Modeling and Managing of Random and Sudden Demand of Inventory

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Abstract

Inventory management represents an important factor for any company or enterprise because it is the key of the market competition feature. Owning a high stocks or stock less than the limit required, represents a challenge for the companies and enterprises, especially in light of exigent circumstances may meet. It is increasingly important when the demand becomes sudden and outside the ordinary situations. The main objective of this study is to model and manage the inventory when the demand of product is sudden (unexpected) and how the company and enterprise can deal with it in case if there is a limit time for delivery which affects the company work and required additional cost for overtime work. So, a general visual basic computer program was designed and tested to control and manage the inventory in all conditions (i.e. normal and emergency). The program was verified on a case study which is the Jordan Chalk Manufacturing Company. The results of the program implementation on the case study have shown that the program can deal with all cases of inventory successfully and efficiently.

Keywords: Demand, Lead time, Safety Stock (SS), Reorder Point (R) and Order Quantity (Q).

Abbreviations:
SS: Safety Stock
R : Reorder Point
Q : Order Quantity
JD: Jordanian Dinar

Introduction:

One of the inventory purposes is to meet the variation in product demand [1]Inventory serves as: A cushion, as it absorbs fluctuation in supply and/or demand of goods, which could be a challenge for companies and potential in some situation and circumstance, especially when these demands sudden and unexpected or random [2]. Inventory is one of things that can not be

dispensed with in most institutions. The concept of inventory includes the following: the materials and components (raw materials, under processing and finished products) which are industrial enterprises retain and doesn't use it at the present time, but to help them in the implementation of the requests for their customer in the future [3]. Inventory modeling uncertainty may result either from demand or from supply processes within demand and supply sources, this uncertainty can divided into timing and quantity effects [4].

When customers request items, therefore the supplier must response for this demand from current inventory at appropriate time and quantity. This situation ″demand″ may represent a challenge for the supplier especially when it is sudden or random .This work will focus on this case and how the company can deal and manage this situation by another mean, also how the company employs its capabilities to meet these emergency situations? [5]

Components of Inventory Policy (Basic concepts):

Before building any model for controlling inventory there are some elements must be defined and well known, which represent the basic of the mathematical inventory model, which are:-

(1) Demand:-

The Inventory demand represents the number of units of any product which is requested during any specific period. It would be a random variable and a stochastic inventory model would be used [6].

(2) Lead Time:-

A component of inventory model represents the amount of time required by the supplier to meet a customer need. Also this is known as a cycle time [7]. It may be fixed or variable.

(3) Safety Stock (SS):-

Safety stock is an excessive amount of stock that the company keeps it to meet the unexpected demand during the period of supply [8].

It is added as a hedge against stock out when demand is uncertain [9]. Safety stock determines the chance of stock out during lead time and the complement of this chance is called the service level. The higher the probability inventory will be on hand, the more likely customer demand will be met. Service level of 90% means there is a 0.9 probability that demand will be met during lead time and 0.1 probability of a stock out [10].

(4) Reorder Point (R):-

It is the amount of the product that when the inventory level reaches to it. So, a new request of the product must be organized in order to ensure that can arrive before the stock reaches to the safety stock level [11]. In another words the number of items left in inventory when an order is placed [10]. So,

determining a reorder point can help in minimizing the chance of stock out, also reducing the amount of money tied up in inventory.

(5) Order Quantity (Q):-

It is the amount of product to be ordered. Also it represents the number of pieces ordered to replenish the inventory [12].

Inventory Management Program Design and Its Verification:-

A general Visual Basic computer program was built and verified to manage and control the inventory of the normal and emergency situations. This program was verified on Jordan Chalk Company as a study case.

Program Description:-

The program focuses on managing and dealing with inventory of the company during a specific time period and controlling the demand quantity and how these demands could be executed depending on mathematical model which was built for these situations. The collected data from different recourses were formulated in the program. The program was written by visual basic language to facilitate the explanation of every thing related to inventory in addition of processing the data the program will store all data entered to it to be used later on. Figure (1) shows the first step which is a shortcut of the program.

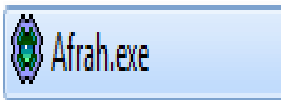

Figure (1): Store Inventory-System shortcut.

This icon represents the shortcut of the program was built which has the name store Inventory-System; to enter just double click on the shortcut icon, as in figure (2).

