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المجلد ١٥٦ - العدد الثالث - أيلول ٢٠١٩

عدد خاص لبحوث المؤتمر الأول للأنظمة الحديثة في الهندسة الكهربائية والميكانيكية وتطبيقاتها - الجزء الثاني

مجلة علمية محكمة

تصدرها

جمعية المهندسين العراقية

(تاسست عام ١٩٣٨)

مجلة المهندس

المجلد ١٥٦ – العدد الثالث – أيلول ٢٠١٩

جمعية المهندسين العراقية

مجلة المهندس

مجلة المهندس هي مجلة علمية فصلية محكمة تعنى بالبحوث الهندسية تصدرها جمعية المهندسين العراقية (ISE) كنسخة مطبوعة وكذلك على الإنترنت. صدرت المجلة لأول مرة في عام ١٩٥٦.

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الرؤى والاهداف

مجلة المهندس هي مجلة علمية فصلية ، تغطي جميع أنواع البحوث العلمية في العديد من المجالات الهندسية مثل: الهندسة المدنية ، هندسة البناء والانشاءات ، الهندسة المعمارية ، الهندسة الميكانيكية ، الهندسة الكهربائية ، هندسة الاتصالات ، هندسة الحاسوب ، الهندسة الكيميائية ، هندسة النفط ، هندسة البيئة ، هندسة المواد ، هندسة الموارد المائية ، فضلا عن الحقول الهندسية الأخرى. تقدم المجلة منصة قوية للمهندسين العراقيين لنشر الأعمال التي تترجم معارفهم وخبراتهم ومهاراتهم.

اخلاقيات النشر

تقبل المجلة تقديم أي أعمال بحثية تتناول المجالات الهندسية المختلفة، سواء المنهجية منها أو التطبيقية. يرجى من الباحثين إرسال اعمالهم البحثية بحيث لا تزيد عدد الصفحات عن ١٥ صفحة للبحث، وباستخدام برنامج MS Word ضمن القالب القياسي. يتم تطبيق مجموعة من الاجراءات لغرض الحصول على قبول النشر. وهذه الاجراءات هي:

- قبول الباحثين
- التحقق من المعايير
- التحقق من الاقتباس او الانتحال
- التحقق من عدم تكرار المنشور
- التحقق من الاستغلال
- التحقق من سوء التصرف
- ان يكون المنشور مقروء للجمهور الدولي (على الأقل العنوان والمستخلص باللغة الإنجليزية).
- التقييم العلمي المحكم
- موافقة هيئة التحرير

ان هيئة التحرير تسعى الى اكتمال هذه الاجراءات خلال مدة لا تتجاوز (١٠) أسابيع من تاريخ تقديم البحث. يجب أن يحتوي البحث المقدم على ما ياتي: (١) اسم المجلة ، (٢) عنوان البحث ، (٣) اسم المؤلف (المؤلفين) ؛ (٤) المستخلص ؛ (٥) الكلمات الدالة ؛ (٦) نص البحث ؛ (٧) المراجع.

جمعية المهندسين العراقية

تأسست جمعية المهندسين العراقية (ISE) في عام ١٩٣٨ من قبل مجموعة من المهندسين العراقيين الرواد. وقد تم تعيين ٣٦ هيئة إدارية منذ تشكيلها حتى الآن. ازداد عدد الاعضاء بمرور الزمن ليصل الى أكثر من ٤٠٠٠ عضو مؤخرا. لدى الجمعية العديد من الهيئات النوعية التخصصية واللجان للاشراف والقيام بأنشطة علمية وهندسية وثقافية بشكل مستمر من أجل دعم المهندسين العراقيين بالخبرات والمهارات المطلوبة. تسعى الجمعية الى تحقيق أهدافها من خلال:

١. تنظيم المؤتمرات والندوات العلمية والمساهمة فيها.
٢. تنظيم دورات التعليم المستمر في الحقل الهندسي.
٣. تنظيم المحاضرات والمنشورات العلمية والثقافية.
٤. دعم وتشجيع البحوث والدراسات الهندسة.
٥. تنظيم الزيارات العلمية.
٦. جمع وتوثيق المعلومات العلمية والهندسية.
٧. تقديم الخبرة والاستشارات العلمية والهندسية.

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The journal accepts the submission of any research work deals with engineering fields, either methodology and/or applications. Prospective authors are invited to submit their draft manuscript in a short paper (no more than 15 pages) using MS Word format. The manuscripts should be processed through many steps in order to get acceptation. These processes are:

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Contents

Using different software to forecast in industrial companies

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ABSTRACT

Forecasting is a technique used for expecting upcoming demand depending past demand data. It is a vital process required for good production planning, selling plan, MRP, scheduling, human resource plan....etc. An accurate forecast application leads to successful plan to achieve its goals. In this paper Forecast Model to be used is selected depending on different forecasting methods, according to real world applications, the form of necessary data and is it dependable for any case study. According to these considerations; a method or more are nominated. For accurate forecasting different software could be adopted. Two software will be applied to reach the most suitable and accurate results, these are WinQSB and QM; using the data collected and calculates the value of the forecast required according to the case study under investigation. This case study is in the General Company for Food Products. The forecasting models are examined and the results are compared for the most suitable solution.

KEYWORDS

Forecasting, selling plan, Win QSB software, QM software, Quantitative methods.

NOMENCLATURES

F_t the exponentially smoothed forecast for period t
a the desired response rate, or smoothing constant
F_{t+1} new foecast
A_t Actual occurrence in duration t
N No. of durations to be as an average

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1. INTRODUCTION

Forecasting is the process of making estimates for the future on the basis of historical and current documents. Assured expectations are dependent for starting forecasting. Management's capability, understanding and decisions are the bases of this startup. The estimations are predictable for the upcoming periods choosing a technique or more such as the method of Delphi, exponential smoothing, the moving average, and analysis of regression and trending projection. In this paper quantitative forecasting methods have been used to predict future data as a function of previous mathematical figures that are presented and realistic for assuming various configurations of the data that are likely to last for future. The approaches are typically applied for short- and moderate-term conclusions. Forecast is more precise for greater sets of object. It is more precise for smaller time. Before adopting any forecasting technique, the technique must be tested and assessed. Armstrong and Green in their paper show that the accuracy of forecasting can be improved by using one of relatively simple evidence-based methods [1]. Forecasting provides a truthful image for future and a powerful power to the forward planning events [2].The forecast objective is to develop a useful forecast from the information at hand with the technique that is appropriate for the different characteristics of demand. Quantitative forecast methods are used to predict future demand using data from the general company for food products. The aim of this paper is to apply Quantitative forecasting techniques in an industrial company to forecast future demand. Two software are used, these are Win QSB and QM.

2. PROCEDURE

2.1 Forecasting process

The forecasting procedure begins with identifying the state in which related records are collected. Forecasting technique is nominated and applied that is followed by assessment of the technique for determining best accuracy. Based on the outcome, the technique needs to be chosen, the stage of forecasting involved are shown in figure (1) as follows [2]:

1. Formulate problem.
2. Obtain data.
3. Select methods.
4. Implement methods.
5. Evaluate methods and,
6. Use forecast.

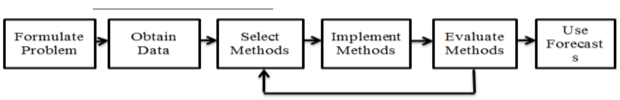

Figure1. Forecasting Process

There are five basic kinds of forecast [3,4]:
1. Economic forecast.
2. Statistical forecasting.
3. Judgmental forecasts.
4. Extensions of pas t history.
5. Cause forecasting.

2.2 Quantitative versus Qualitative Methods

Forecasting techniques could be categorized as qualitative techniques and quantitative techniques. Differences among these techniques are the procedure in which forecasts are produced. Quantitative techniques use accurate representations of association between related variables depend on historical data. The techniques are to be formulated in combination with old data for forecasting requests. These procedures may occasionally mention an objective forecasting technique due to the basic expectations of the forecasting technique and the records used may be starts exactly.

Qualitative techniques depend on an individual or more to produce forecasts without adopting precise techniques alone. They are reflected to individual forecasting techniques due to the absence of determine accurately the data used by the forecasting team.

Although it may appear that quantitative models should be more consistent and accurate because of their results depend on the circumstances. Qualitative methods can be superior to quantitative methods because they are better able to anticipate and evaluate the possible consequences of such structural changes [5].

Forecasting methods involved very advanced statistical techniques to expect future by adopting or quantitative techniques or qualitative techniques as illustrated in figure (2).

2.2 Forecasting techniques

Forecasting system involved very advanced statistical techniques to expect upcoming periods by using qualitative or quantitative techniques as illustrated in figure (2) [6]:

1-Qualitative techniques: depend on domination thoughts from an expert or more.

2-Quantitative techniques: depend on figures and investigative procedures.

2.2.1 Qualitative techniques

These methods are used when historical data are scare or not available at all, and as follows:

1- Grass Roots: developing upcoming requests by inquiring the one neighboring the customer.

2-Market Research: try to recognize client lifestyles; novel product concepts, consumer market surveys and interviews.

3-Panel Consensus or Administrative Decision: view a collection of top level specialists or directors is shared.

4-Historical analogy: identifying another similar market. The promotion staffs adopt past correlation

among two products and develop the request for the novel produce according to the past records of the previous produce.
5-Delphi method: panel of expert is Queried iteratively until consensus is reached.

2.2.2 Quantitative methods

Quantitative method required numerical data or related to the forecasting problem and these are [7]:

2.2.2.1Time series forecasting technique

The techniques of time series are algebraic approaches to be used with past sales records covers comparatively strong and steady relations and trends when obtainable. "Time series techniques are quantitative- that is they use values recorded at regular time intervals (sales history) to predict future values" Time series investigation is adopted to detect season base, repeated forms besides trends. When specific forecast modules are documented, the technique of time series adopt the upcoming period will mirror to the historical period that recommends historical request forms and to be lasted for the upcoming period. The prediction is frequently practically right for small period and thus time series procedures are best suitable for small period. The technique of Time series forecasting contain a range of procedures which investigate the forms and movement for past records to create repeated features. Although, there are several dissimilar methodologies, frequently two methodologies are used these are exponential smoothing and moving average.

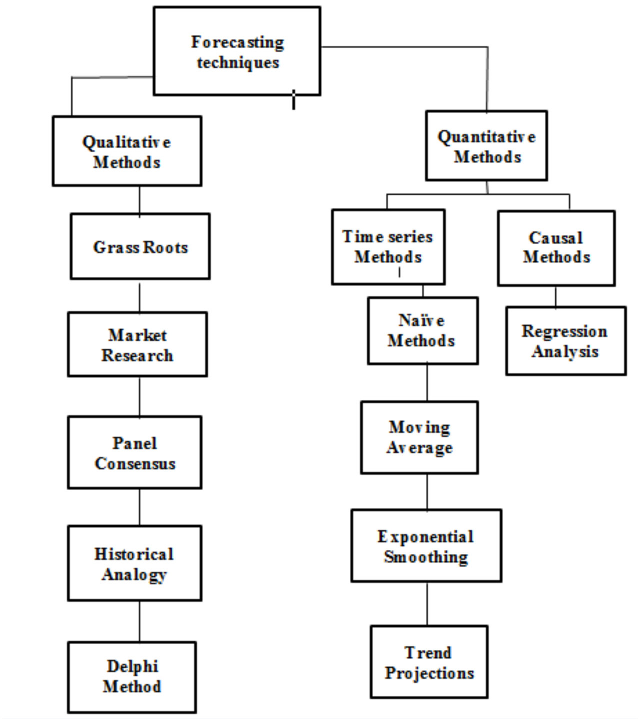

Figure2. Different forecasting methods

2.2.2.2 Naive Techniques

Forecasting techniques of this class are one of the easiest statistical techniques. The easiest of them adopts the newest practical rate in the time series to prediction for the following period. Efficiently, this suggests all previous data are not taking into account. Alternative technique of this category is the 'free-hand projection technique', which consists of plotting records series on a chart paper and fit a free hand curve for it. This curvature is stretched into the upcoming period to develop the predictions. The 'semi-average projection technique' is alternative naive technique. In this technique, the time-series is separated into two equivalent shares, means are calculated for them, and then a link is figured linking the two semi means. This line is proposed for the upcoming period and the forecasts are established.

2.2.2.3 Moving Average Technique

It is significant to choose the finest period for the technique of moving average, but numerous conflicting properties of altered period extents are existed [8]. The extended the period of moving average, the more the unplanned features are leveled; this is required in many circumstances. If trend is existed in the data, weather increasing or decreasing, the moving average has the adversarial representative of covering the trend style. Smaller time duration yields further fluctuation, but a faster subsequent of the trend is missed. On the other hand, extended time duration provides an evener answer but gaps the trend.

$F_{t+1} = {A_{t+}A_{t-1+}A_{t-2+}A_{t-n+1}}/{n}$…………...equation (1)
$F_{t+1=} is\ the\ forecast\ for\ next\ period.$
$A_{t=}$Actual occurrence in duration t
N=No. of duration for being averaged
The Features of the technique of moving average are:
1-Altered moving averages yield dissimilar predictions.
2-When the original trend of the previous records is supposed to be properly constant by considerable uncertainty; more amounts of durations must be selected.
3- If there is thought to be some change in the underlying state of the data, more responsiveness is needed, therefore fewer periods should be included in the moving average.
The Limitations of moving averages are:

1- Equal weighting is given to each of the values used in the moving average calculation, whereas it is reasonable to suppose that the most recent data is more relevant to current conditions.
2- An n period moving average requires the storage of n – 1 value to which are added the latest observation. This may not seem much of a limitation when only a few items are considered.

3- The calculations of moving average technique neglect the records outer the duration of mean, consequently, not all the available records are to be completely used.
4- When adopting not attuned moving average as a prediction, this will affect confusing outcomes if an underlying periodic dissimilarity is existed.

2.2.2.4 Exponential smoothing:

The expectation of the upcoming periods is influenced frequently by the utmost new reflection, and on the fault and errors of the newest prediction.

$F_{t+1}=F_{t}+\alpha\,(A_{t}-F_{t})$…………………equation (2)

F_t = the exponentially smoothed forecast for period t

a = the desired response rate, or smoothing constant

$F_{t+1}=new\ foecast$

$A_{t}=Actual\ demand\ in\ period\ t-1$

3. A brief description of QM program

QM program is a package which is adopted to assist some lectures in the Decision Skills comprehensive platform. This platform consists of Manufacturing and Operations Managing, Quantitative techniques, Organization Skill, and Operation Researches. DOS version was the older style of this software which was printed in 1989 with a written guide. It was spreader in 1997. Form two of the package was produced for Windows ninety five and spread in 1999. In form three, the software is directed for Windows produces into unique creation titled POM-QM for Windows. The packages of QM are displayed in figure (3).

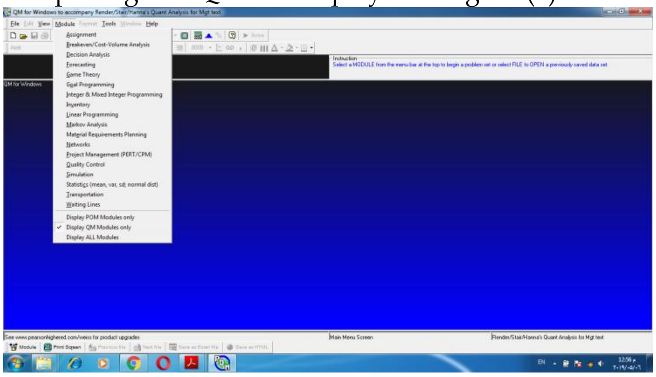

Figure 3. Programs of QM

4. A brief description of the program Win QSB

Win QSB is a package covers the utmost commonly used problem resolving procedures in operation researches and managing skill (OR/MS). Win QSB is windows constructed numerical structure for Commercial and Industry. Job and flow shop forecasting problem can be solved by Win QSB software.

It is noticed that the planning process is done manually using simple and superficial mathematical methods, based on personal diligence and experience and with pride in those experiences in the field of production planning, but it does not keep pace with the development of the world in terms of applying modern scientific methods in the production planning area. One of the reasons for this is sudden changes in both available capacities, in the quantity of demand, and in the quantity of storage of products. The programs of Win QSB are shown in figure (4).

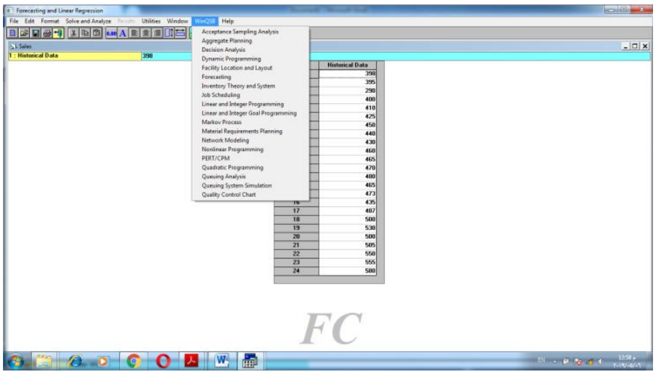

Figure4. Programs of Win QSB

5. Applying forecasting technique and methods

In this sector the following forecasting techniques which are discussed above are applied according to the data summited from the general company for food products:

1- Naive Method.
2- Exponential Smoothing.
3- Moving Average Method.
4- Regression method.

These methods explained in Chapter two is to be applied using two programs mentioned above, these are Win QSB and QM. Inorder to eliminate the calculations and the figures different methods with different products are selected as will be mentioned in the following sectors.

5.1 General Company for Food Products

The company has the financial and administrative independence with of all legal actions amended its aims to fill part of the local market needs of services and goods .The company aims to achieve profitability and performance of service in order to ensure the sustainability of the company's work in spite of competition challenges with the private sector companies and imported products in accordance with the applicable laws and regulations.

5.2 The company's products and plans

The company’s products and Plans are summarized in the following tables (1), (2), (3), (4), (5) and (6) which shows, the plans of 2013, 2014, 2015, 2016, 2017and 2018 years consequently.

