	0.01018	0.00285	0.0407	0.00305	29	20	83	426	660	19	22.30298019	-3.30298
186	0.9901	0.0071	0.0028	0.0408	0.0031	24	17	80	414	673	21	19.46110202	1.538898
187	0.4354	0.0096	0.0029	0.0637	0.0032	29	14	82	435	706	18	19.2252696	-1.22527
188	0.7958	0.0101	0.0027	0.0403	0.003	29	21	76	443	747	18	20.54781477	-2.547815
189	0.667	0.0111	0.0043	0.0635	0.0048	33	27	83	433	727	17	20.11220753	-3.112208

Figure (18-i) Testing the prediction model and calculating the mean error in predicting the elongation ratio.

190	0.93306	0.00976	0.00293	0.0434	0.00325	39	21	87	423	672	19	23.81384107	-4.813841
191	0.77837	0.00841	0.00284	0.04207	0.00316	30	17	73	402	605	19	19.19603686	-0.196037
192	0.98979	0.00737	0.00284	0.04212	0.00316	33	20	77	433	726	18	20.75527761	-2.755278
193	0.98968	0.00745	0.00287	0.04257	0.00319	30	24	81	444	606	17	20.65891213	-3.658912
194	0.98796	0.00926	0.00278	0.04116	0.00309	30	22	72	437	703	18	20.90057317	-2.900573
195	0.7475	0.00769	0.00297	0.04397	0.0033	30	17	82	448	744	17	19.37208998	-2.37209
196	0	0.02595	0.01001	0.18539	0.01112	31	27	88	378	610	21	20.03699016	0.96301
197	0	0.03186	0.01229	0.22758	0.01365	30	16	76	433	787	18	19.90216066	-1.902161
								Average Prediction Error = - 1.153241					

Figure (18-i) Testing the prediction model and calculating the mean error in predicting the elongation ratio.

From Figure (18) the prediction process for the elongation ratio was carried out for 197 samples and the average error was very small 1.153241 - compared to the sample size 197 and the mean error sign was negative and this indicates that the real value is smaller than the prediction value, so we increased the average error to the prediction to get the mean error equal to zero.

3.5. Prediction Facilitation Model for Mechanical Properties:

To facilitate the prediction process, we made a model shown in Figure (19) to calculate the mechanical properties of iron for 10 samples at once from cells introducing chemical additives and cells for predicting mechanical specifications, and this is because the LISCo does 10 diets per day.

Input Cells For Chemical Additives								Expected Mechanical Specifications		
DRI	FeMn	FeSi	Lime	Dol.	C	Si	Mn	جهد الخضوع	قوة الشد	الاستطالة%
0.7958	0.0101	0.0027	0.0403	0.003022	29	21	76	407.9867174	634.4847658	20.54781477
0.667	0.0111	0.0043	0.0635	0.004764	33	27	83	435.8850129	730.4449011	20.11220753
0.9331	0.0098	0.0029	0.0434	0.003255	39	21	87	396.7607883	724.9590273	23.81384107
0.7784	0.0084	0.0028	0.0421	0.003156	30	17	73	401.6996346	591.018618	19.19603686
0.9898	0.0074	0.0028	0.0421	0.003159	33	20	77	405.1409158	663.5611413	20.75527761
0.9897	0.0074	0.0029	0.0426	0.003193	30	24	81	421.3688381	704.9184526	20.65891213
0.988	0.0093	0.0028	0.0412	0.003087	30	22	72	406.2842606	649.1640521	20.90057317
0.7475	0.0077	0.003	0.044	0.003298	30	17	82	407.2701825	622.2687546	19.37208998
0	0.026	0.01	0.1854	0.011123	31	27	88	437.0503779	677.7939577	20.03699016
0	0.0319	0.0123	0.2276	0.013655	30	16	76	390.9556703	514.6043996	19.90216066

Figure (19) Model to facilitate prediction of mechanical properties.

3.6. Matching Model:

To facilitate the prediction process, we made the model shown in Figure (20) for the cells for the quality of the products and their conformity with the specifications approved by the LISCo, where the model puts a mark (OK) if the prediction is within the acceptable limits, and a mark (Rejected) if the prediction is within the limits rejected.

Quality Mechanical Products		Quality of Elongation Ratio
Subjection Stress	Tensile Strength Quality	
OK	OK	OK
OK	OK	OK
OK	OK	OK
OK	OK	OK
OK	OK	OK
OK	OK	OK
OK	OK	OK
OK	OK	OK
OK	OK	OK
OK	OK	OK

Figure (30) Matching Model.

Conclusion:

From the results and prediction models of this study, we can conclude the following:

1. The LISCo's lack of knowledge of the importance of prediction models for mechanical properties that reduce uncertainty.
2. Through the use of the model in forecasting, prediction values were obtained that are very close to the real results of the mechanical properties of longitudinal rolling iron for iron and steel plant.
3. Obtaining an error rate close to zero in the process of predicting the mechanical properties of longitudinal rolling iron for the iron and steel plant, and this increases its accuracy.
4. Such model lead to save time and contribute in cost reduction as compared to the traditional tests that used to ensure the quality of mechanical properties.
5. The possibility of modifying the chemical composition of the mixture to obtain the required mechanical specifications before the manufacturing process and the production of out-of-spec products.

Recommendations:

Through this research, we can recommend the following points:

1. Emphasis on the importance of applying the forecasting process in decision-making as a method for building the future and reducing costs for the organization.
2. Emphasis on the importance of statistical modeling using forecasting modeling techniques in calculating expectations.
3. We recommend paying attention to databases and previous statistical information in order to serve the planning process satisfactorily.
4. The higher the efficiency of the predictive operations of the LISCo, the closer the picture will be to the desired reality requested by the institution.
5. Developing statistical and planning training methods and methodology for preparing plans and formulating decisions in order for the LISCo to keep pace with recent developments in the administrative, economic and social sciences.
6. The use of programs for the forecasting process, such as the mechanical specifications of the company's products in various other products, which allows the company to increase its production by reducing the percentage of rejected products that are out of specifications.
7. The use of this model, which was prepared to predict the mechanical specifications of the company's longitudinal rolling products, and whose predictive ability has been proven through that the average error is almost equal to zero, before the manufacturing process, which leads to an increase in the company's productivity, reduces the percentage of rejected and raises the quality of its products.

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