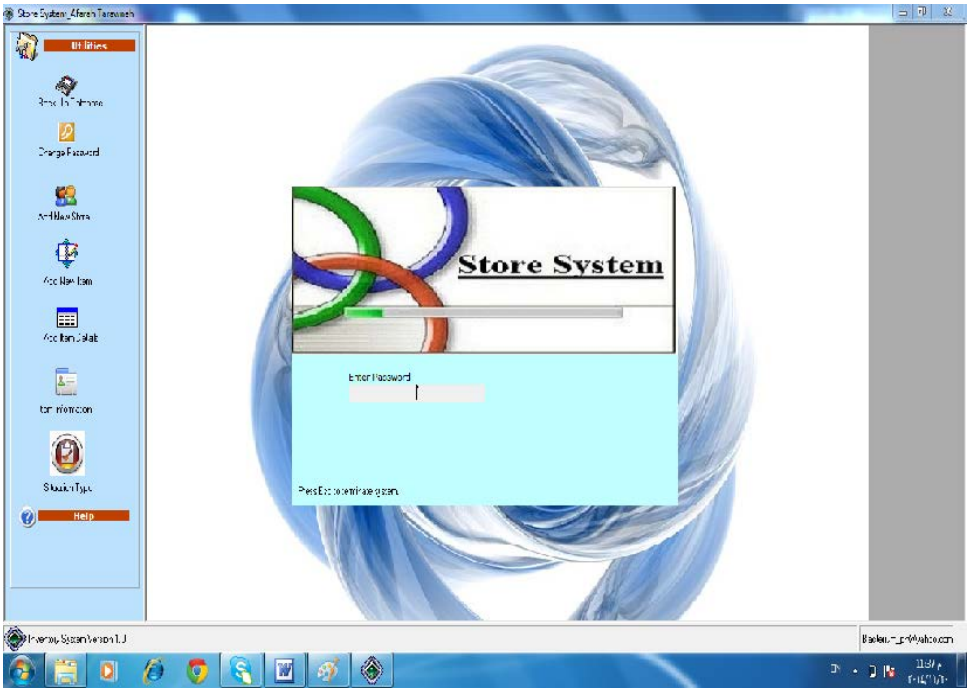

Figure (2): Store Inventory-System window.

After opening the program window user will see the "Enter password" message which requires to enter the password to allow the user to enter the pass- word which is "invent6" then by clicking on the enter key as in figure (3).

Figure (3):"Enter password" window.

Figure (4): Entire program window.

Figure (4) shows how to enter the program window. There are several utilities are required to deal with the company inventory, as following:

(1) Click on the back up database utility, a backup database utility window will open as this in figure (5):

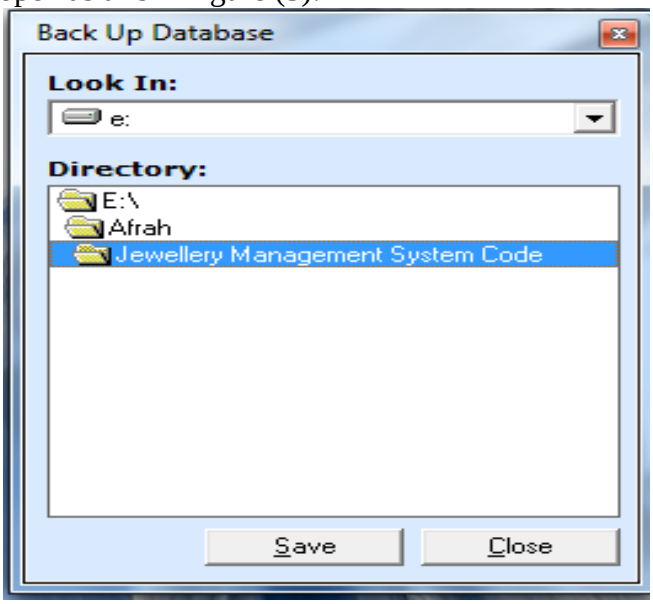

Figure (5): Back up Database utility window.

This utility is used to make a copy of all data, files, directory and information that entered to the program about the store and their products.

(2) Click on the (change password) utility, a change password utility will open as in Figure (6):

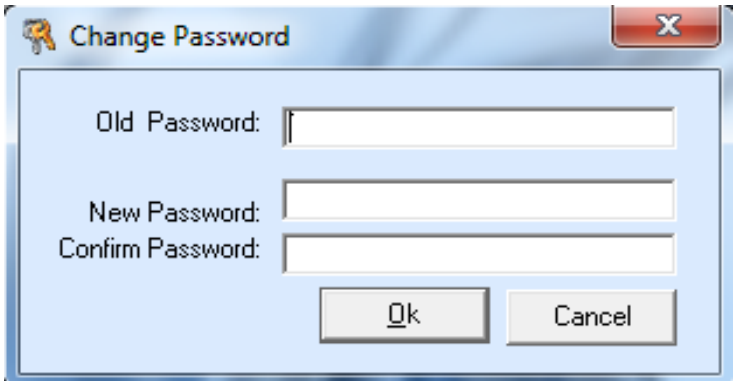

Figure (6): Change Password utility window.