Table1. Planning quantity of production for 2013

The products	Measuring unit	Total
Liquid oil	Ton	1650
Laurel soap	Ton	4500
Cleaners	Ton	2000
Soap	Ton	600
Laundry soap	Ton	500
Liquid soap	Ton	750
Liquid cleaners	Ton	1750
Liquid soap	Ton	350
Shampoo	Ton	450
Tooth paste	Ton	150
Shaving cream	Ton	100
Minor clothing	Ton	350
Dehumidifier	Ton	65
Sterilizing hands	Ton	7
Sulfonic acid	Ton	750
Industrial printing	Ton	500

Table2. Planned quantity of production for year 2014

The products	Measuring unit	Total
Liquid oil	Ton	400
Laurel soap	Ton	4500
Cleaners	Ton	6000
soap	Ton	300
Laundry soap	Ton	400
Liquid soap	Ton	800
Liquid cleaners	Ton	2500
Liquid soap	Ton	150
Shampoo	Ton	100
Tooth paste	Ton	100
Shaving cream	Ton	100
Minor clothing	Ton	150
Dehumidifier	Ton	70
Sterilizing hands	Ton	6
Sulfonic acid	Ton	1200
Industrial printing	Ton	250

Table3. Planned quantity of production for year 2015

The products	Measuring unit	Total
Liquid oil	Ton	5000
soap	Ton	6000
Laurel soap	Ton	1200
Laundry soap	Ton	1000
Liquid soap	Ton	300
Liquid cleaners	Ton	500
Cleaners	Ton	400
Shampoo	Ton	600
Tooth paste	Ton	800
Shaving cream	Ton	1000
Minor clothing	Ton	60
Dehumidifier	Ton	100
Sterilizing hand	Ton	100
Sumer Liquid	Ton	100
Sulfonic acid	Ton	120
Sterilizing baths	Ton	30
Freshener flooring	Ton	100
Industrial printing	Ton	250

Table4. Planned quantity of production for year 2016

The products	Measuring unit	Total
Liquid oil	Ton	5500
Soap	Ton	200
Laurel soap	Ton	700
Laundry soap	Ton	1500
Liquid soap	Ton	60
Liquid cleaners	Ton	1000
Cleaners	Ton	150
Shampoo	Ton	100
Tooth paste	Ton	75
Shaving cream	Ton	75
Minor clothing	Ton	150
Dehumidifier	Ton	30
Sterilizing hand	Ton	6
Sumer liquid	Ton	1500
Sulfonic acid	Ton	100

Table5. Planned quantity of production for year 2017

The products	Measuring unit	Total
Liquid oil	Ton	6500
Soap	Ton	500
Laurel soap	Ton	1500
Laundry soap	Ton	1500
Liquid soap	Ton	60
Liquid cleaners	Ton	1500
Cleaners	Ton	2000
Shampoo	Ton	125
Tooth paste	Ton	75
Shaving cream	Ton	50
Minor clothing	Ton	50
Dehumidifier	Ton	45
Sterilizing hand	Ton	6
Sumer liquid	Ton	70
Sulfonic acid	Ton	100
Sterilizing baths	Ton	80
Freshener flooring	Ton	35
Industrial printing	Ton	250

Table6. Planned quantity of production for year 2018

The products	Measuring unit	Total
Liquid oil	Ton	30000
Soap	Ton	2650
Laurel soap	Ton	2000
Laundry soap	Ton	2000
Liquid soap	Ton	100
Liquid cleaner	Ton	2000
Cleaners	Ton	2000
Shampoo	Ton	125
Tooth paste	Ton	80
Shaving cream	Ton	75
Minor clothing	Ton	300
Dehumidifier	Ton	40
Sterilizing hand	Ton	6
Sumer liquid	Ton	50
Sulfonic acid	Ton	50
Sterilizing baths	Ton	15
Freshener flooring	Ton	8
Industrial printing	Ton	250

5.3 Naive Method

Nanvie method is applied on five products for six years according to the data mentioned in the tables (1), (2), (3), (4), (5) and (6) which shows the plans of 2013, 2014, 2015, 2016, 2017and 2018 years for the general company of food products. These products are liquid cleaner, cleaner, shampoo, tooth paste and shaving cream.

Figure (5) shows a sample of the calculations and the results for applying QM software. While figure (6), shows a sample of the calculations and the results for applying Win QSB software. Sanders and Manrodtin their paper [9] adopt survey data from 240 US corporations to evaluate the use, satisfaction and performance of forecasting software. Despite large choices in commercial forecasting software packages only 10.8 percent of the responding report using them.

Naive Method

	Demand(y)
1	2000
2	6000
3	1000
4	1500
5	6500
6	2000

Measure	Value
Error Measures	
Bias (Mean Error)	0
MAD (Mean Absolute Deviation)	3800
MSE (Mean Squared Error)	17300000
Standard Error (denom=n-2=3)	5369.668
MAPE (Mean Absolute Percent Error)	1.804
Forecast	
next period	2000

Figure5. Using Navei method to forecast liquid cleaner product in QM

05-07-2019 Year	Actual Data	Forecast by 1-MA	Forecast Error	CFE	MAD	MSE	MAPE (%)	Tracking Signal	R-square
1	2000								
2	6000	2000	4000	4000	4000	1.6E+07	66.66666	1	
3	1000	6000	-5000	-1000	4500	2.05E+07	283.3333	-0.2222222	0.68
4	1500	1000	500	-500	3166.667	1.375E+07	200	-0.1578947	0.9285715
5	6500	1500	5000	4500	3625	1.65625E+07	169.2308	1.241379	0.8217822
6	2000	6500	-4500	0	3800	1.73E+07	180.3846	0	1
7		2000							
8		2000							
9		2000							
CFE		0							
MAD		3800							
MSE		1.73E+07							
MAPE		180.3846							
Trk.Signal		0							
R-square		1							
		m=1							

Figure6. Using Navei method to forecast liquid cleaner product in Win QSB

5.4 Exponential Smoothing technique

The technique of Exponential Smoothing is applied on the same five products for six years according to the data mentioned in the tables (1), (2), (3), (4), (5) and (6) which shows the plans of 2013, 2014, 2015, 2016, 2017and 2018 years for the general company of food products. These products are liquid cleaner, cleaner, shampoo, tooth paste and shaving cream.

Figure (7) shows a sample of the calculations and the results for applying QM software. While figures (8) shows a sample of the calculations and the results for applying Win QSB software.

Exponential Smoothing

	Demand(y)	Forecast
1	450	125
2	100	0
3	100	0
4	100	0
5	125	0
6	125	0

Forecasting Results

Measure	Value
Error Measures	
Bias (Mean Error)	-.13
MAD (Mean Absolute Deviation)	109.245
MSE (Mean Squared Error)	25295.1
Standard Error (denom=n-2=4)	194.789
MAPE (Mean Absolute Percent Error)	.67
Forecast	
next period	124.609

Figure7. Using exponential smoothing method to forecast shampoo product in QM

Forecast Result for shampoo

04-21-2019 Year	Actual Data	Forecast by SES	Forecast Error	CFE	MAD	MSE	MAPE (%)	Tracking Signal	R-square
1	450								
2	100	450	-350	-350	350	122500	350	-1	
3	100	450	-350	-700	350	122500	350	-2	
4	100	450	-350	-1050	350	122500	350	-3	
5	125	450	-325	-1375	343.75	118281.3	327.5	-4	
6	125	450	-325	-1700	340	115750	314	-5	
7		450							
8		450							
9		450							
CFE		-1700							
MAD		340							
MSE		115750							
MAPE		314							
Trk.Signal		-5							
R-square									
		Alpha=0							
		F(0)=450							

Figure8. Using exponential smoothing method to forecast shampoo product in Win QSB

5.5 Moving Average Method

Moving Average method is applied on five products for six years according to the data mentioned in the tables (1), (2), (3), (4), (5) and (6) which shows the plans of 2013, 2014, 2015, 2016, 2017and 2018 years for the general company of food products. These products are liquid oil, minor, sterilizing hand and industrial printing.

Figure (9) shows a sample of the calculations and the results for applying QM software. While figures (10) shows a sample of the calculations and the results for applying Win QSB software.

Moving Averages

	Demand(y)
1	350
2	150
3	120
4	150
5	50
6	300

Forecasting Results

Measure	Value
Error Measures	
Bias (Mean Error)	136
MAD (Mean Absolute Deviation)	136
MSE (Mean Squared Error)	18496
Standard Error (denom=n-2=-2)	NA
MAPE (Mean Absolute Percent Error)	.453
Forecast	
next period	186.667

Figure.9 Using Moving Averages method to forecast minor product in QM

05-07-2019 Year	Actual Data	Forecast by 1-MA	Forecast Error	CFE	MAD	MSE	MAPE (%)	Tracking Signal	R-square
1	350								
2	150	350	-200	-200	200	40000	133.3333	-1	
3	120	150	-30	-230	115	20450	79.16666	-2	
4	150	120	30	-200	86.66666	13933.33	59.44444	-2.307692	
5	50	150	-100	-300	90	12950	94.58333	-3.333333	
6	300	50	250	-50	122	22860	92.33333	-0.4098361	
7		300							
8		300							
9		300							
CFE		-50							
MAD		122							
MSE		22860							
MAPE		92.33333							
Trk.Signal		-0.4098361							
R-square									
		m=1							

Figure10. Using Moving Averages method to forecast minor product in Win QSB

5.6 Regression method.

Regression method is applied the products for six years according to the data mentioned in the tables (1), (2), (3), (4), (5) and (6) which shows the plans of 2013, 2014, 2015, 2016, 2017and 2018 years for the general company of food products. These products are liquid cleaner and shampoo. Figure (11) shows a sample of the calculations and the results for applying Win QSB software.

Forecast Result for liquid cleaner

04-18-2019 Year	Actual Data	Forecast by LR	Forecast Error	CFE	MAD	MSE	MAPE (%)	Tracking Signal	R-square
1	1750	1750	0	0	0	0	0	0	0
2	2500	1700	800	800	400	320000	16	2	
3	1000	1650	-650	150	483.3333	354166.7	32.33333	0.3103448	1.111111E-02
4	1000	1600	-600	-450	512.5	355625	39.25	-0.8780488	4.080808E-02
5	1500	1550	-50	-500	420	285000	32.06667	-1.190476	0.0483871
6	2000	1500	500	0	433.3333	279166.7	30.88889	0	2.545455E-02
7		1450							
8		1400							
9		1350							
CFE		0							
MAD		433.3333							
MSE		279166.7							
MAPE		30.88889							
Trk.Signal		0							
R-square		2.545455E-02							
		Y-intercept=1800							
		Slope=-50							

Figure11. Using Regression method to forecast liquid cleaner product in Win QSB

6 Results and discussion

According to the forecasting methods applied in the general company for food products on ten products using four quantitative forecasting methods and using Win QSB and QM programs; the results are summarized in table (7).

Table7. Results summarization

Years/ Products	2019 Win QSB	2020 Win QSB	2021 Win QSB	2019 QM	2020 QM	2021 QM
Liquid cleaners	**2000**	**2000**	**2000**	**2000**	**2000**	**2000**
Cleaners	2000	2000	2000	2125	2125	2125
Shampoo	450	450	450	425	425	425
Tooth paste	96	96	96	85	85	85
Shaving cream	105	105	105	81	81	81
Liquid oil	255	255	255	281	281	281
Sterilizing hand	2600	2600	2600	2600	2600	2600
Industrial printing	6	6	6	6	6	6
Soap	2850	2850	2850	3500	3500	3500
Minor	300	300	300	286	286	286

The forecasted quantities according to the data from the general company for food products for the following years 2019, 2020 and 2021are calculated in Win QSB and then in QM programs and the results are mentioned in table (7) for ten products. Some of the results required more calculations. The results show that the production must be increased for the later years. Even with this increasing the available capacities are not reached.

It was noticed that the result of Win QSB program is more accurate because the forecast of sales is obtained for three years later. This period is longer period than the period obtained from QM program for the QM gives only forecasted values for only one year.

The company should increase the quantity of sales to reduce imports and encourage the national products besides improving advertising to encourage the consumers to buy their products for better competition.

7. Conclusions and Recommendations

The conclusions of this paper illustrates that Forecasting is a method adopts old records as an input to create reliable estimations which are analytical. Quantitative methods are adopted in this paper on a case study in the "General Company for food products" to compare the best result for using different methods and different programs. The methods applied are Naïve method, exponential method, moving average method and regression method. Two programs QM and Win QSB are applied on the products depending its demand for six years. It is concluded that the results of Win QSB program is more accurate because the forecast of sales is obtained for three years later. This period is longer period than the period obtained from QM program.

The recommendation for future work is to apply more methods for more accuracy, and to use different programs to calculate the forecasting for more years required.

For the company it is recommended to increase the quantity of sales to reduce imports and encourage the national products, and to improve advertising for encouraging the consumers to buy their products for better competition.

8. REFERENCES

[1] J.S.Armstrong and K.C.Green, Forecasting methods and principles: Evidence checklists, 128-clean, Research gate publication/ 318392870, Journal of global scholars of marketing science, Dec. 1, (2017)

[2] S.K.Mukhopadhyay, Production planning and control, 2nd edition, Prentice-Hall of India, New Delhi (2007).

[3] R.I.Levin, C.A.Kirkpatrick and D.S.Rubin, Quantitative approaches to management, McGraw-Hill, Inc. (1982)

[4] MahendraGor, Ravi., Industrial statistics and operational management", ICFAI Business school, e-mail:ravigor@hotmail.com.

[5]L.J.Krajewski and L.P.Ritzman, Process management, process and value chaines, 7th edition, pearson prentice hall (2005)

[6] J.Moisanen, Demand forecasting in the apparel industry, Helsinki, Metropolia University of applied science Bachelor of business administrator Eurpon management (2012)

[7] J.S.Maartinich, Production and operations management, John Wiley & Sons. Inc. (1997)

[8] P.Garg, Production and operation management, S.K.Kataria & Sons, (2010)

[9] N.R.Sanders and K.B.Manrodt, Forecasting software in practice: use, satisfaction and performance, Wright state university, Dayton, Ohio, Oct. (2002)

Developing of a 3D printer to produce parts using powder metal

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ABSTRACT

The three-dimensional printing (3DP) process is making stereoscopic shapes using a layered system. Recently, the focus has been on metal printing, but the problem is that the high energy used such as laser, electron beam, or high heat to melt the metal to print it as required. In this paper, design and implementation of a 3D printer for metal parts production are worked. The work also includes making an experimental test for the new 3D printer and printing 3D metal parts without using heat. In this work, two new extruders are designed to inject the metal powder and adhesive, where the heat was removed from the extruder head and the printer bed. The metal powder extruder contains a powder reservoir, glass funnel, and access valve where controlled through the solenoid valve. The adhesive extruder is controlled using a simple hydraulics. The printing process was done by printing two layers of metal powder and a layer of adhesive depending on the desired shape to create 3D objects using the SolidWorks software.Different metal models were printed and these models were compared with the original design which was drawing by SolidWorks software. The difference between the actual model drawing and the printed parts is differences between (0.004 mm) for some parts to (2.3 mm) for other parts or the percentage of error is between (0.1% - 4%) for the printed parts. However, the material can be used in high temperatures, where plastic materials (as ABS and PLA) cannot be used, and in applications requiring porosity.

KEYWORDS

3D printer, powder metal, adhesive, layered system, FDM.

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1. INTRODUCTION

3D Printing, or so-called Additive Manufacturing (AM), indicates operations utilized to make 3D parts. The parts are printed using the layered system. The part is slicing into a number of layers by software in Personal Computer (PC) control [1]. Stereolithography (STL) is one of the most widely recognized types of documents that 3D printers can handle. In contrast, materials extracted in conventional processing, 3D printing, or AM make a 3D part of the Computer-Aided Design (CAD) pattern or AMF document by gradually adding the material layer to the layer [2]. The fundamental zones in this operation vary are the technologies utilized as a part of the process and the materials. Several of the various kinds of processes incorporate extrusion, light polymerized, continuous liquid binder fabrication and powder bed [3].

Each one of the 3D printing operations contains features and defects, so any type of the sort of 3D printer selected for an application often times depend upon the materials to be utilized and how the layers in the completed item are bonded. There are seven most usually utilized additive manufacturing technologies [4]:

1. Binder Jetting
2. Sheet Lamination
3. Directed Energy Deposition
4. Powder Bed Fusion
5. Material Extrusion
6. Material Jetting
7. Vat Photo-Polymerization

Thfirst four types are currently used in metal printing, but the other three types are not applied to metal technologies. The material extrusion method (Fused Deposition Modeling) is used in this project to print metal parts.

FDM is the most widely recognized 3D printing strategy utilized as a part of PC 3D printing. It uses thermoplastic wire for the printing, where the wire is warmed and ejected through the printer head and builds the 3D objects by a layered system. The head of the printer moves in two directions (X-Y) while the Z-direction is driven by the movement of the heated bed. Effectively, the part is constructed from the base and rises up, as shown in figure 1.

FMD technology does not require dissolvable material. It can be done in such a way with ease and flexibility in processing materials, as well as does not require high experience. The utilization of a filament material additionally decreases its living arrangement time in the warming chamber and permits nonstop generation without the need of supplanting [5].

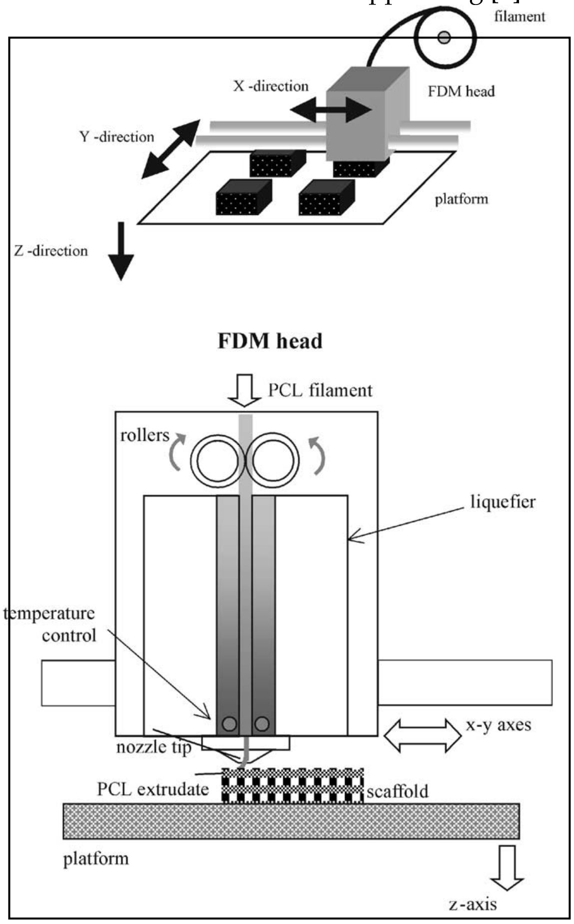


Figure1. A schematic diagram of the FDM extrusion and deposition process [5]

A 3D printer has been studied and developed by researchers like Santos et al. [6] presented the different research where a focus placed on the fabricating of metal parts using various laser techniques such as selective laser sintering and selective laser melting, as well as the use of different commercial machines. They proved that it is possible to produce high-intensity metal parts with perfect mechanical properties utilizing the layered fabricating with laser-based technicality. Schurig [7] concentrated on FDM because it is easy to use especially in offices and the cleanest method to print a part. Another advantage of FDM is the utilization of environmentally friendly and mechanically steady, printable material. Jaksic et al. [8] depicted an implementation of cheap, secure, experiential and open source 3D printer (Mini Metal Maker). It is used the metal clay for printing and utilizes in engineering laboratories to print bronze parts. After printing, metal clay parts were dried and then fired in a small digital kiln. The system of this printer is based on FDM.

Hunko and Payton [9] developed Wire 3D (Wir3D) printing process (greatly inexpensive) using an electric circular arc to fusion metals at higher sedimentation averages than another added substance methods in metals. Wire and arc additive industrialization empowered producers to construct parts by sedimentation metal in layers utilizing welding techniques. It had been set up additive machine successfully based on the main basics and techniques of Metal Inert Gas (MIG) welding technology. Du et al. [10] presented the development of the process for new metal additive manufacturing (AM), indicated to as the Metal Fused-Coating Additive Manufacturing (MFCAM), for the consolidation of high-efficiency metal parts. This method was developed precisely because of the need for high-efficiency deposition of larger metal parts. Capel et al. [11] described the utilization two AM processes, stereolithography and selective laser melting, to make multi-functional fluids gadgets with built-in interaction control ability. The eclectically laser-melting components were the initial distributed models of multifunctional 3D printed metal fluidic gadgets. These gadgets permit high temperature and pressure which should be present in solvents systems destroyer for the most gadgets made by stereolithography, polymer jetting and fused deposition modeling operations. Murr and Johnson [12] showed the over thirty years of improvement of metal droplet era for precision additive fabricating implementations using progressing, high-temperature metals and alloys. Utilizing multi-wire metal and alloy group 3D droplet printers, product functionality could be treated in the incorporated industrialization process taken advantage of rapid-speed and multi-metal 3D printing. Wire feed system frugally could be worked at minimizing material cost, decrease refuse, semi-net shape production, decreased or disposed of tooling, and product characteristics and performance improvement through microstructure control.

Until now, some researchers focused on printing different materials using a specific printing method and measurement of mechanical properties and the comparison of properties. Most researchers had focused on using new methods or developing old ways to print metals and their alloys. Few researchers focused on the software used in printers and developed.

As illustrative previous researches, metals printing need high energy or high temperature using laser, electron beam or melt the metal to be printed, and if printed in other ways, printed parts put in the oven for several hours to treat the piece.

As well as, the high prices for metal printers which are currently (from $100,000 to $ 500,000), due to the use of different heating technologies. Thus, the objectives of this work are designing a 3D printer for metal parts production, implementation and make an experimental test for new 3D printer, and printing 3D metal parts without using heat.

2. MATERIAL AND METHOD

In this project, iron metal and cyanoacrylates adhesive are used as a raw material to print 3D parts. Iron powder has various utilizations. The molecule sizes differ somewhere in the range of 20-200 μm, as shown in figure 2. The iron properties vary contingent upon the generation strategy and history of a particular iron powder [13].

Figure2. Iron Powder about 100 mesh (about 150 μm)

Cyanoacrylates are within a group of solid quick acting adhesives with mechanical, therapeutic, and home uses. Cyanoacrylate adhesives are occasionally recognized nonexclusively as immediate glues, strength glues or super glues (albeit "Super Glue" is a commerce name). It is liquid matter as shown in figure 3. Generally, it is an acrylic sap that quickly polymerizes within the existence of water (particularly hydroxide ions). It is used thinly, to guarantee that the response continues quickly to bond. They don't fill spaces, not at all like epoxies, and light layer affixes more efficiently than a thick layer that does not treat appropriately [14].

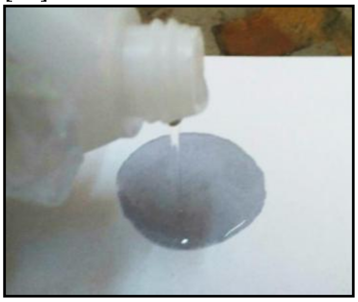


Figure3. Cyanoacrylates adhesive

A. *Research Approach*

This project was based on the basics of the work of 3D Tevo-Tarantula (Prusa i3) printer, as shown in figure 4, where this printer works on the FDM system. For the printer was modified to print the metal parts, the solid metal structure, stepper motors, and MK3 heated bed are used from the Tevo tarantula 3D printer. Furthermore, the new parts that are used are: a push tubular solenoids valve, a glass funnel, check valve, a nozzle with 1mm diameter, a simple hydraulic system using syringe and water, and other new parts designed and printed for a new design of 3D printer details are given later. Arduino Mega 2560, a shield for a 3D printer, and stepper motor driver are used for controlling the 3D printer. The primary materials use powder metal and adhesive to print the parts.

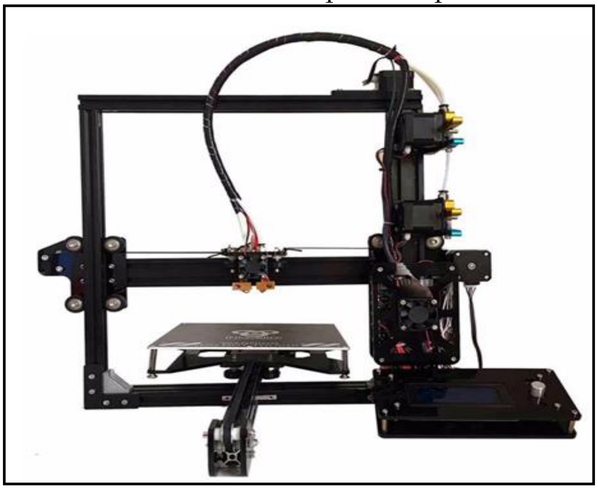


Figure4. Tevo-Tarantula (Prusa i3) 3D printer

B. Mechanical Design

On the basis of the used printer, which works on the FDM system, also depending on the metal powder and the used adhesive, it is designed new extrusion systems for printing metal powder and adhesive with layered systems easily.

1) *Metal Powder Extruder:* The first option chosen for the design of the new extruder is the access valve, as shown in figure 5, which works as a check valve system, allowing the material to pass through it in one direction when the force (weight) is placed on the spring located in the middle of the valve. After practical experiments, the total springing stroke is approximately 3 mm and the force (weight) to open the spring is 10 N (1 kg).

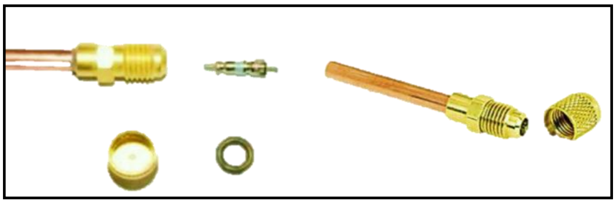


Figure5. Access valve

After that, a nozzle was selected, as shown in figure 6, It is suitable for crossing the metal powder through it where contains a 1 mm hole. When experiment the smaller nozzle openings, the powder cannot pass smoothly and close the nozzle opening.

Figure6. Nozzle of 3D printer

For the powder to reach the passage area through the access valve, a glass funnel was selected. As explained previously, the access valve needs a force (weight) to open the spring, so the solenoid push shown in figure 7, is chosen to do this task.

Figure7. Push Tubular Solenoids

To set up the solenoid over the glass funnel, a special holder is designed. It is contains two holes in the bottom. One of the holes is for the passage of the solenoid stick and the second is for the placement of a plastic tube through which the metallic powder comes from the external reservoir which is also as a funnel-shaped to drop the powder into the tube easily. For the purpose of protecting the glass funnel from external conditions and for the connecting it to the solenoid holder, the funnel holder is designed. A clamp is used to attach the solenoid holder to the glass funnel holder. To fix the new extruder with the X-axis, two new pieces were designed. The first was directly connected to the acrylic part that is moved by the X-axis stepper motor as shown in figure 8.

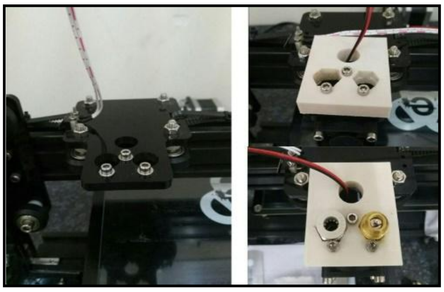


Figure8. Connecting the extruders holder with the acrylic part

The second piece is designed to support the whole new extruders for not falling or tilting during the movement of the x-axis through the printing process, as shown in figure 9.

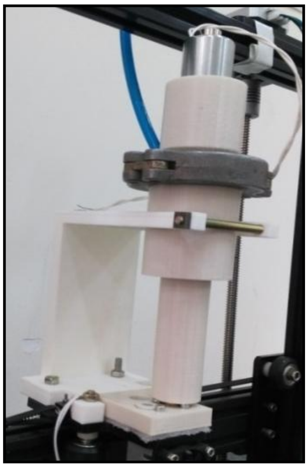


Figure9. Connecting the powder extruders support with the acrylic part

2) *Adhesive extruder:* A simple syringe pump was designed to push adhesives. The parts are designed and printed with a (PLA) material. The first part is to connect with the stepper motor. The second part is to connect the lead screw with the nut to be pushed the syringe. The third part is to fix the system on the wooden base through two screws and catch the syringe. The first syringe (20 ml) of the original system was attached to a second syringe of the same size by a plastic tube and filled one syringe with water to act as a simple hydraulic system while pushing the syringe by the stepper motor. All the parts used are shown in figure 10.

Figure10. All top parts of adhesive extruder

A new part is designed to hold the second syringe with the third small syringe (3 ml) in opposite directions where the small syringe is filled with the adhesive material and it is pushed by the large second syringe. At the end, a special syringe needle was used with a (1 mm) hole to do the work of the nozzle. By the calculation of the amount of fluid flow by two different syringes (3 ml - 5ml), it was noted that the lower the size of the syringe, the less the amount of the adhesive was exited from the head of the extruder, as illustrated in Table 1.

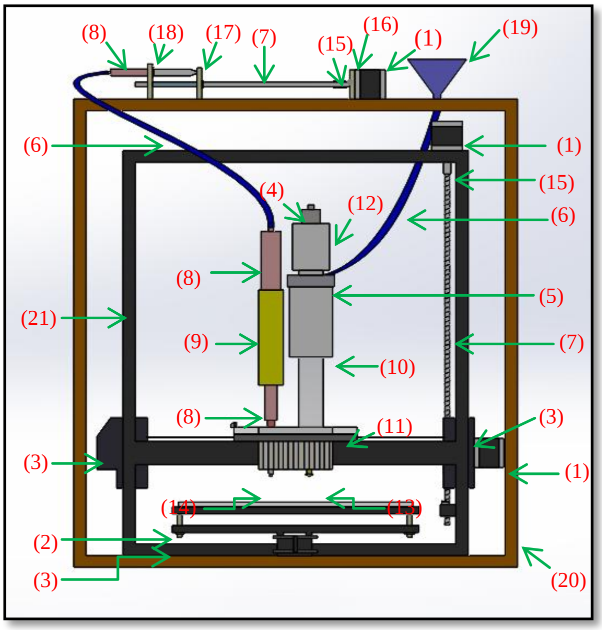
Table1. liquid flow by two different syringes

Syringe Size (ml)	Total Liquid (ml)	Total Time of Discharging (sec)	Discharge Liquid in Second (ml/sec)
3	2.6	335	0.00776
5	4.5	333	0.0135

*These amounts were calculated under the same speed and pushed by the same syringe (20 ml).

C. *Printer Assembly*

The 3D printer modification and assembling was started with the aid of the newly designed parts. The new extruders, described previously, are installed. The 3D printer appears in the final shape in figure 11. The schematic drawing in figure 12 shows all the parts of the 3D printer after modification.



(1) Stepper motor (12) Solenoid holder
(2) Heated bed (13) Nozzle
(3) Acrylic parts (14) Needle
(4) Solenoid push (15) Couple
(5) Clamp (16) Stepper motor holder
(6) Tube (17) Nut holder
(7) Lead screw (18) Syringe holder
(8) Syringe (19) Powder reservoir
(9) Syringes grip (20) Wooden frame
(10) Glass funnel holder (21) Metal frame
(11) Extruders holder

Figure11. Final shape of the 3D printer

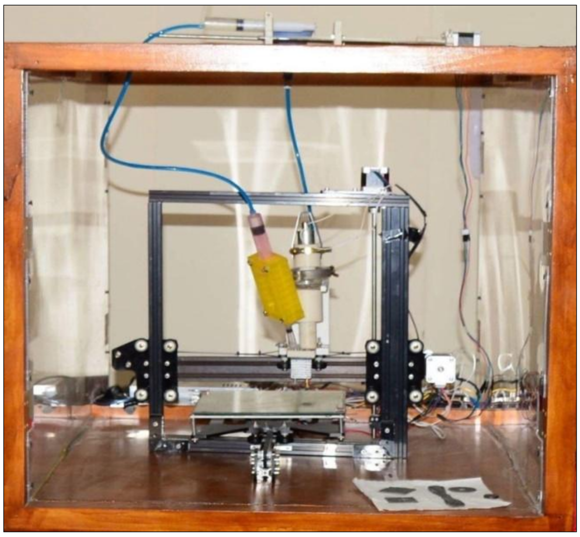


Figure12. The 3D printer for production metal parts

All steps of the 3D printer metal procedure are illustrated in figure 13.

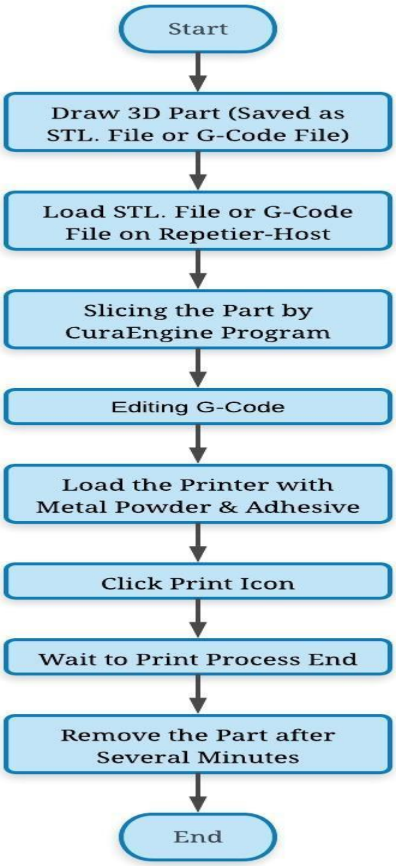


Figure13. Flowchart of 3D printer of metal procedure.

D. Controlling of 3D printer

The 3D printer is controlled using Repetier-Host as a program interface and is controlled by Marlin Firmware. Initially, many of the steps in Marlin's firmware have been modified, such as:

(1) Adjusting the dimensions of the 3D printer being used.
(2) Selecting the number of extruders.
(3) Adjusting the distance of the head of each extruder from the zero point and from the other extruder.
(4) Adjusting the temperature range with the lowest temperature at 5 °C and the highest temperature at 250 °C.
(5) Adjusting the motor speed for the extruders and the three axes (x, y, z).
(6) Adjusting a minimum temperature for the extruder at 15°C, where this option prevents extrusion if the temperature is below than 15°C.

Apart from controlling the printer by Marlin firmware, there are steps that can be changed to print an individual piece such as the print speed and the number of extruders used, through the printer settings window in the Repetier-Host interface.

Several important commands are controlled by the CuraEngine slicing program, such as:

(1) Filling density
(2) A thickness of each layer
(3) A thickness of the top and bottom of the piece
(4) Infill pattern
(5) Filament diameter (the diameter of the nozzle hole)
(6) Print and bed temperature

3. Results and Discussion

After several attempts and corrections such as the deletion of the basic part and its framework from printing and also determining the number of layers of powder metal and the number of layers of adhesive where it is noted that in the printing of two layers of powder metal and one layer of adhesive, the result is better than if the printing in equal layers of the materials.

As shown from figure 14 to figure 17, The difference between the actual model drawing and the printed parts is between (0.065 mm) for some parts to (2.1 mm) for other parts or the percentage of error is between (0.13% - 5.25%) for the printed parts. The main reason for this difference is the printer's lack of precision since when it prints plastic parts (before modification), there is a difference of (1 mm) or (3.33%) between the printed piece and the original model. It was also noticed that the larger the height of the piece, the greater the error rate.

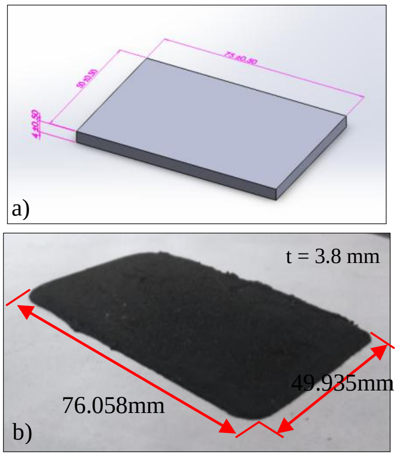


Figure14. Rectangular Shape, a) Solidworks Drawing, b) Printed Part

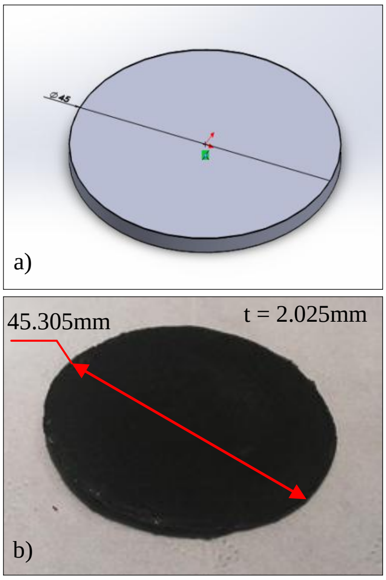
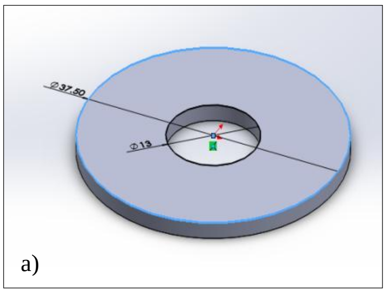


Figure15. Circular Shape (t = 2mm), a) Solidworks Drawing, b) Printed Part



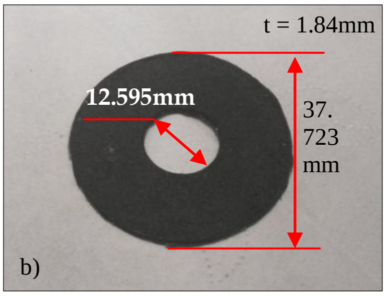


Figure16. Washer Shape, a) Solidworks Drawing, b) Printed Part

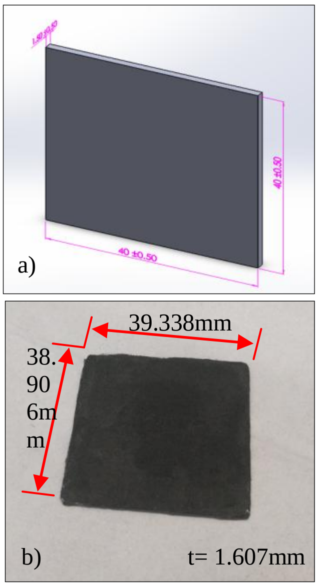


Figure17. Cubic Shape, a) Solidworks Drawing, b) Printed Part

4. Discussions

As shown above, several parts were printed in different forms and the tensile strength and hardness were measured and the microstructure was examined.