This will be used to change the password in order to enter the program. Depending on this window the following procedure will be used to change the password:-

- Enter the old password of the program in the old password box.
-Then enter the new password in the new password box which can include characters and /or numbers.
- Then re-entered the new password in the confirm password box.
- Click on ok key to adopt the new one, the cancel key is used to avoid changing the password

(3) Click on the (add new store) utility, add new store utility window will open as in figure (7):

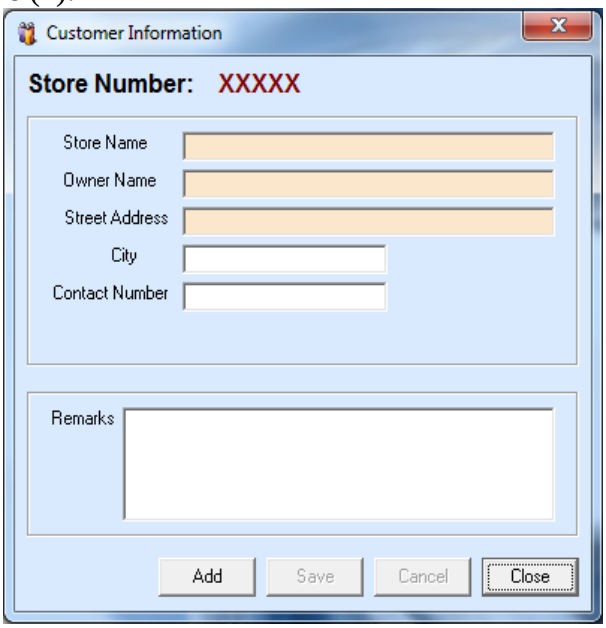

Figure (7): Add new store utility window.

This utility is used to add a new store to the company and to describe the general information about it. When clicking on this utility the store number has the form as (xxxxx) value at the first time. Boxes can't be filled unless the add key is pressed. When the add key is pressed the store number change form (xxxxx) value to specific value depends on what last store numbers were entered, and the pointer also will appears in first box (store name) when add key pressed.

- Store name box: It is used to enter the name of the company store.
- Owner name box: To insert supervisor name of the store.
- Street address: To insert the address of the company store.
- City: In which area/zone in which the store is located, if the company has many branches.
- Contact number: It is used to enter the phone number that used to communicate with the worker in this store
- Remarks: It is used to enter any additional important data and notes about the store that can't entered in the previous boxes but it must be known.
- Save key: Used to keep all information that entered in this window about the store "keep it in a specific database".
- Cancel key: To avoid all information entered in this window about the store and close key: To exit from this window.

(4) Click on the (Add New Item) title, and add new item utility window will open as in figure (8).

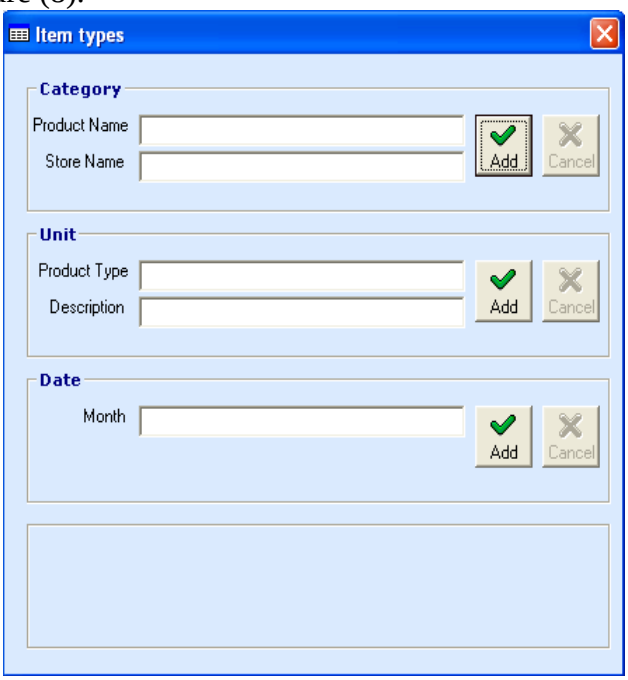

Figure (8): Add New Item utility window.

This utility is used to insert the product that was stored in a specific area. Also this window includes different boxes to describe this product. The required informations divided into three groups as the follows:-
Can't add any information in these boxes without clicking on the add key.

(a) Category group: This is including the followings:
- Product Name box: In this box will insert the type of the product which will be stored in the warehouse? (General name of it)
- Store Name box: Used to insert how this product is stored (some products may have a name as number or symbol)

(b) Unit group: This is including the followings:
- Product type box: It is used to insert the state of the product if it is under processing or final product.
- Description: To insert data that describes how product is store and used? As number, kilogram, etc.

(c) Data group: This is including the followings:
- Month box to insert in which month the product is entered to store as inventory. (Click on cancel to delete any data was entered in the boxes).

(5) Click on the (Add Item Details) utility, the window will open as in Figure (9)

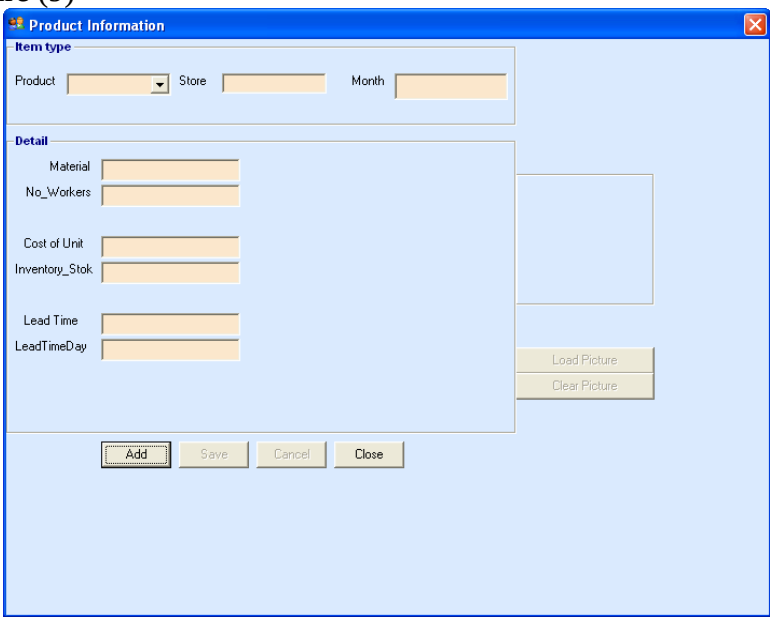

Figure (9): Add Item Details utility window.

This utility used to insert important information about the product that stored, so it is also called product information window. It includes two parts:-

(I) Item type part: It includes the following boxes: product box: Used to select a specific product has already been entered by clicking on the arrow to see all the products inserted using the previous window. Then the stored product will appear in the second box and in the third one the month in which the product is stored will appear automatically when user selects the required material.

(II) Detail part: It contains the followings:-

- Material box: It is used to insert how many or what are the materials used in the manufacturing of this product (can insert number or character).
- No of workers box: To insert the number of workers participants in producing this product through all production stages.
- Cost of unit box: How much does each unit of the product cost including direct and indirect cost.
- Inventory-stock box: How many units of this product exist in the store?
- Lead time box: The time from demanding the product until it delivers to the customer (in month).
- Lead time day box: The value in the previous box but in days (Lead time days = lead time *30).

(6) Click on the (Item Information) title, an item information utility window will open as in Figure (10):

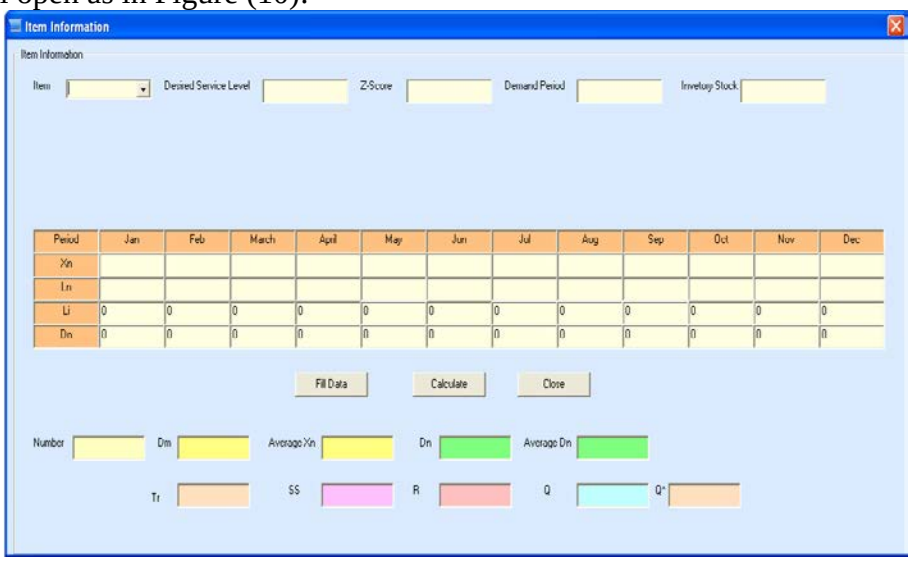

Figure (10): Item Information utility window.