When the rectangular piece was printed using a layer of powder and a layer of adhesive, it was observed that the amount of glue was more than the amount of powder used by a large percentage, which led to the flow of powder with the adhesive material and did not give a good result compared to the pieces that were printed using two layers of powder with one layer of adhesive material.

It was noticed that the higher the height of the printed piece, the greater the error rate because the powder layers would flow with the adhesive material.

When circular shapes are printed, there is less roundness in the printed prototype, therefore the cubic shape is more accurate than circular shapes.

5. Conclusions

A 3D printer for metal has designed and implemented, as it is simple and inexpensive compared to 3D printers for metals currently used in factories. The metal parts were printed in layers (FDM) system successfully, where printing two layers of metal powder and a layer of adhesive and without the use of heat. Similar 3D objects have obtained for the drawn pieces by SolidWorks, with percentage error between (0.13% - 5.25%).

In the future: it is possible to work on a 3D printer with higher efficiency to print more precise parts, and it is better to make a special software for this printer to be able to work without any temperature limit, where the current program should use heat sensors (thermocouple) to measure the temperature, but we can control the lowest possible temperature through which the 3D printer works.

6. References

[1] S. M. Adil, A. R. Chhapra, S. Junaid, and K. Nehal, "*3D Printer*," Kaisekar Technical Campus, New Panvel, Students of final year electrical 2016.

[2] B. S. Shahi, "Advanced Manufacturing Techniques(3D Printing)," *International Journal of Mechanical And Production Engineering*, vol. 4, no. 4, pp. 16-23, April 2016.

[3] C. S. Lee, S. G. Kim, H. J. Kim, and S. H. Ahn, "*Measurement of anisotropic compressive strength of rapid prototyping parts*," Journal of Materials Processing Technology, pp. 627–630, 2007.

[4] ASTM International, "*Standard Terminology for Additive Manufacturing Technologies*," MIT Libraries, United States, sep 2013.

[5] I. Zein, D. W. Hutmacher, K. C. Tan, and S. H. Teoh, "*Fused deposition modeling of novel scaffold architectures for tissue engineering applications*," Biomaterials, vol. 21, pp. 1169–1185, June 2001.

[6] E. C. Santos, M. Shiomi, K. Osakada, and T. Laoui, "*Rapid manufacturing of metal components by laser forming*," International Journal of Machine Tools & Manufacture, vol. 46, pp. 1459–1468, 2006.

[7] F. Schurig, "*Slicing Algorithms for 3D-Printing*," Technische Universitat Munchen, Munchen, B.Sc. Computer Science student 2015.

[8] N. Jaksic, N. D'Angelo, and G. Vig, "*Inexpensive Metal 3D Printers in Engineering Education:The Revolution Continues*," in ASEE Rocky Mountain Section Conference, Cedar City, UT, 2016.

[9] W. S. Hunko and L. N. Payton, "*Development of Wire 3D (Wir3D) Printing Parameters*," in Proceedings of the ASME 2016 International Mechanical Engineering Congress and Exposition *(Advanced Manufacturing)*, Phoenix, Arizona, USA, p. 8, 2016.

[10] J. Du , X. Wang , H. Bai , G. Zhao , and Y. Zhang, "*Numerical analysis of fused-coating metal additive manufacturing*," International Journal of Thermal Sciences, vol. 114, pp. 342-351, January 2017.

[11] A. J. Capel et al., "*3D printed fluidics with embedded analytic functionality for automated reaction optimisation*," Beilstein Journal of Organic Chemistry, vol. 13, pp. 111–119, January 2017.

[12] L. E. Murr and W. L. Johnson, "*3D metal droplet printing development and advanced materials additive manufacturing*," Journal of Materials Research and Technology, vol. 6, no. 1, pp. 77-89, March 2017.

[13] Central Drug House, "*IRON FILINGS ABOUT 100 MESH*," Central Drug House (P) Ltd., New Delhi, Product specification 2016.

[14] E. M. Petrie, *Handbook of Adhesives and Sealants*, 2nd ed. United States of Amireca: McGraw Hill Professional, 1999.

Pneumatic control system of automatic production line using SCADA

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ABSTRACT

SCADA system is in the heart of the modern industrial application which is used to provide immediate knowledge of the pneumatic system with help of HMI. SCADA system is used to generate alarms, trends, and reports The objectives of this work; to monitor the pneumatic system which used in the manufacturing process and evaluate the pressure losses in air distribution lines, to design, fabricate and simulate the production line, to design and implement of the SCADA system to access, control, monitor, and analyze live data of the pneumatic system of the automatic production line which helps the decision-making during and after the process The pneumatic system is used in this work because the pneumatic components are simple in design, easily fitted, with relatively low maintenance cost (economic) and have long working life. It also unaffected by overload and do not produce heat As a result, Success of reducing the cost associated with building SCADA system. success of represent the pneumatic components in SCADA system in new way. As well as theoretical approach and experimental test were used to measure the pressure losses caused by long lengths of piping and connecting elements (such as elbows, straight fittings, and tees) to determine how these pressure losses are affected by upstream pressure, number of fitting, flow rate and temperature.

KEYWORDS

SCADA, HMI, Pneumatic system, pressure, PLC

NOMENCLATURES

Δp = pressure drops in a pipe, L = length, D= diameter.
λ = the dimensionless friction coefficient. ,p = the fluid density.
w =the mean value of the flow velocity., P and p =, the absolute and relative pressure respectively.
KG is a coefficient which depends both on the type of element in question and on its size

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1. INTRODUCTION

SCADA is an abbreviation of Supervisory Control and Data Acquisition. A SCADA system is a PC based data acquisition which is intended to collect working data from a variety of field devices and to transmit this data by means of a communication link to at least one control center for control, show, and reporting to form information to the operator [1].

The information is to be displayed on a screen to the operator. The operator may then issue supervisory commands to the field device in light of the incoming data. A commonplace SCADA system includes I/O hardware, controllers, software, communication, computer, networks and interfaces [2].

SCADA system task includes data acquisition from the field devices and processes this data just as with control systems, for example, PLC or RTU. The processing data is displayed as symbols, alarms, trends, and reports. SCADA is the most modern tool used for collect data which is designed to assist operators in the operation of the any system using real-time and historical information [3].

In simple terms, a SCADA system is gathering of programming and equipment parts (software and hardware) that enables the user to perform of explicit with capacities. These capacities include [4]:

- Checking and assembling process data(continuously).
- Interacting with field devices and control stations like sensors and actuators by means of an HMI (Human Machine Interface).

Recording system occasions (data and information) in a log document.

2. PROCEDURE

First of all, the production line was designed, then the hardware and software were prepared then the production line is implemented. Then, the system was simulated in three stages. First, the production line function was simulated using factory I/O. Second, the electric and pneumatic circuits were simulated using automation studio software. Finally, the PLC was connected with designed system using factory I/O software and, with electric and pneumatic circuit using automation studio software. The simulation was used to make sure the designed system corresponds with the purpose of its creation.

S7-1200 PLC is used to control the production line so, Step7 TIA portal software was used to control all units of automatic production line. HMI was used to help to visualize the values that were generated in the process alarm also generate when the pressure of air in pipe less than desired values.

2.1 The pneumatic circuit

The pneumatic circuit of the production line is implemented by using Automation studio software. The pneumatic circuit consists of five pneumatic cylinders selected to represent the pneumatic cylinder used in the actual system. The five cylinders are connected with five (5ports,2position) direction control valves, all valves are connected with the same air source. Then the electric and control circuits are implemented. The start button and all sensor types are connected with PLC input card and power source(24v). Five solenoids and one motor are connected with PLC output card and a power source. After that, the rung is added to program the sequence of the operation and connecting the programs with the electric and pneumatic components, as shown in figure (1).

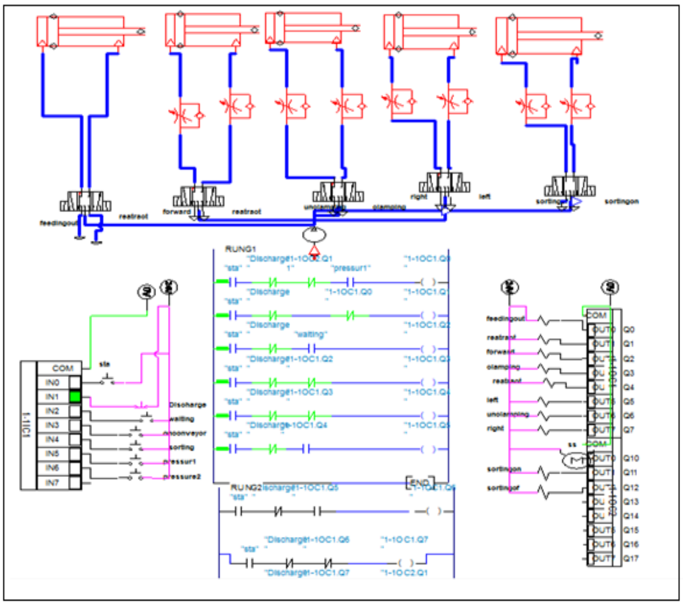


Figure 1. **The Pneumatic Circuit Working Principle**

2.2 Mathematical model to estimate the pressure drops.

1- Straight Pipes Pressure Losses

Theoretical techniques used for deciding pressure drop in relative to flow rate for a given line section, taking into record both the opposition and friction attributes of smooth lines, to set up which approach is most dependable. The distinctive methodologies depend on expression ,which is valuable either in laminar and turbulent flow[5].

$$\Delta p = p2 - p1 = \lambda \cdot \rho \cdot \frac{w2}{2} \cdot \frac{L}{D} \quad (1)$$

The air medium velocity w is related to the flow rate is calculate using equation1

$$w = \frac{4.Qn}{\pi.D2} \cdot \frac{Pn}{p1} \cdot \frac{T}{Tn} \quad (2)$$

Pn , Tn = the pressure and the temperature of the air in standard conditions (International Standard).

Q_n =the volume flow-rate in standard conditions

Q_n, P1and T are directly measured by the test bench

Λ applies to smooth pipes with Reynolds numbers up to 1010.

$$\lambda = \frac{1}{(0.75 \ln(Re)1.15)2} \quad (3)$$

2-Connecting Elements Pressure Losses

$$\Delta P = KG.\frac{Qn^2}{P1} \quad (4)$$

2.3 Experimental test to estimate the pressure drops.

Gefran (TK)pressure sensor is shown in figure (2), TK transmitters are based on the extensimeter thick film measuring principle. Thanks to highly stable electronic components, these transmitters can be used in applications requiring long-distance signal transmission or in smart control systems. TK pressure transmitters are designed mainly to measure pressure in oil, air, and hydraulic circuits. They can also be used in the technical and process measurement application as well as for compressors, presses and mobile hydraulic. with description [6]:

-Pressure ranges from: 0...3 to 0...500 bar.

-Power supply 10...30Vdc.

-Output signal 4….20mA.

- Max current absorption 13mA…. 32mA.

Two Gefran (TK) pressure sensors that were used for estimating pressure sub-current condition are principally done to control and regulate compressors just as to assess compressed air systems. An electronic pressure sensor changes over the pressure esteems into analog signals.

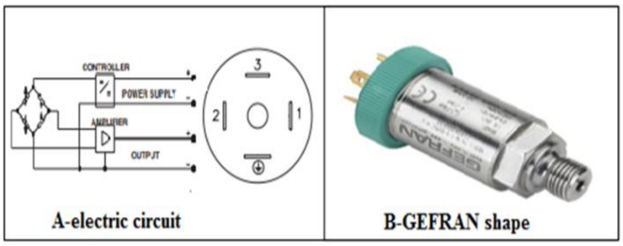


Figure 2 PRESSURE SENSOR

2.4 SCADA/HMI IMPLEMENTATION

HMI screen was designed to represent the actual system. HMI helped to visualize the values that were generated in the process. HMI is used to monitor the pneumatic component as shown in figure (3)

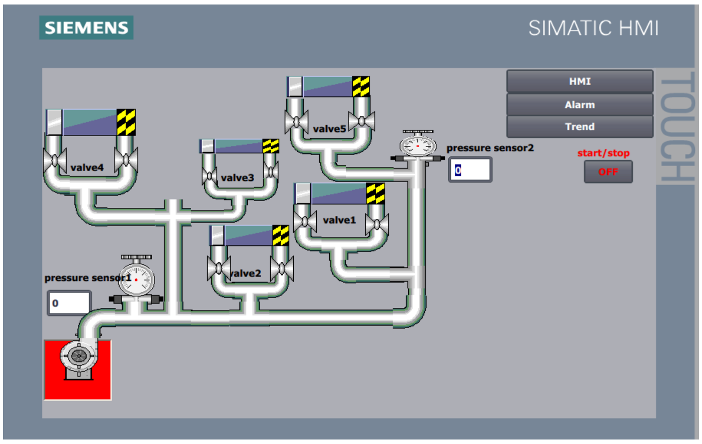


Figure (3) HMI

Charts was created in the trend to represent the pressure values with respect to time, as shown in figure (4)

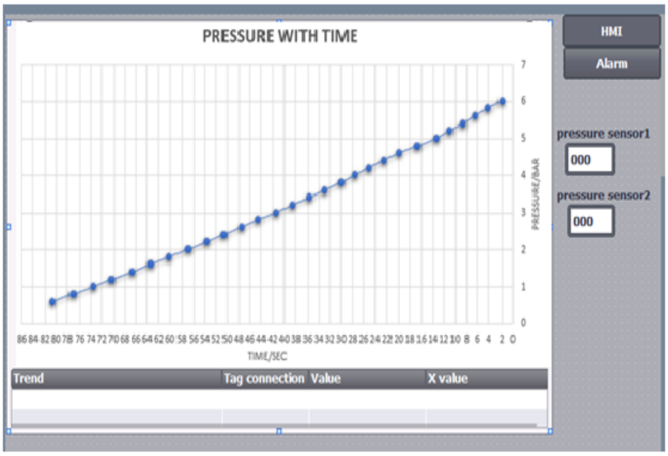


Figure 4 THE TRENDS

And analog alarms were used to indicate if the pressure was above or below the desired values, as shown in figure (5).

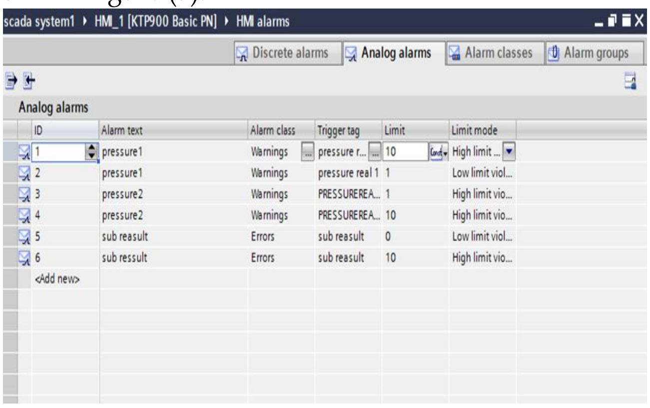


Figure 5 ALARMS

3. THE RESULTS

In a compressed air distribution network, it is important to evaluate the pressure losses. experimental tests and a theoretical approach were carried out. Figure (6) shows the theoretical results of the pressure drops that estimate by compensation the piping and connecting element specifications in theoretical formulation (equation two) with constant flow and temperature. Figure (7) shows the theoretical results of the pressure drops with change in temperature with constant flow. As a result, the pressure drops in the pipes depended on the fitting number and type, temperature, flow and pressure.