This utility is used as a report to record the demand on the product during specific period of time at almost for a year (12 month) as shown in the table within figure (10) which illustrates :-

- Desired service level box: In this box user can enter the desired (preferable) value of the service level adopted by the company. While service level represents the expected probability which does not hitting a stock-out [13&14].
- Z –score box: When clicking this box, a specific value will appear ; this value represents the appropriate value that corresponding to the value that was chosen by the company in the previous box (Desired service level box) , depending on table for this relation stored in a database was built to save and call it when needed.
- Demand period box: In this box, can enter the required value for the time between orders (in days) and this value may change from period to another depending on some factors such as customer desires and requests.
- Inventory stock box: To insert how many units of this product exist in the store.
- The table: Includes:-

  * Period: Refers to the months (from January to December). This means user will take the value (quantity) of the demand monthly.
  * X_n: Represents the amount of demand each month.
  * L_n: Represents the time from the product request to deliver it to the client (lead-time) in month.
  * L_i: represents the value of L_n (lead time) but in days, where ($L_i = L_n * 30$)
  * D_n: Represent the daily demand on the product and $D_n = X_n/30$; to find approximately how many units of the product which were demanded in each day depending on the full monthly demand.

Also, in this table user can enter values using keyboard for the X_n and L_n variable and then when clicking on the fill data key the L_i and D_n cells will be filled automatically depends on the ratio:-

$L_i = L_n * 30$ and $D_n = X_n/30$.

Note: It is possible to enter values for X_n and L_n for all months or for some of them as needed by clicking on the calculate key. This will allow boxes at the bottom to fill automatically with appropriate value that refers to the title of the box depending on a specific equation for each symbol on each box as follows:-

- Number: To calculate the number of cell that to be filled.
- D_m: Represents the standard deviations of the demand X_n as in equation; $[\sum (X_n - \text{Average } X_n)^2$ divided by a number$]^{1/2}$.
- Average $X_n = (\sum X_n) / \text{Number})$.
- D_n: represents the standard deviations of demands in days D_n as in equal $[\sum (D_n - \text{Average } D_n)^2$ divided by (a number)$]^{1/2}$.
- Average $D_n = (\sum D_n / \text{Number})$.

- T_r (time ratio) = [L_i / demand period] $^{1/2}$. This factor will be calculated if the demand period doesn't equal the lead-time and it is used in safety stock calculation as follows:
- SS (Safety Stock) = Z-Score * D_m * T_r.
- R (Reorder Point) = Average D_n * L_i +Z * D_n * $(L_i)^{1/2}$.
- Q (Order Quantity) = [Average D_n * (Demand period + Li)] + [Z * D_n * (L_i + Demand period)$^{1/2}$] – Inventory Stock.
- Q* (Optimal Order Quantity) = Z-Score + Average X_n.

(7) Click on the (Situation Type) title: The situation utility window will open as in Figure (11).

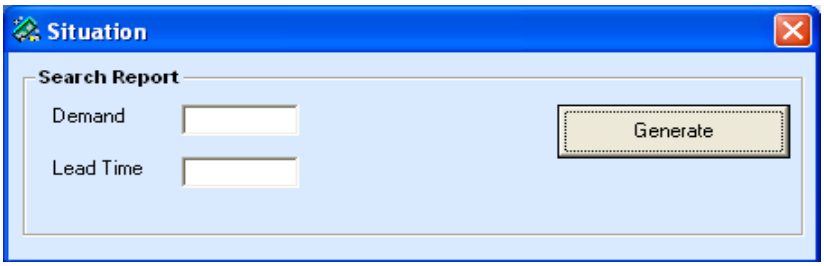

Figure (11): Situation Type utility window.