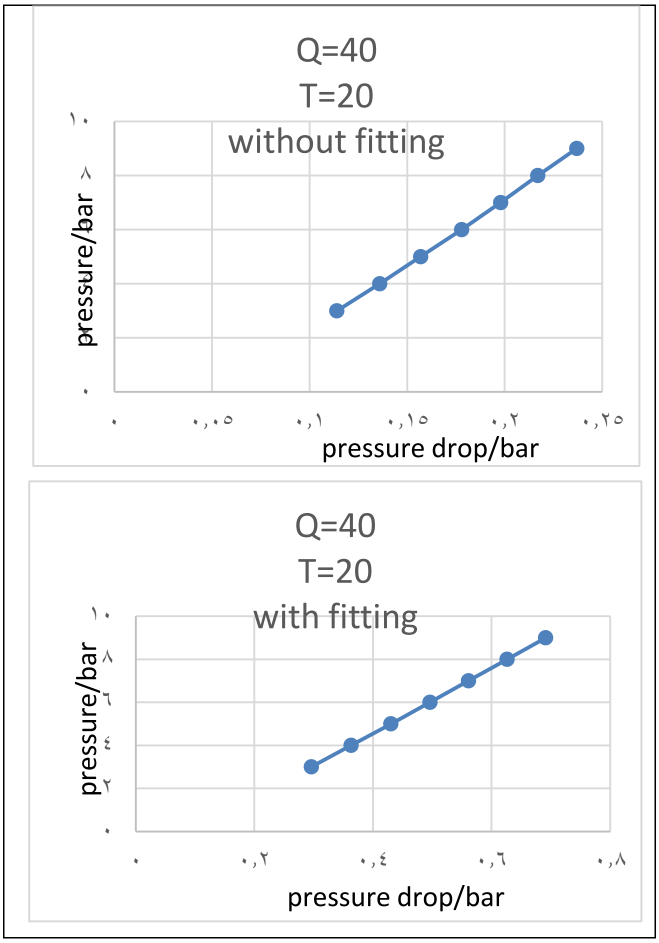
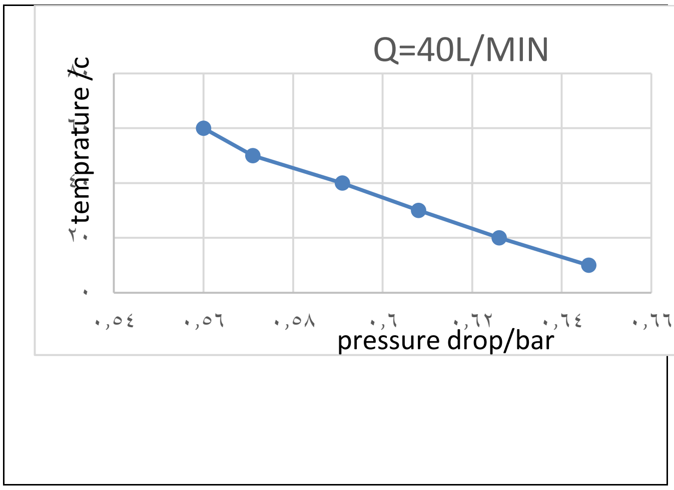


Figure 6 **The relation between pressure and pressure drops with and without fitting.**



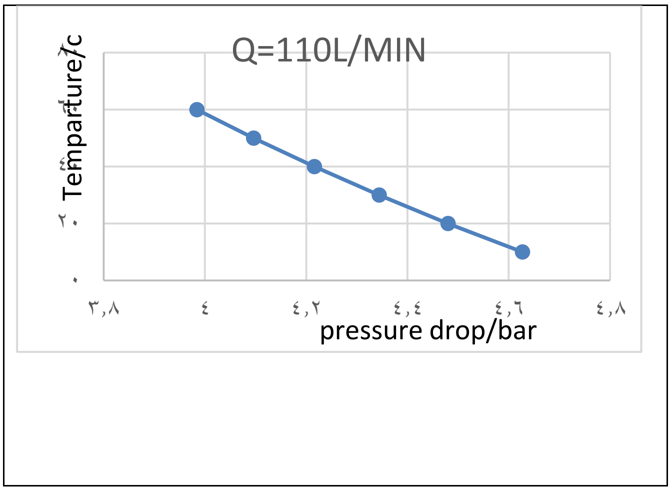


Figure 7 ***The relation between temperature, pressure drops and flow***

2.5 Abbreviations and Acronyms

SCADA: Supervisory Control and Data Acquisition
PLC: Programmable Logic Controller
HMI: Human Machine Interface

4. CONCLUSION

SCADA system is used to represent the pneumatic components that used in industrial application with mainly low cost

And the system is proofed that the pressure drops in pipe depending upon the pressure, the flow of the air and the temperature of the environment as well as the pipe fittings type.

5. REFERENCES

[1] L. A. Sabri, S. A. Mohammed, and M. I. Issa, “Design of SCADA System for Oil Pipeline Control Using LabVIEW,” *Al-Nahrain Journal for Engineering Sciences*, vol. 20, no. 3, pp. 600–614, 2017.

[2] S. Duque, et al. "Two decades of SCADA exploitation: A brief history." 2017 IEEE Conference on Application, Information and Network Security (AINS). Miri, Malaysia,13-14 Nov. 2017.

[3] V. B. Kumbhar, D. Gokhale, V. S. Kumbhar, and M. K. Patil, “Implementation of Customised SCADA for Cartoner Packaging machine for Cost Effective Solution,” *International Research Journal of Engineering and Technology*, vol.4, issu.01, pp. 996–1001, 2017.

[4] R. Hemavathi, and H. P. Kumar, “Automation of Level and Temperature Control in Food Industries using PLC and SCADA", *International Journal of Electrical and El*

[5] M. Carello, A. Ivanov, and L. Mazza, “Experimental and theoretical methods to evaluate the pressure losses in air distribution lines,” *International journal in Fluid Power*, vol. 7, no. 2, pp. 5–9, 2006.

[6] Gefran pressure sensor, Available http:// www.gefran.com, Accessed Nov11-2018.

Fabrication and mechanical properties of zinc alloy based metal matrix composites reinforced with nano-particles

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ABSTRACT

This paper concludes the mechanical properties and microstructural analysis of metal matrix composites prepared using zinc alloy as a matrix, nano boron nitride as reinforcement particles. The stir casting process was utilized to fabricate the composites of varying weight percentages of nano boron nitride (2,4,6,8 wt. %).

A Vickers microhardness, tensile properties tests were evaluated, and the microstructural investigation was applied to characterize the composites fabricated. Results show the hardness values were increased with an increase in reinforcement and were better than that of the base alloy. The maximum of values observed for as much as 8% boron nitride nanoparticles reinforcement. The mechanical increased by increasing increase in the weight ratio of boron nitrides nanoparticles in the composites and all composite have a higher tensile strength in comparison the base alloy. Microstructure analysis was observed that uniform distribution of reinforcement particle in the composites are alike, consisting of the dendritic structure of the zinc alloy matrix with an excellent steady dispersion of the reinforcing particles.

KEYWORDS

Zinc alloy; Stir casting; Mechanical properties; Nanoparticle; Boron nitride.

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1. INTRODUCTION

Zinc alloys were the last little decades taking heed of both researches and industry, as a tribomateriale of significant potential. It can be said that, at this time, ZA alloys commercially available, due to excellent castability and individual compound of characteristics, which enhance the alternative metal mainly for many aluminium alloys and bearing bronzes, also plastic materials, even for steels that operate under requirements of special mechanical loadings and average sliding speeds. The concern in prolonging the effective utilisation of these alloys, besides the tribological, the economic and ecological character. They are known to be cheap material processed energetically, efficiently and without endangering the environment [1].

The excellent mechanical and physical properties, superior finishing characteristics, and corrosion resistance have enabled zinc alloys to die casting to withstand the time tests after having been used for several decades with great success [2]. They allow for larger difference in section design and the maintenance of closer dimensional tolerances [3].

ZA-8 is the high strength performer of the zinc alloys. It is also the lightest alloy and allows great bearing resistance, the higher aluminum and copper contents in traditional zinc alloys, provide many advantages including high strength, excellent wear resistance, excellent creep resistance, and lower densities, However, when wear resistance properties are needed, zinc alloy has demonstrated exceptional performance [4].

In the exact casting requirements, the zinc alloys have a typical dendritic structure, which depends on several factors. Namely, the cooling rate requires a powerful influence on the structure fineness [5].

Zinc alloys are of great importance in the automotive industry because of their excellent mechanical properties,e asy castability, superior variety of properties and casting and finishing characteristics. They are also applied where more excellent performance is required, unusually for bearing applications. The zinc-aluminum ZA-8 alloy is usedin some application such as bearings, Gear shift bracket and thin wall decorations due to its good hardness, strength and pressure tightness [6].

Seah et al. [7] Addition of Gr particles dramatically reduces the hardness for the cast and at the same moment raised for the age samples after comparing the hardness of the cast and the synthetic age samples of ZA/Gr particulate composites that have an influence barely on the matrix rather than the alloys. Babic et al. [8] The results were showed decreased in the ultimate tensile strength and hardness with an improvement in elongation of the composite when compared the casting and the heat treatment of the ZA alloy reinforced with Gr.

Ranganath et al. [9] Discussed the mechanical characteristics of ZA-27 that is strengthened by different amounts of Titanium dioxide .the presumption was by including the strengthened particles; there was an improvement of ultimate tensile strength, modulus of elasticity, yield strength and hardness of the composite materials. Meanwhile, there was a decrease in ductility. Prasad approximated the characteristic of the tension of ZA -27, microstructural and compositional features and experiment circumstances. The operations were achieved at varying temperatures and strains values. The property of tension was advanced as the rates of strain increased, nevertheless at more elevated temperatures, an opposite shift attended. Elongating did not have any influence on train rate or temperature that retained on enlarging.

The aims of this study have been evaluated the mechanical behaviour and study the microstructure of zinc alloy was produced by stir casting and study the effect nanoparticles on composite with different percentages.

David et al. [10] The results showed an increase in the hardness of composites when compared the casting of ZA-27 alloy matrix composites reinforced with TiC. However, the hardness of the composite reduces on increasing the reinforcement percentage.

The aim of this study the effect of nano additives (BN) particles for zinc alloy which produced by stir casting on mechanical behavior and microstructure.

2. Methodology

2.1 Materials Selection

2.1.1 Matrix Materials

Matrix material used in this research was zinc alloy, which has excellent properties with a wide range of applications. Its chemical analyses are shown in table (1).

Table 1. : Chemical analyses of zinc alloy as a cast

Element	Al %	Cu %	Mg %	Fe %	Cd %	Pb %	Zn %
Chemical Composition of zinc alloy	8.34	5.14	0.013	0.014	0.0015	0.0009	Rem

2.1.2 Nano Boron Nitride as a Reinforcing Materials

It was used as a ceramic powder (nano BN) as reinforcement for zinc alloy. The morphology of raw powder was done made with Scanning Electron Microscopy (SEM) as shown in fig. (1).

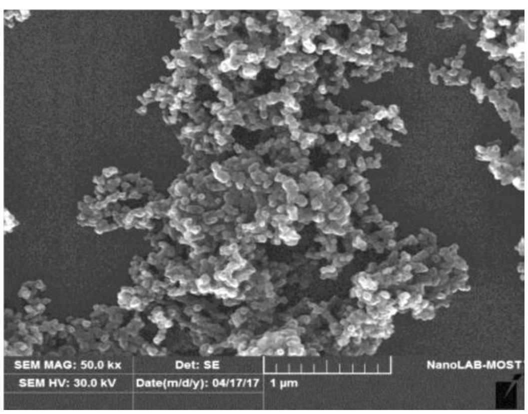


Figure 1. SEM of nano-BN powder.

2.2 Preparation of Matrix Material and its Composite

For the Preparation of composite materials, the zinc alloy was melted in a graphite crucible using a gas furnace to about 700 °C (above its melting point) to ensure full melting [11]. The molten material was mixed using a mechanical stirrer to get a homogenous mixture. Flux cleaning (KCl-NaCl- NaF) with weight percentage 0.25% were used which usually richer in chlorides to facilitate wetting of the oxide inclusions for easier separation from the melt. The melt was degassed utilising hexachloroethane to remove the impurities and gases [12]. The reinforcement BN nanoparticles with different weight percentages were added to the melted matrix as packaged in aluminum foil and continuously stirred using a mechanical stirrer for 2-3 times and speed 1000-1200 rpm. To get a regular mixing of particulate reinforcing material in the matrix. The slag was removed, and then the molten material was poured into a cylindrical graphite mold (permanent mold casting) for casting, and the temperature was gradually lowered. Figure (2) and figure (3) show the mold preparation and sketch of the mold with dimensions, respectively.

Figure 2. Mold preparation

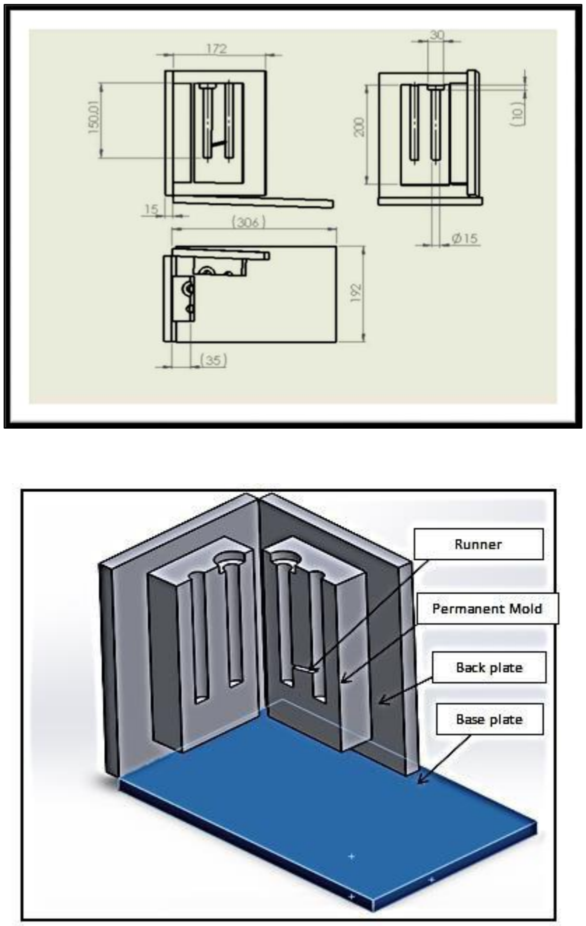


Figure 3. Sketch of the mold with Dimensions. (All dimensions are in mm)

2.3. Hardness:

Hardness test was carried to the base metal and its composites using standard Vickers hardness test machine. Vickers hardness test was indicated the effect of weight fraction of the particles on the matrix hardness. Loads that applied are 0.2kg at 10 sec. And the indenter used was a square-based diamond pyramid.

2.4. Tensile test:

The tensile test was performed on cylindrical specimens. Through the analysis, a uni-axial load was applied to both ends of the sample. The specimen's dimensions were according to the standard sample of tensile test ASTM E82. The dimensions of tensile specimens are shown in figure (4).

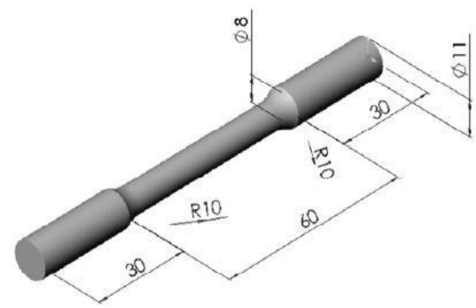


Figure 4. Tensile specimen's dimensions according to (ASTM E82) (All dimension are in mm).

2.5. Microstructure:

An optical microscope was used to study the microstructure of zinc alloy and its composites. The samples are etched using 200 gm CrO_3, 15 gm Na_2SO4, 1000 ml H_2O [13].

3. RESULTS AND DISCUSSION

A. Microhardness measurement:

The value of Vickers microhardness is given in figure (5). The results indicate that the hardness of matrix material and its composite increased when increasing the weight percentage of nanoparticles. The presence of hard reinforcement BN particles increase the load-bearing capacity of the composite material and also limit the matrix deformation by impeding the movement of dislocation. The maximum value of hardness was observed at 8% BN weight fraction.

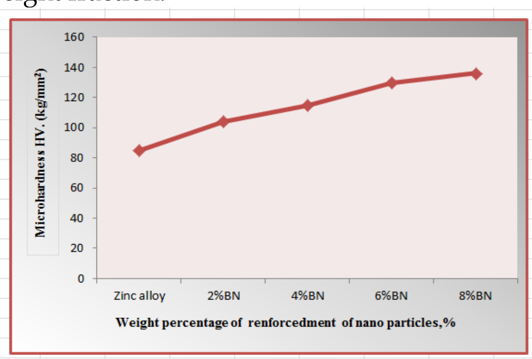


Figure 5. Microhardness values of zinc alloy and its composites.

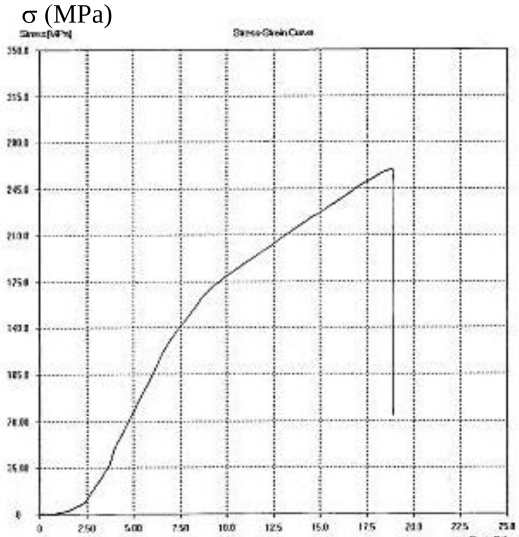
B. Tensile Test:

The strength has prime importance in engineering design, as the ultimate tensile strength (UTS), yield strength and modulus of elasticity. ASTM standardized testing method was used to determine most of these properties. Table (II) shows the fabricated tensile strength values of zinc alloy and its composites. Mechanical properties (**σ**T) are reported. Figure (6) depicts the stress-strain diagram of the fabricated zinc alloy and its composite produced by casting.