This window represents the search report; it is used to determine if the demand on the product within the normal boundaries, values in the terms of demand quantity and/or lead time, because if the demand and/or lead time contrary with normal situation this means there is an emergency situation. The company could face an addition production cost. If the company has agreed to perform this emergency demand, this requires an additional cost for overtime work. The normal value of demand and lead time for the normal situation of the company will be stored in program as a reference for any new demand. In this window there are two boxes:-

- Demand box: To insert the quantity of the product that was requested
- Lead time box: To insert the time from the product request until it delivers to the customer who demands it. When clicking on generate key the values which are inserted in these boxes will be compared with these were stored in the program and a message box will appear like as in Figure (12) to tell which situation will go.

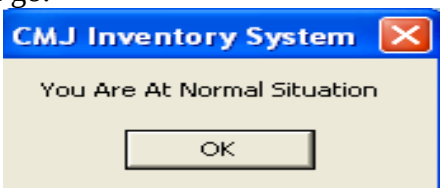

Figure (12): Comparing messages window.

If the values in these boxes are the same as that stored in the program, the program will send normal situation as in figure (13).

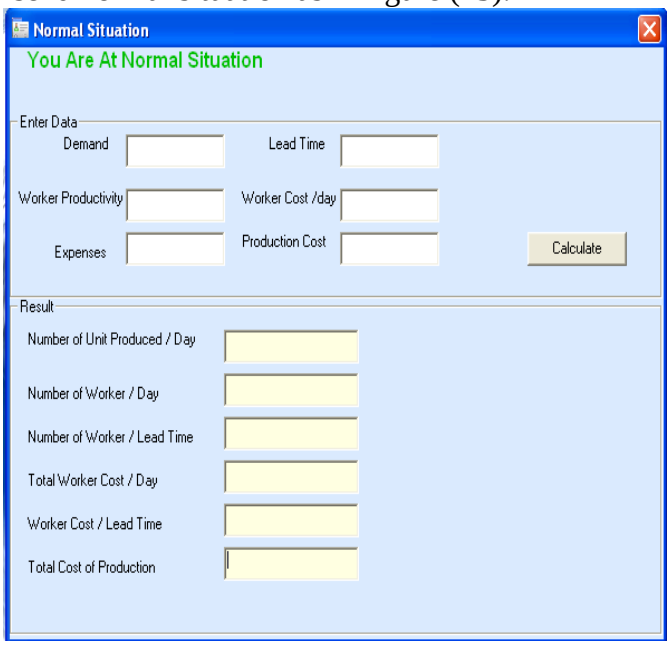

Figure (13): Normal Situation window.

But if these values doesn't equal with those stored in the program then the program will go to the emergency situation window, as in Figure (14).

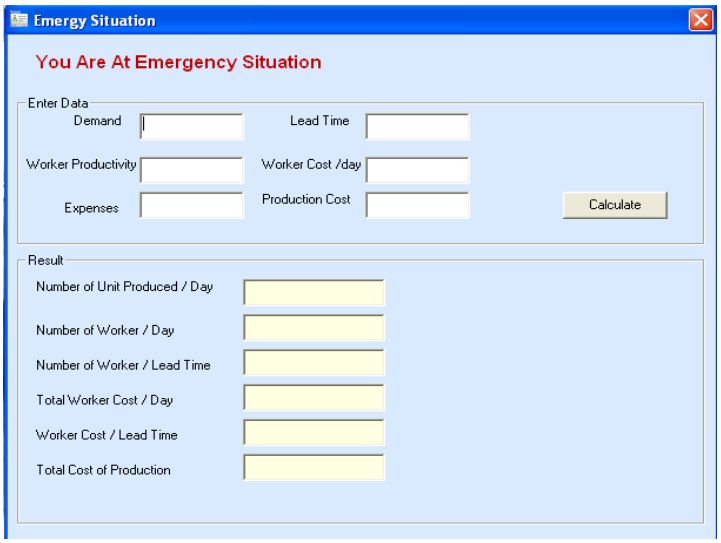

Figure (14): Emergency Situation window.

In the previous boxes as shown in figures (13) and (14):-

- Enter data parts:-

** Demand: Numbers of units requested.

** Lead time: Time from request demand to deliver.
** Worker productivity: Number of units per employee per day.
** Worker cost/day: The wages of the worker for each working day.
** Expenses: Includes: Insurance, transfer expenses, taxes and etc.
** Production cost: How much does it costs to obtain the final product (raw material cost, for example).

After clicking on generate key the user will go to the second part (results part) in each box as in figures (13) and (14):-

Number of unit produced/day = demand/lead time.
Number of workers/day = (Number of unit produced/day)/worker productivity.
Total worker cost/day = (Number of workers/day) * worker cost.
Worker cost/lead time = (Total workers cost/day) * lead time.
Total cost of production = Workers cost/lead time + Expenses + Production cost.