Table (II): Tensile properties for zinc alloy and its composites

Materials	Tensile Strength, **σ**T (MPa)
Zinc alloy	254
Zinc alloy + 2%BN	273
Zinc alloy + 4%BN	285
Zinc alloy +6%BN	289
Zinc alloy +8%BN	297

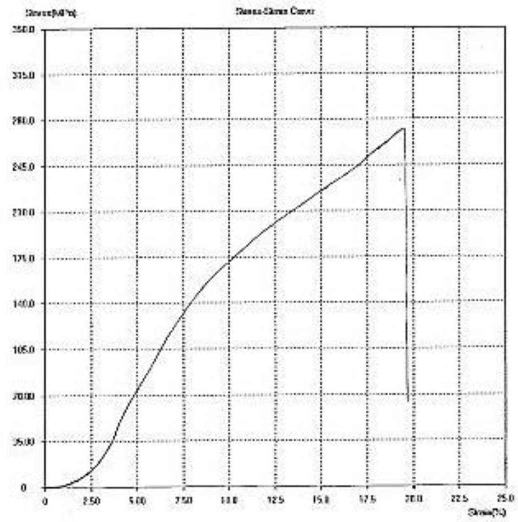
σ (MPa)



ε (%)

A-

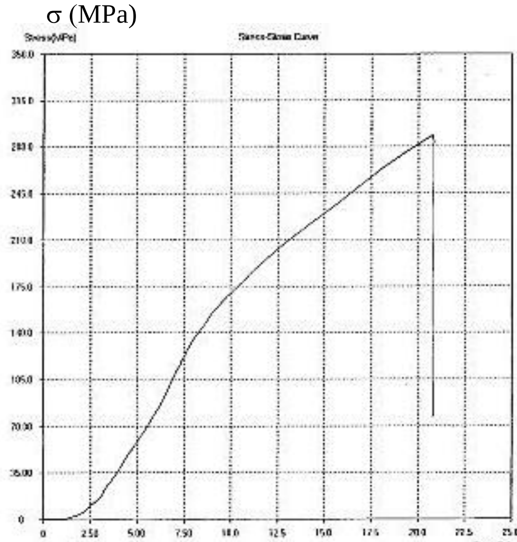
σ (MPa)



ε (%)

B-

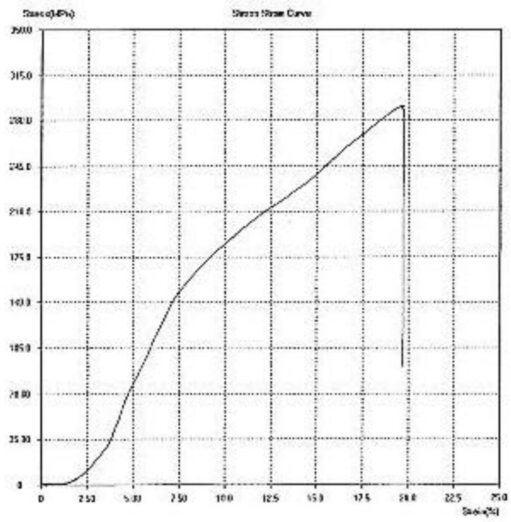
σ (MPa)



ε (%)

C-

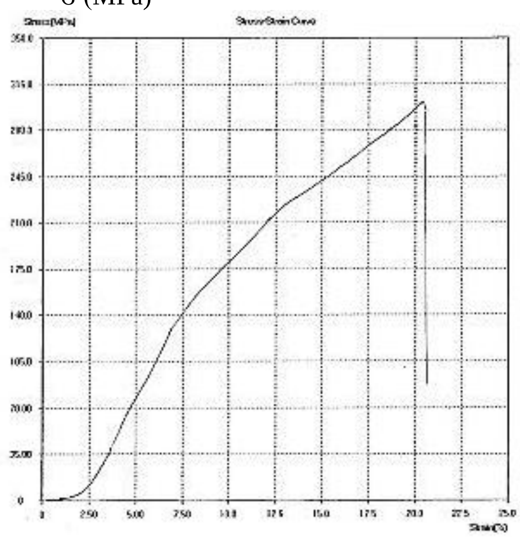
σ (MPa)



ε (%)

D-

σ (MPa)



ε (%)

E-

Figure 6. Tensile strength for nano boron nitrite particles at different weight percentages in ZA-27 alloy- matrix.
A) Zinc alloy
B) Zinc alloy/2%BN C) Zinc alloy/4%BN
D) Zinc alloy/6%BN E) Zinc alloy/8%BN

This figure shows the effect of the additive of nanoparticles on the tensile strength of zinc alloy and its composites. The best composite in tensile strength is zinc alloy/8wt% nano BN, where an increase of 20% than base alloys.

From the above, it is concluded that the UTS of zinc cast composite materials is totally controlled by the reduced particles size, the selection of matrix composition, and increasing the wt. % of particles. An additional enhancement in mechanical properties of zinc alloy based casting composite can be accomplished by adjusted the bonding between the dispersions and matrix, the process parameters of metal treatment and also the decreasing of microporosities in the casting.

In general, the proof stress increases with the particle weight percentage [14]. The distribution of the reinforcements and homogeneity plays a significant role in this property. It is observed that the addition of nanoparticles effects on the tensile strength for all composites due to that the interaction of dislocations with the nation-shearable nano-particles increase the strength level of composite specimens. According to the Orowan mechanism, the nano-particles particles act as obstacles to impede the movement of dislocations near the reinforcing particles in the matrix. This can be improved by the increase in weight per cent of particles.

These results manifest the effectiveness of the particulates in the strengthening of the zinc alloy and enhancement in tensile strength is fundamentally due to grain refinement according to Hall-Petch theory and the confined movement of dislocations in the matrix due to nanoparticles according to Orowan mechanism. The increase of UTS of the composites over the zinc matrix can be concerned to the interaction between the dislocations and particulates within the matrix, and to the grain refinement of zinc with increasing addition of the particulates.

The test results revealed that the tensile strength of zinc composites are mainly depended on the distribution of the particles in the matrix. The increase of tensile values for composites can be attributed to the presence of brittle (BN)p, which may act as a stress concentration area.

C. Microstructure Analysis

The microscopic structure was examined using optical microscopy to study the microstructure and the formed phases using a metallographic microscope. It gave better dispersion of the reinforcement in the matrix was better. Where the reinforcement particles increase and the inter particle space decreases with the rising increase of the There is no sign of the conglomerate of reinforcement in the matrix. The microstructure is dendritic, and the primary dendrites are fragmented because of mechanical stirring that demonstrates the development in the chance of combining and catching nano-sized particles in the interdendritic interface occurring through the solidification of the scattered alloys as shown in Fig. (7).

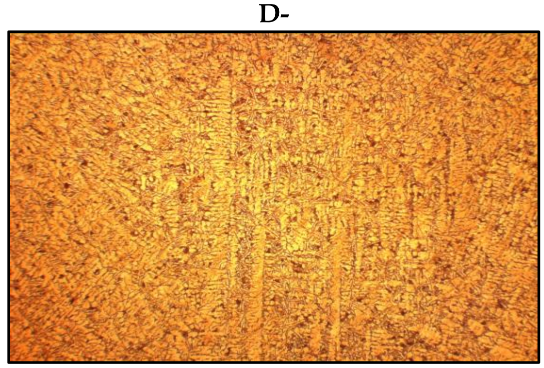
A-

B-

Eutectic α- Al phase **Eutectoid (η + α)**

C-

D-



E-

Figure 7. The microstructure of zinc alloy-matrix with nanoparticles a different weight per cent
A) Zinc alloy
B) Zinc alloy/2%BN C) Zinc alloy/4%BN
D) Zinc **alloy/**6%BN **E)** Zinc **alloy/**8%BN

4. CONCLUSION

From the results have been provided with the following conclusions :

-The nano additive were improved the microhardness with base alloy.

-The zinc alloy composite reinforced with (8%BN) nano composites displayed maximum tensile strength due to the presence of ceramic materials.

-The microstructure of zinc alloy is dendritic structure, and the composites reinforced with nanoparticles observed to be uniform distribution and noting to presence the agglomeration particles. So, enhanced nanoparticles with weight percentage increase the mechanical properties of the composite.

-The nanocomposites were cast successfully with liquid metallurgy technique.

5. REFERENCES

[1] S. S. Owoeye, D. O. Folorunso, B. Oji & S. G. Borisade,, , "Zinc- aluminum (ZA-27)-based metal matrix composites: a review article of synthesis, reinforcement, microstructural, mechanical, and corrosion characteristics", The International Journal of Advanced Manufacturing Technology", Springer Nature, (2018).

[2] W. K. Meyers, "Zinc-Aluminum alloys as tribomaterials", Journal Metals, Vol. 22, No. 4, Dec (2003), p. 259.

[3] S. C. Krishna, M. Bhattacharyya, "Dry sliding wear behavior of reinforced ZA-27 Alloy based metal matrix composites" International Journal of Modern Physics B, Vol. 20, Issue 25-27, (2006), pp. 4703-4708.

[4] Y. H. ZHU, "Microstructure dependence of damping behavior of eutectoid Zn–Al based alloy (ZA-27)", J. Mater. Sci. Tech. , Vol. 15, No.2, (1999).

[5] M. Kaplan, M. Ileriturk, Z. Balalan, "Relationship between microstructure, hardness, XRD and wear performance of cast ZA alloy", Materials and Manufacturing Processes, (2008), pp400-406.

[6] M. Gagné, "Zinc Die Castings for Automotive Applications," SAE Technical Paper 0148-7191, 2011.

[7] S., K.H.W.; Sharma, S.C.; and Girish, B.M. Effect of artificial ageing on the hardness of cast ZA-27/graphite particulate composites. Materials and Design, 16(6), (1995),337-341.

[8] B., M.; Mitrovic, S.; and Ninkovic, R. Tribological Potential of Zinc-Aluminum Alloys Improvement. Tribology in industry, 31(1-2), (2009), 15-28.

[9] R., G.; Sharma, S.C.; Krishna, M.; and Muruli, M.S. , A study of mechanical properties and fractography of ZA-27/Titanium-dioxide metal matrix composites. Journal of Materials Engineering and Performance, JMEPEG, 11(4), (2002), 408-413.

[10] R. David, V. Shrivastava, R. Dasgupta, B. K. Prasad, and I. B. Singh, "Corrosion Investigation of Zinc–Aluminum Alloy (ZA-27) Matrix Reinforced with In Situ Synthesized Titanium Carbide Particle Composites", Journal of Materials Engineering and Performance, Vol. 28, Iss.4, PP.2356–2364, 2019.

[11] ASM Handbook, "Casting ", Vol. 15, (1988).

[12] K., T. S., M. Prasanna K., Basajarappa, S., Vishwanatha, B. M., "Mechanical Properties Of As-Cast ZA-27/Gr/SiC_p Hybrid Composite for The Application of Journal Bearing", Journal of Engineering Science and Technology, Vol. 8, No. 5, (2013), 557 – 56.

[13] N. Shivakumar, V. Vasu, and N. Narasaiah, "Synthesis and Characterization of nano-sized Al2O3 particle reinforced ZA-27 metal matrix composites," Procedia Materials Science, vol. 10, pp. 159-167, 2015.

[14] B. Fatile, B. Adewuyi, and H. Owoyemi, "Synthesis and characterization of ZA-27 alloy matrix composites reinforced with zinc oxide nanoparticles," Engineering science and technology, an international journal, vol. 20, pp. 1147-1154, 2017.

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Sequence operation of automated systems using PLC

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ABSTRACT

A Pneumatic robotic is controlled with compressed air which used in factory in automatic application to speed up the workflow, it's the study of how pressured gases effect on the mechanical motion, and how can use this effect on engineering applications. Pneumatic robot has a simple design and can use cheap materials. Design and implementation a pneumatic system that controlled by PLC which can move in three axis (x, y, z). the system grasps an object from fixed position to another one. Sensors used to control the moving of robot – the needed pressure for the arm to move to the right position - and to avoid arm from collision by any object that intercepts its way. A simulation programs used to simulate the moving of system, solid work form 3D module of system, and automation studio for electro-pneumatic circuits. Three cylinders use in the system, one for vacuum-gripper that hold the object which connected with the cylinder that move in Z axis, the last one connected with cylinder that control the move in X axis A wall intercepts the motion of arm. The main goals of the system are reduce both of time and increase in working accuracy, that goals can checks through finding the shorter distance with shorter time required to complete the required action, that may change when a obstacle used.

KEYWORDS
Automation, PLC, pneumatic system, pick and place, operation.

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1. INTRODUCTION

One of the most important section in manufacturing and distribution is the handling machine because the final product depend on it. Compressed air is suitable in manufacturing production lines. Handling machine do different activities such as movement, holding, sorting, storing and separated of materials.

To reduce the time required in manufacturing factory, material handling machine are use, where more than 80% of time spend by material in waiting or transport in shop floor, that make material handling reduce that time. Pneumatic system has characteristics distinguish it from hydraulic system such as low cost and more safety. Some influential in handling material is important in factory such as reduce of material wastage, breakage and loss. [1]

An automatic pneumatic system used to pick and place the object from one position to another by using three pneumatic cylinder to do this objective. These cylinders provide three-axis movement x-y-z.

A vacuumed gripper used to do the pick function which connected to the cylinder that moves in the z axis. The whole system which includes cylinders and vacuumed gripper works with compressed air which is low cost in addition to safety in the workshop.

Image process robot system that can distinguish between shape and size of parts is needed in many application especially in pick and place operations, A microcontroller will control the pressure regulator that control of pressure required to hold the desired part. Then the object can move very easily as all the weight of the object is balanced by the pneumatic arm[2].

A two figure move can move toward each other by use a parallel jaw gripper that fingers not use to shift the parts by moving independently from each other. Simple operation can be performed by this like open or close. 5/2 way valve are used to flow the compressed air and a pressure reading fixed on dial gauge use to control the desired pressure. A two double acting cylinder are use which controlled by 5/2 way valves that active manually or solenoid electrical circuit. The system work with highly dynamic operation and high acceleration [3].

A camera, sensor ,encoder and information processing system are used to generate a sensor-based system. The vision and infrared sensor outputs are integrated as sequential multi-mode sensors. Conveyer which move parts on it are tracked by the vision system, then pick and place them in to desired place. The speed of conveyor is (max 16 cm/s), where a parts along the conveyor is tracked by the robot. Position and orientation are detected by the vision subsystem of ten different parts. A fuzzy logic controlled the algorithm that control the robotic manipulator, which include a camera image processing unit and end-effector based sensor used to make a robotic manipulator grasp an object on a moving conveyor belt. The actual results indicate a rate in the region of 500 parts/h, therefore the system described is felt to be a significant step forward in material handling technology[4].

A pick and place robot sense an object moving on conveyer, color and shape recognized by camera that send online video to MATLAB so as to analyzed it and recognized the color that may be red, blue, green or black, the conveyer surface is white, also the camera used to find area and corner of the object. The conveyer stop every second to give time to the camera to take online to send it to MATLAB to analyzed. As the motor gets the order it's work to pick and lift the object. a pick and place robot can recognize different object by variety in colors and shapes on moving conveyor[5].

A press machine is face a pick and place automated machine. Unfinished objects must be pressed where they locate in stock. Two arms are used one to pick the unfinished components and the other the finish one. The mechanical structure consists of pneumatic cylinders. A SOLENOID VALVE is used to control the occurrence of each action. The objective is more safety than manual by replacing humans in tasks that involve the hard physical, dangerous environment, also used in tasks that beyond humans capabilities such as heavy load or large object with the economy improvement[6].

2. EXPERIMENTAL WORK

To build the system, four cylinders used to provide the three-axis movement, one for the x-axis, the second and third for the y-axis that holds the forth one to provide the z-axis, the gripper fixed on the third cylinder

A Five-way/two-position single solenoid return spring valve used to actuate each of double acting pneumatic cylinder. The position of the cylinder can be determined through two sensors placed in the end stroke of the cylinder.

Siemens Sematic S7 1200 PLC used to control the system -cylinder pressure needed to move to the desired position also pressure for the vacuum gripper to pick or place the object- by programmed the electro-pneumatic circuit using a ladder diagram.

The operation sequences of three paths are shown in the tables 1,2 and 3, that describe the logic number of sequences need from pick object from its position till place it in the final destination with description for each one. Different paths are implemented and find with different time of movement by the system. The best path of movement that gives faster movement with less time was found by building a simulation prototype for the system and compare between those paths.

Table 1: Sequences of path 1

Sequence	Actuators			
	A	B	C	D
1	0	0	0	1
2	0	1	1	1
3	0	0	0	1
4	0	0	0	0
5	0	0	0	0
6	0	0	0	1
7	1	1	1	1
8	1	0	0	1
9	1	0	0	0
10	0	0	0	0

Cylinder D is operated (on) and extracted forward in Z-direction above piece position, cylinders B&C are moved (on)downward in Y-direction with pick the piece by vacuum gripper. After picking the piece from its initial position both cylinders B&C return upward(off) and cylinder D is still (on) forward, then after the two cylinders B&C reach their end position, cylinder D is retracted (off), after that cylinder A is moved (on) in X-direction and still until the piece will placed in another position.

Cylinder D is operated (on) and extracted forward in Z-direction above piece´s second position, then cylinders B&C are moved (on)downward in Y-direction and release the piece by vacuum gripper to place it in the end position. Both cylinders B&C will be retracted(off) once the piece is released, then cylinder D is retracted (off)after placing process. Finally, cylinder A is return (off),and these sequences are repeated again, that was a description for 10 sequences operator, as shown previously in table 1.

Table 2. Sequences of path 2

Sequence	Actuators			
	A	B	C	D
1	0	1	1	1
2	0	0	0	0
3	1	0	0	0
4	1	1	1	1
5	1	0	0	0
6	0	0	0	0

Cylinder D is extracted forward (on) in Z-direction above the piece position while B,C cylinders are moved downward(on) in Y-direction with pick the piece by vacuum gripper . After picking the piece from its initial position both cylinders B&C is returned upward(off) and cylinder D is returned backward (off), then cylinder A is moved (on) in X-direction and still moving until the piece will be placed in another position. Cylinder A is still (on),and cylinders B,C moved downward(on) and D is extracted forward (on). All D,B, and C cylinders are retracted (off) with release the piece in the end position. Cylinder A is retracted(off),then all previous sequences are repeated again, that was a description for 6 sequences operator, as shown previously in table 2.

Table 3. Sequences of path 3

Sequence	Actuators			
	A	B	C	D
1	0	1	1	1
2	1	0	0	0
3	1	1	1	1
4	0	0	0	0

Cylinder D is extracted forward (on) in Z-direction above the piece position while B,C cylinders are moved downward(on) in Y-direction with pick the piece by vacuum gripper . After picking the piece from its initial position both cylinders B&C is returned upward(off) and cylinder D is returned backward (off) and through that cylinder A is moved(on) in X-direction. Cylinder A is still (on),and cylinders B,C moved downward(on) and D is extracted forward (on) with release the piece to place it in the end position. All A, B,C, and D cylinders are retracted (off) AND all previous sequences are repeated again, that was a description for 4 sequences operator, as shown previously in table 3.

As mentioned earlier, four cylinder (double acting pneumatic cylinder) are used, each one has two sensors for IN and OUT stroke position, with four directional valve (Five-way/two-position single solenoid return spring valve), also (three way /two- -position single solenoid return spring valve). The system components and connection shown in figure (1), and table (4) describe system parts.

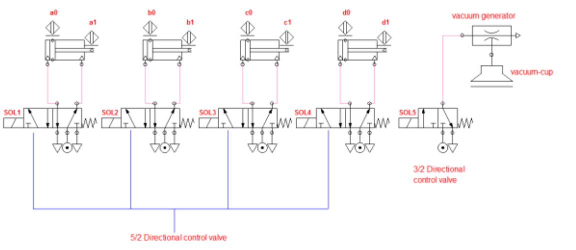

Figure 1: system components and connection.

Table 4: system parts description.

Component symbol	Symbol name	Descreption
A	Cylinder A	Double acting pneumatic cylinder moving in X-axis.
B	Cylinder B	Double acting pneumatic cylinder moving in Y-axis.
C	Cylinder C	Double acting pneumatic cylinder moving in Y-axis.
D	Cylinder D	Double acting pneumatic cylinder moving in Z-axis.
Ao	Sensor1 for A	Sensing initial position of cylinder A (In stroke A-).
Bo	Sensor1 for B	Sensing initial position of cylinder B (In stroke B-).
Co	Sensor1 for C	Sensing initial position of cylinder C (In stroke C-).
Do	Sensor1 for D	Sensing initial position of cylinder D (In stroke D).
A1	Sensor2 for A	Sensing end position of cylinder A (Out stroke A+).
B1	Sensor2 for B	Sensing end position of cylinder B (Out stroke B+).
C1	Sensor2 for C	Sensing end position of cylinder C (Out stroke C+).
D1	Sensor2 for D	Sensing end position of cylinder D (Out stroke D+).
SOL1	Directional valve of cylinder A	5/2-way-position operating of cylinder A.
SOL2	Directional valve of cylinder B	5/2-way-position operating of cylinder B.
SOL3	Directional valve of cylinder C	5/2-way-position operating of cylinder C.
SOL4	Directional valve of cylinder D	5/2-way-position operating of cylinder D.
SOL5	Directional valve of vacuum gripper	3/2-way-position operating of vacuum gripper.

3. RESULTS

The main goals of the system are reduce both of time and increase in working accuracy, that goals can checks through finding the shorter distance with shorter time required to complete the required action.

Single cylinder need for 0.3 second to operate because the 5/2 valve need 0.3 second to change from one position to another, that mean time between one cylinder and other 0.3 second. The valve that connected with vacuum gripper need 0.2 second to change from one position to another because of use 3/2 valve.

That sequences and different between valves operating gives the required results that need to minimize the time required to increase the system productivity, also increase the number of parts handling.

To verification in increase in profits and minimize in time we need to decrease in sequences need to operate the system, such as power ON more than one cylinders in the same time to reach the desired position, that mean increase in profit, and number of parts handling when compared with larger sequence, as shown in figures 2.3 and 4 that show time needed for 3 paths and show the difference between them.

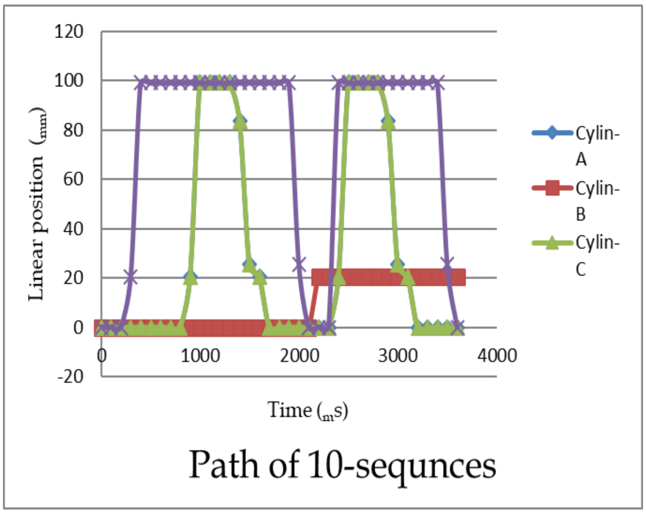

Figure 2: path for 10 sequences (Distance with respect to time)

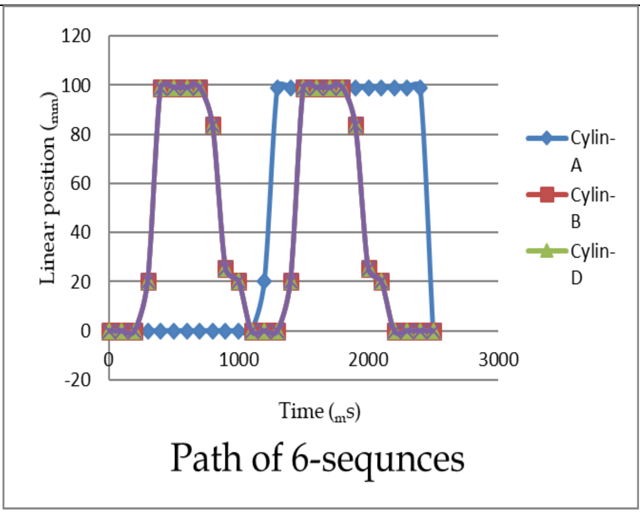

Figure 3: path for 6 sequences (Distance with respect to time)

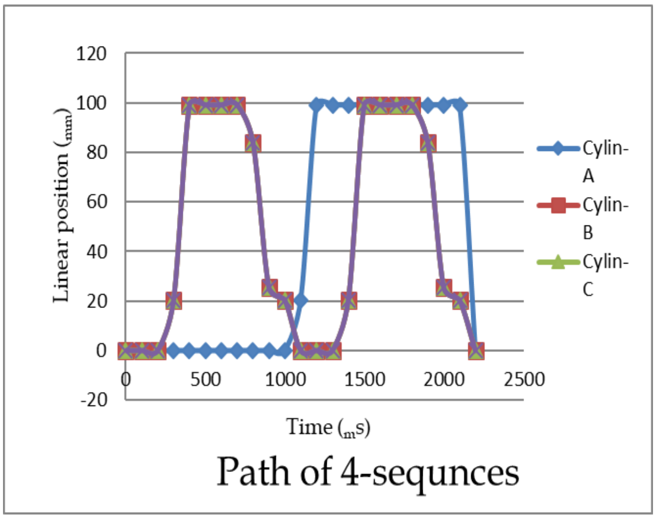

Figure 4: path for 4 sequences (Distance with respect to time)

4. CONCLUSION

Times approximately between paths 1, 2 and 3 are 3.6 second, 2.5 second and 2.2 second sequentially, this results for ideal system (simulation) to reach this results calculate them in real. This times may change if any objects (barrier) objections motion path.

5.REFERENCES

[1] A. Jahid, S. Mustakim, S. Sahil, S. Shaibaz, and V. D. Londhe, "SIX AXIS PNEUMATIC MATERIALS HANDLING ROBOTIC ARM," pp. 3955–3959, 2018.

[2] S. S. Dinde, S. M. Kawale, Y. T. Parkhe, and S. R. Shaikh, "Pneumatic Arm Control Using Microcontroller," vol. 6, no. 4, pp. 681–683, 2016.

[3] M. Khadeeruddin, T. V. S. R. K. Prasad, and R. Mohammed, "Design & Analysis of a Two-jaw parallel Pneumatic Gripper Abstract :," vol. 03, pp. 41–46, 2013.

[4] I. Macadios, "litis r," 2000.

[5] S. Kazemi and H. Kharrati, "Visual Processing and Classification of items on Moving Conveyor with Pick and Place Robot using PLC," *Intell. Ind. Syst.*, pp. 1–7, 2017.

[6] O. K. Sastr, S. B. Hampapur, and S. S. Kamat, "Automated Pick and Place System l," no. Icmet, pp. 682–686, 2010.

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A Simplified model of the electro-pneumatic position control system

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ABSTRACT

This paper deals with simplified electro-pneumatic position control system involves double acting pneumatic cylinder steering by directional control solenoid valve. The suggested control system requires to build a test rig includes combination of pneumatic instruments associated with electrical control circuit and distance sensor to ensure that the piston of the cylinder will stopped at the desired position. In this work the mathematical models of the cylinder and the solenoids valves in the pneumatic system have been calculated based on their related parameters and the simplification in the obtained models has been carried out under assumption of neglecting some unaffected parameters in the pneumatic system leading to create the simplified position control model. A comparison between practical and simplified position control model has been done via simulation process using Matlab software environment to investigate the results of each model with different set points of the stroke distance. The obtained results of the simplified position control system are quite similar to the results of the typical model with very small tolerances.

KEYWORDS

Electropneumatic system, position sensor, solenoid valve, proportional controller

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1. INTRODUCTION

Pneumatic control system behaves as an interconnection of components to form the control system configuration that provides a required system response. This involves the basic mathematical model that depends on the foundation of the linear system. Therefore, to obtain a linearity of the pneumatic system, it demands to carry out some assumptions that neglected some effects of the components in the system. Frequently, lot of e electro pneumatic control systems have been set up in the applications of economic automation systems because of the low-cost pneumatic and electrical components that are used to work in (on/off) industrial applications [1, 2].

Actually a very large development of the electro pneumatic systems are conducted due to the wide improvement in electrical control systems, such as sensors, controller units and mechatronic devices [3, 4].

Pneumatic systems are used in many engineering applications which have been energized and worked with compressed air source or may be compressed gases such as nitrogen and driven by various pneumatic equipment involving motors, valves and cylinders. The basic principle of the pneumatic systems is very similar to the hydraulic system, but the major difference can be observed in the two systems was that in the hydraulic system depends on the liquid energy instead of gas to provide the necessary mechanical forces [5, 6].

The main objective in the suggested work is to realize the purpose of the simplified position control pneumatic system. This includes building a laboratory test rig as prototype test bench and containing the electro-pneumatic devices in addition to the position sensors to achieve the position control action of the actuator. The suggested control system was mathematically modeled and the obtained approximation model of system has been taken into account with using different parameters of the system and without changing the physical construction. Matlab simulation process of the position control model has been implemented to observe the best behavior of the suggested system

The current paper has been arranged as in the following; the details of the electro-pneumatic system are presented briefly in the second section.

The construction of the pneumatic position control model and the simulation results of the simplified model are introduced in the third and fourth sections following by the remarked conclusions.

2. PROCEDURE

2.1 The Construction of the Electropneumatic Position Control System

Basically, the proposed pneumatic position control system includes directional control pneumatic valve with two solenoids, pneumatic cylinder in addition to controller circuit interfacing with position sensor as described in figure (1).

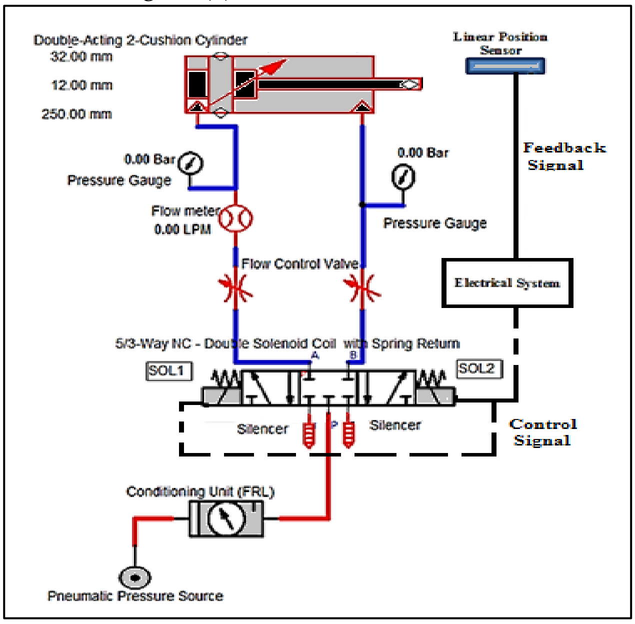


Figure 1. The Schematic Layout of the Electro-pneumatic Position Control System

The pneumatic system is also included some accessories which represented by pneumatic pressure gauges, air flow control valves and rate meter beside air filters. The main purpose of these devices is to provide clean and safety maintenance process of the applied system. The piston rod of the double acting cylinder can be moved in dual direction either to the forward or backward direction, this motion is depended on the incoming electrical signal from the controller unit and reached to the determined solenoids valve. The piston rod of the cylinder is stopped when reached the desired point which has set up in the controller unit.

In the pneumatic system the source of the air pressure represented by air power unit which included compressor driven by (AC) electric motor. The required flow of air pressure was controlled and regulated through directional and pressure regulator valves and it passes to the various devices of the pneumatic system through pipes and hoses. The pneumatic cylinder was mounted horizontally and the rod of the cylinder was connected with the position sensor using mechanical

Linked as mentioned in figure (2).

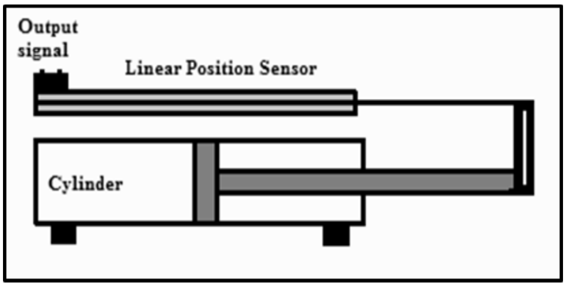


Figure 2. The Mechanical Connection of Position Sensor with Cylinder rod

The position sensor converts the displacement in the stroke of the cylinder rod into proportional electrical signal and sends it in feedback loop to the main controller unit in the electrical subsystem.

In proposed pneumatic circuit; the employed solenoid valve represents the basic part of the control process for the direction of the pneumatic actuators. The solenoids were interfaced with the controller unit through the position sensor as in figure (3).

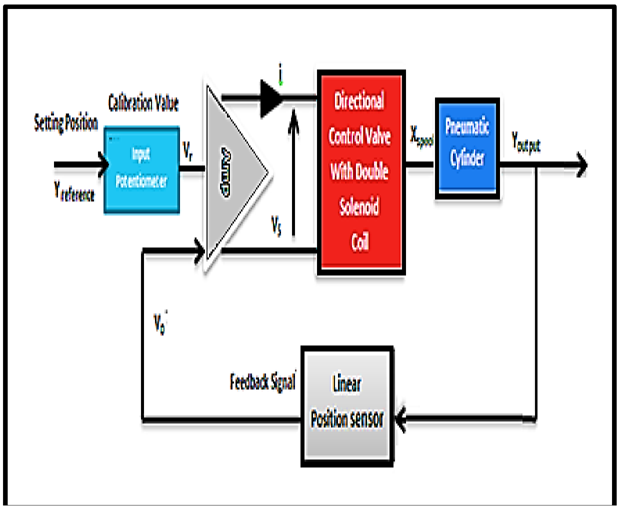


Figure 3. The Schematic of Control Diagram Pneumatic Solenoid Valve and Position Sensor

In the suggested position control system the electrical subsystem was including electrical energy and controller circuits in addition to the driving circuit of the solenoids valves. The electrical energy supply circuit contains relays, fuses, overload protection unit and several electrical elements such as switches that are all electrically wired and the feedback signal which sends from the position sensor to the controller unit will be compared with the reference value of set point that represented the measured distance to stop the rod of cylinder in the forward direction motion. If the value of the feedback signal is equal to this set value then the controller unit will cut off the solenoid coil and the control circuit will provide the backward motion of the rod of the cylinder to the started original position. The layout of the electronic circuit of the controller unit including the linear position sensor can be depicted as in figure (4).

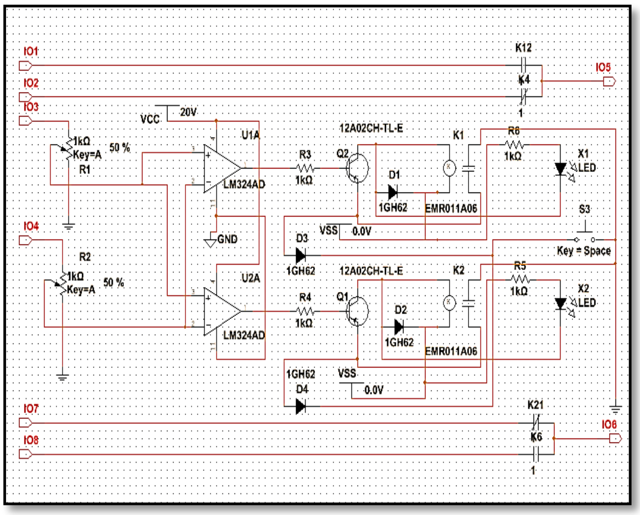
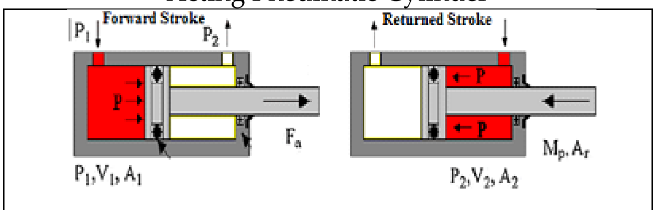


Figure 4. The Layout of the Position Controller Unit (Electronic board)

2.2 The Mathematical Models of the Simplified Position Control System

The mathematical models of the simplified pneumatic position control system has been obtained according to the characteristics of the pneumatic cylinder and the directional solenoids control valves. To obtain the corresponding transfer functions for these elements; the employed characteristics of the pneumatic cylinder including the physical parameters such as the air flow through the cylinder as well as the solenoid valve has been taken into account in the description of the mathematical model. These parameters are listed as shown in table 1 concerning with the suggested systems.

Table (1) the Applied Characteristics of the Dual Acting Pneumatic Cylinder



Area of the piston	A_P= (804.24 mm²)
Area of the piston rod	A_r = (691.1 mm²)
Mass of the Piston rod	m_p = (0.532 Kg)
Air pressure source	Max pressure =(12×10⁵ Pa)
Cylinder viscous coefficient	C=(100 Nm/s)

Starting with calculating the developed force obtained by the cylinder rod in the forward and backward stroke direction as shown in the following equations [6-9]:-

$$M\ddot{y} + B\dot{y} + F_f = P_1A_1 - P_2A_2 - P_{atm}A_r \quad (1)$$

$$M\ddot{y} + B\dot{y} + F_f = P_2A_2 - P_1A_1 - P_{atm}A_r \quad (2)$$

Where

$A_1 = \frac{\Pi}{4} * D^2$ = Area of the cylinder piston in forward direction. (3)

And

$A_2 = \frac{\Pi}{4} * (D^2 - d^2)$ = Area of the cylinder piston in backward direction. (4)

$$V = {}^{Q}/_{Ai} \quad (5)$$

$$\dot{m} = \rho * Q \quad (6)$$

Where

D= Diameter of the cylinder rod.

d =the diameter of the return rod of the cylinder.

Q = Air flow rate enters the cylinder.

ρ= the density of supply air.

M =the value of mass.

B = the damping factor.

F= the constant factor of the external force and it can be neglected because it is equal to zero.

The air pressure in chamber of the cylinder was approximately determined as in the following equations:-

$$\dot{P}_1 = \frac{K}{A_{Py}}((\dot{m}_1T * R) - P_1\dot{V}_1)) \quad (7)$$

$$\dot{P}_2 = \frac{K}{A_{r(L-y)}}((\dot{m}_2T * R) - P\dot{V}_2)) \quad (8)$$

Where:

$\dot{m}1, \dot{m}_2$ = value of mass flow in two chambers 1 and 2.