Case Study:-

Hussein bin Abdullah II Industrial City.

Jordan Chalk Manufacturing Company:

Jordan Chalk manufacturing company is a Middle Eastern company located in south of Jordan (karak). It manufactures exporters and suppliers of all types and shapes of chalk for:

* School, institutes and universities.
* Child hoppy (kids).
* Small and medium enterprises, shops, restaurants and industrial markers.

From the discussion with the company manager and from his answering to questions, also from the weekly reports about the company work the following informations were collected:-

- ✓ In this company all the departments are located in the Jordanian industrial companies such as production, procurement, financial and marketing department… etc. There is few staff controlling these departments.
- ✓ Storage in the company:-
  - The company has three contiguous stocks (their names are the same names of the substances were stored in them): Raw materials such as (bentonite that stored as (kg) unit , and motors spare parts that were stored as (number) units, packaging such as (internal cardboard ,external cardboard and bottles that were stored as (number) units and the final product stock (chalk as packet or box that was stored as number) units.
- ✓ Inventory management in the company:-

- The larger value (quantity) of material exists in the raw material stock because the shortage of these materials represented a real problem for the company where some of these materials require a long time to be supplied to the company.
- The final product store is the smaller one of the three stores because it doesn't prefer having a lot inventory which means frozen money.
- There is only one stock supervisor for all stocks; the contact with him is through interfacing, mobile phone and through online reports (through internet services).
- Weekly inventory of the warehouse is made to follow the actual quantity of materials and spare parts, while keeping the minimum level of the materials to prevent stock out state that affect negatively on the company work.

- The warehouse deals with three suppliers for the materials and spare parts because if one can't provide material the second one may provide it and so on. But the warehouse depends on one supplier with 90%, the second one with 5% and the third also with 5%.
- If the company has encountered a sudden (unexpected) demand, the company is able to implement only one container but if the request is more than one, the company will be unable to provide it.

✓ Other information:-

- The company produces about 10 containers (28 Ton) of chalk each month (demand quantity).
- The company produces 1 container each three days.
- The container costs approximately 12500 JD (without worker cost).
- The number of the employees in the company = 90.
- Each employee costs about 300 JD monthly.
- Each employee has productivity about 300kg / month.
- Over time work is about 3 hours.

After entering this information that has been collected from the company, the present work program needs the followings to be obtained:

>> Add new store as in figure (15):-

In this window store name (s4), the supervisor store name (Ahmad), the store location (Karak/Mutah), the phone number of the supervisor and (store for the final product) as a remark has been added.

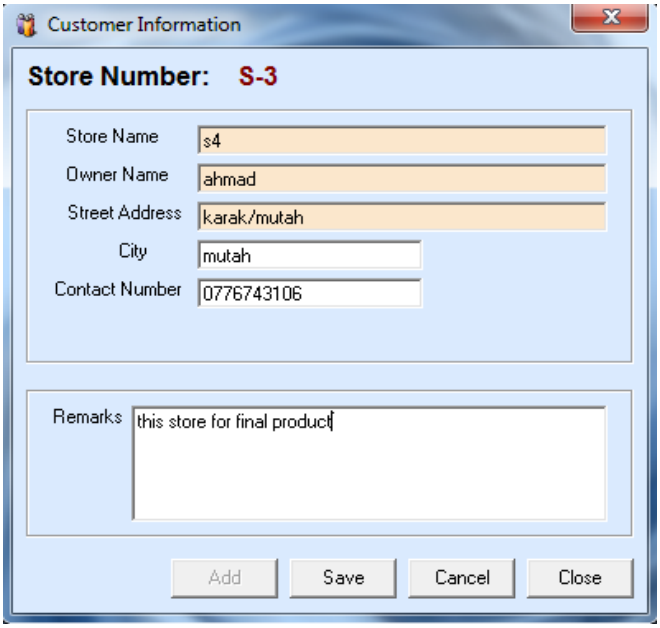

Figure (15): Add new store for Jordan Chalk.

Then save the information that was inserted.