T = Temperature of the supplied air.

k = Ratio of air specific heat.

R = Gas constant.

If the air circulating inside the cylinder is assuming that an ideal gas, then the transfer function of the cylinder will be calculated as in equation (9):-

$$\frac{y(s)}{x(s)} = \frac{(C_x/Ap)}{(\frac{1}{W_n{}^2}s^3 + \frac{2*\zeta*s^2}{w_n} + s)} \quad (9)$$

Where $y(s)$ represents the stroke distance of the rod of the cylinder while $x(s)$ represents the spool displacement of the solenoid valve. The natural frequency (Wn) and damping ratio (ζ) of the pneumatic cylinder can be calculated as shown in the following [9]:-

$$(w_n)c_{yl} = \sqrt{\frac{2(A^2*ka*P_i)}{(M*V_c)}} \quad (10)$$

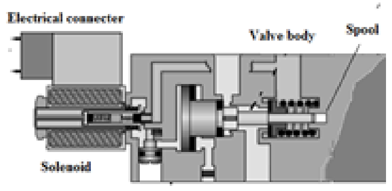
$$(\zeta)c_{yl} = (\frac{c_f}{2A})(\sqrt{\frac{V_c}{2(M*k*P_i)}}) \quad (11)$$

Where (Vc) represents the calculated volume of cylinder while (c_f) represents the viscous friction factor of the pneumatic cylinder.

As a sample of the mathematical calculations if the value of the air flow rate is setting equal to 6 (l/min), then the damping ratio and natural frequency will being 1.216 and 82.18(rad/s) respectively for the set position point equal to 10 cm.

The solenoid valve can be mathematically modeled into electromagnetic part and mechanical part based on the applied characteristics of the solenoid valve that listed in table (2).

Table (2) Applied Parameters of the Pneumatic Directional Control Solenoid Valve [9]



Item	Description	Value
L	Inductance of the solenoid coil	0.98H
R	Resistance of the solenoid coil	230.77Ω
Kc	The coil force coefficient	1.3 N/A
mp	Mass Spool of the solenoid	10 g
C	Damping Coefficient	0.01N/(m/s)
K	Spring Stiffness	75N/m

Hence, the obtained differential equations of the solenoid valves can be written as in the following [10, 11]: -

$$m\ddot{x} = (F_m - c\dot{x} - kx) \quad (12)$$

$$(m\ddot{x} + c\dot{x} + kx + F_f) = F_m = k_{coil}\, i(t) \quad (13)$$

Where

(x) represents the position of the spool,(F_m)represents the magnetic force,(k) represents the stiffness constant of the spring, (c) represents the damping factor , (F_f) represents the coulomb friction factor and it can be neglected while (k_{coil}) represents the force coefficient of the coil and i(t) represents the supplied electric current to the solenoid coil.Taking Laplace transformations for the equation (13) with assumed the initial conditions equal to zero, then

$$(s^2m * x(s) + sc * x(s) + k * x(s)) = k_{coil}\ I(s) \quad (14)$$

Hence, the transfer function of the directional control solenoid valve will be calculated as shown in the following equation [10]:-

$$\frac{x(s)}{I(s)} = \frac{k_{coil}}{(ms^2+cs+k)} \quad (15)$$

3. SIMULATION PROCESS RESULTS

The Simulation process of the position control system has been done depending on using the mathematical models with the obtained transfer functions of the pneumatic position control system as described in figure (5)[12]. As the feedback voltage signals reach the controller unit from the position sensor, it will be compared with the reference voltage signal value of the set point in order to stop the rod of cylinder. If the feedback signal is equal to the set value of the voltage signal then the error between these values will be equal to zero and result in controller unit will be turned off the solenoid coil and stop action of the cylinder rod motion. The controller unit is also returned the rod of the cylinder in backward motion to the start point of its position.

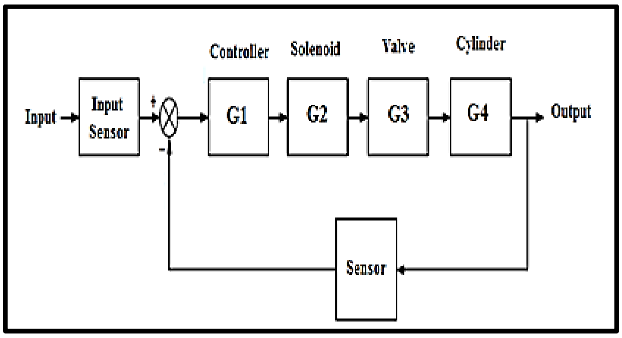


Figure 5. The Proposed Electropneumatic Position Control System

In suggested control system, the following transfer functions will be determined:-(G1) which represents the transfer function of the proportional controller unit and it is equal to (Kprop) (G2) represents the transfer function of the solenoid coil and it is equal to $(\frac{1}{Ls+R})$ and (G3) represents the transfer function of the directional control valve = $\frac{k_{coil}}{(ms^2+cs+k)}$Also (G4) represents the transfer function of the pneumatic cylinder = $[\frac{C_x/Ap}{s(\frac{1}{Wn^2}s^2+\frac{2*\zeta*s}{wn}+1)}]$.To make a simplification of the previous transfer functions G2, G3 and G4 respectively in the obtained mathematical models it can be noticed that:- The transfer function (G2) will be approximated to (G2 = $\frac{1}{R}$) since the value of the inductance reactance (XL) is much smaller than the value of the resistance (R coil).

The transfer function of the directional control valve (G3) will be G3= $[\frac{k_{coil}}{k}]$ because of the mass of the spool of the valve is very small and it can be neglected. The values of the natural frequency as well as the damping ratio of the pneumatic cylinder can be neglected leading to simplify the transfer function G_4= $[\frac{C_x/Ap}{s}]$.

Therefore, the block diagram of the simplified position control system will be redrawn as in figure (6).

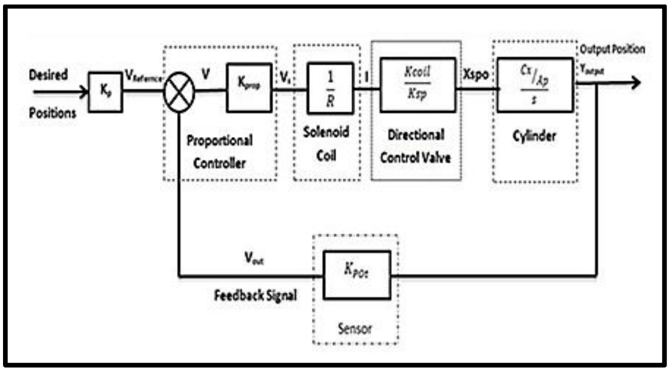


Figure 6. The Simplified Block Diagram of the Position Control System

With taking the transfer function (Kpot) of the sensor then the relation between overall output and input in the position control system will be:-

$$\frac{y_o(s)}{x_{ref}(s)} = \frac{Ksys}{1+Ksys*K_{pot}} \qquad (16)$$

Where

$$K_{sys} = \frac{K_{coil}*C_x*K_{prop}}{R*Ap*k*s}$$

The overall transfer function of the simplified position control model will be calculated as shown in the following:-

$$\frac{y_o(s)}{x_{ref}(s)} = \frac{\frac{K_{coil}*Cx*Kprop}{R*Ap*k*s}}{1+\frac{K_{coil}*Cx*Kprop*Kpot}{R*Ap*k*s}} \qquad (17)$$

$$\frac{y_o(s)}{x_{ref}(s)} = \frac{K_{coil}*C_x*K_{prop}}{(R*Ap*k)s+K_{coil}*C_x*K_{prop}*K_{pot}} \qquad (18)$$

It can be noticed from the obtained transfer function of the simplified model that the response of the position control system depends on several parameters such as the value of the electrical resistance of the coil of the solenoid, the damping coefficient of the solenoid, the force coefficient of the coil as well as the gain factors of the proportional controller as in figure (7).

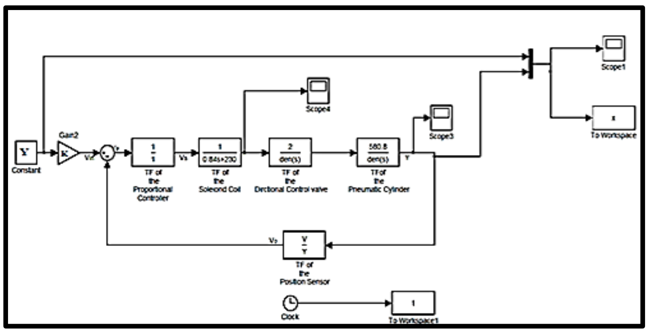


Figure 7.The Simplified Control Pneumatic Position Model

The process of simulation of the simplified Simulink position control model in Matlab software package will be started with set point determined equal to (10cm) with equal to (6 l/min) and the process will be again repeated with taken another value of air rate flow equal to (15 l/min). The results of the step response input for the control system will be appeared as in figures (8) and (9) respectively.

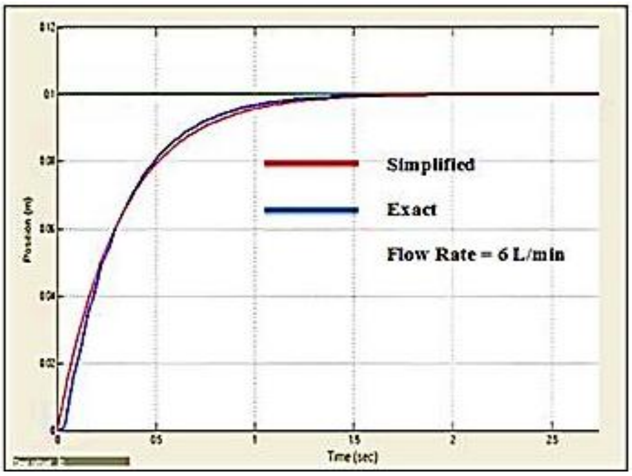


Figure 8. The Step Input Response of the pneumatic Position Control System
(Set point=100mm) and (air flow rate=6 l/min)

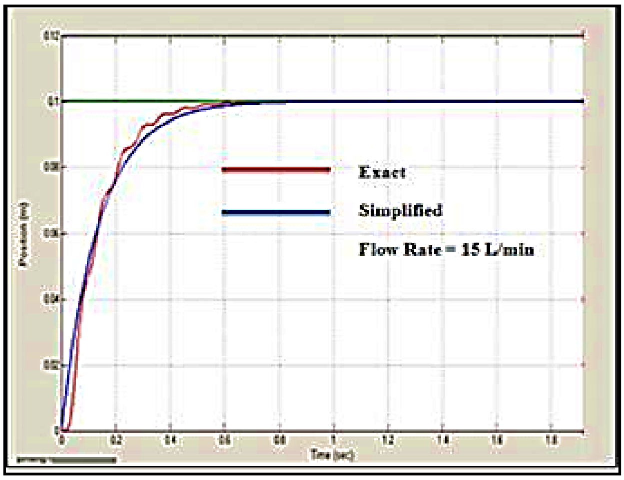


Figure 9. The Step Input Response of the Pneumatic Position Control System
(Set point =100mm) and (air flow rate =15 l/min)

To make another attempt of testing the flexibility of the proposed position control model another set point was selected equal to (20cm) with two values of air flow that previously determined and the obtained results are displayed as shown in Figures (10) and (11).

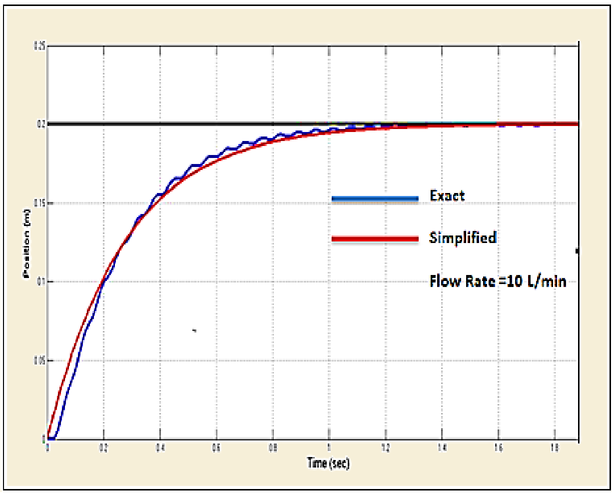


Figure 10. The Step Input Response of the pneumatic Position Control System at set point (200mm) and air flow rate equal to (6 l/min)

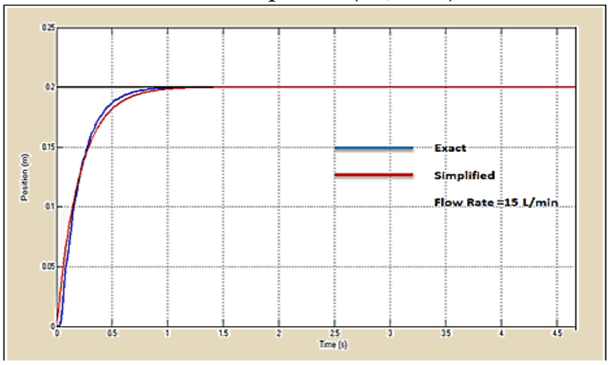


Figure 11. The Step Input Response of the Pneumatic Position Control System at set point (200mm) and air flow rate equal to (15 l/min)

In the experimental work, the equipment of the suggested position control system required to set up the electro-pneumatic equipment are connected in test rig which had done in the control laboratory of the Mechanical Department in the college of engineering of the Mustansiriyah University as depicted in figure (12).

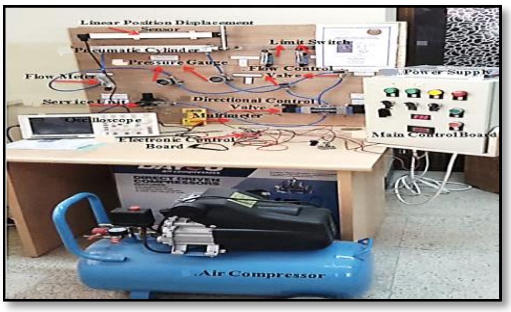


Figure 12. The Laboratory Test bench of the Position Control System

In calibration process of the position sensor, the simulation of motion for the sensor was done with applied different values of (DC) voltage signals. The theoretical and the obtained practical results of the calibration process will be listed as in table 3.

Table 3: Calibration Results of the Employed Position Sensor

Steps	Equivalent Length (cm)	Resistance (kΩ)	Voltage (v)
1	1	0.56	1.399
2	6	1.39	3.994
3	9	1.91	5.389
4	10	2.16	6.38
5	12	2.46	7.75
6	13	2.6	8.5
7	14	2.8	9.22
8	15	3.01	10.23
9	17	3.36	11.78
10	20	4.40	12.8

The laboratory results of the applied pneumatic position control system with using linear position sensor are listed as in table 4. The obtained practical results also included the measured values of the corresponding speed for the rod of the pneumatic cylinder with the calculated values of the settling time.

Table 4: Experimental Results of the Pneumatic Position Control System

Air Flow rate (L/min)	Air Flow rate (m^3/min)	Velocity of rod (m/s)	Position of rod (m)	Settling Time (sec)
0	0	0	0	0
4.5	0.0045	0.093	0.2	3.45
6	0.006	0.12	0.2	3
7	0.007	0.145	0.2	2
8	0.008	0.165	0.2	1.8
10	0.01	0.207	0.2	1.62
11	0.011	0.228	0.2	1.4
12	0.012	0.248	0.2	1.22
15	0.015	0.311	0.2	0.73

4. CONCLUSION

The main objective of this work is to achieve a simplified model of the pneumatic position control system based on using low cost pneumatic components such as (ON/OFF) type of solenoid directional control valve instead of proportional or servo valve types. According to the practical and theoretical results, It can be concluded the following remarks:-

1-The suggested design depends on using the linear position sensor as a measurement device for the stroke displacement of the cylinder rod. This process has been done to meet the demand of the high accuracy of the controller unit and to gain more convince experimental results.

2-Simulation process has been carried out via Matlab software environment for analyzing the performance of the position control system and to compare with practical results.

3- The mathematical models of the simplified pneumatic control model has been obtained and it can be noted according to the calculated simulation results there is no difference between practical and simplified model.

4- The percentage error between the simulation results in practical and simplified position control models is near to zero and the efficiency of the simplified control model equal to 100%.

5. REFERENCES

[1] Roland S.Burns "Advanced Control Engineering "First published University of Plymouth, UK, (2001).

[2] Anthony Esposito "Fluid Power with Applications", USA: Miami University, Oxford, USA, (2009).

[3] Kyoungkwan Ahn and Shinichi Yokota "intelligent switching control Pneumatic actuator using on/off solenoid valves", ELSEVIER Mechatronics, (2005), pp. 683–702

[4] Robert B. and Gary "Accurate Position Control of a Pneumatic Actuator Using On/Of Solenoid Valves", IEEE/ASME, Transactions on Mechatronics, 2 (1997), pp.683-702.

[5] M. F. Rahmat, et.al "Review on Modeling and Controller Design in Pneumatic Actuator Control System", International Journal on Smart Sensing and Intelligent Systems, 4 (2011), pp.633-660

[6] Michael Brian Thomas, "Advanced Servo Control of a Pneumatic Actuator ", Ph.D. Thesis, the Ohio State University, (2003).

[7] Mohsen Heydari Beni, et.al." Dynamic Modeling and Simulation of Control System for Pneumatic Servo Valve Using Piezoelectric Actuator "Ciência e Natura, Santa Maria, 1 (2015), pp.153−16.

[8] Z.G. Zhang, G. Shi, S. Wang, X. Fang, X. Liu, Thermal energy storage cementmortar containing n-octadecane/expanded graphite composite phase

changematerial, Renewable Energy, (2013)pp. 670–675.

[9] M. F. Badr, Yahya Abdullah, Ahmed Kadhiam Jaliel, Position control of the pneumatic actuator employing ON/OFF solenoids valve. International Journal of Mechanical Engineering and Mechatronics, 2(2017), pp. 29-37, IJENS publishing.

[10] Boylestad, R.L" Introductory circuit analysis" Pearson New International Edition, (2013).

[11]M. F. Badr, "A Simplified Method for Energizing the Solenoid Coil Based on Electromagnetic Relays. ARPN Journal of Engineering and Applied Sciences", 22(2018), pp. 8750-8754, Asian Research Publishing Network (ARPN).

[12] Houpis, C H and S N Sheldon, "Linear control system analysis and design with MATLAB", Sixth Edition, CRC Press, (2013).