>> Add new product:-

- Adding product name and store name in the category group as in Figure (16- a):

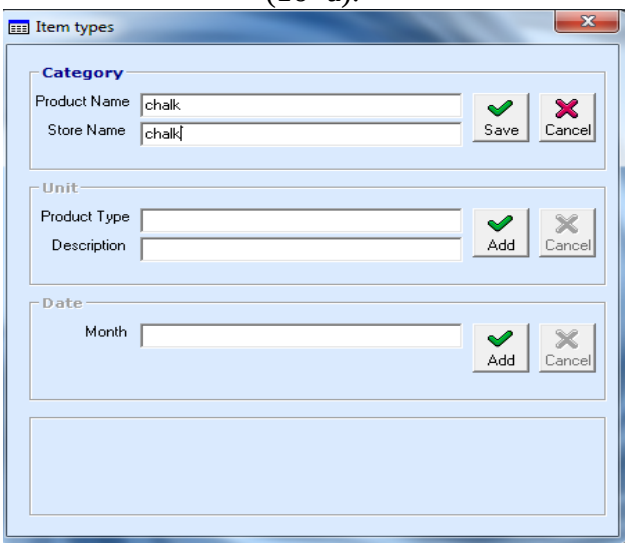

Figure (16-a): Add new product for Jordan Chalk.

- Adding product type and its description in the unit group as in Figure (16 - b).

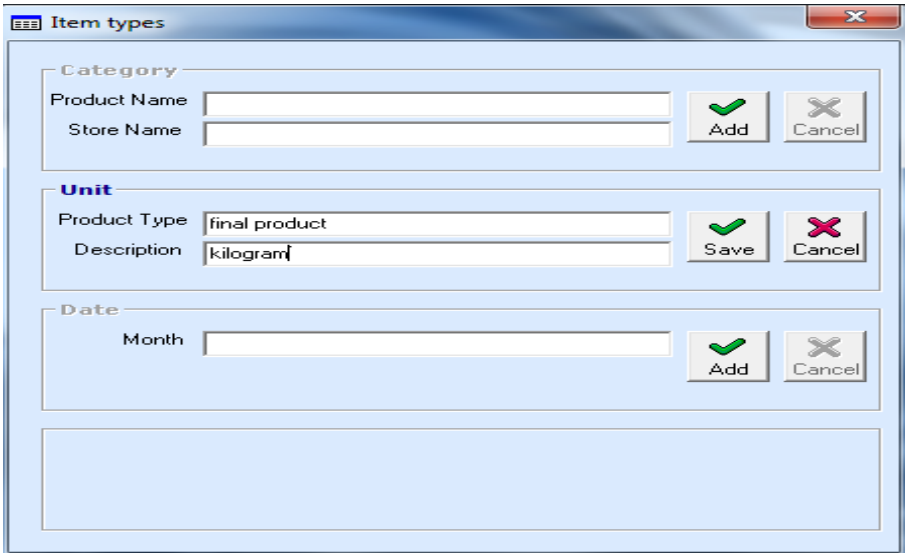

Figure (16-b): Add new product for Jordan Chalk.

- Adding the month of this product as in Figure (16-c).

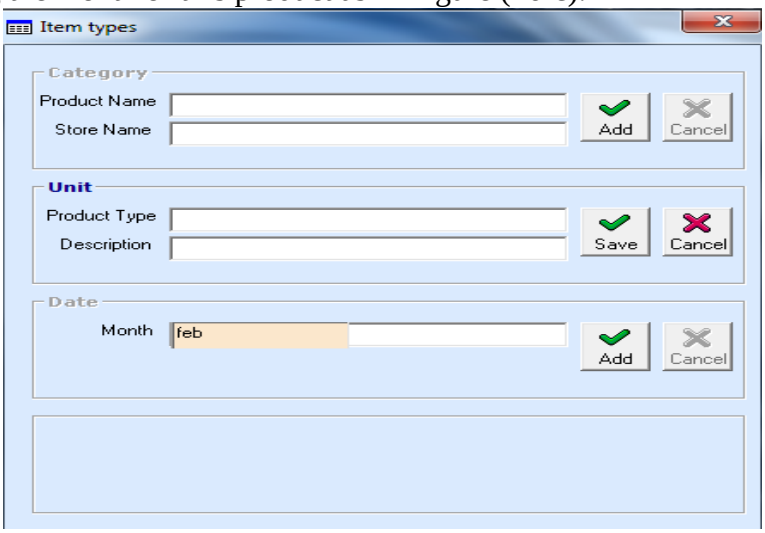

Figure (16-c): Add new product for Jordan Chalk.

>> Add item information as in Figure (17):

The product name is a chalk and it was stored in the store in February. This is shown in item type parts as in Figure (17) .The product consists of 5 materials such as (bentonite), no stock of this product exists in the store; each container of chalk costs about 12500 JD (without employee cost) and the lead time equal one month. These informations are shown

in detail part in figure (17). All these informations will enter after clicking on add key, to save them just press the key.

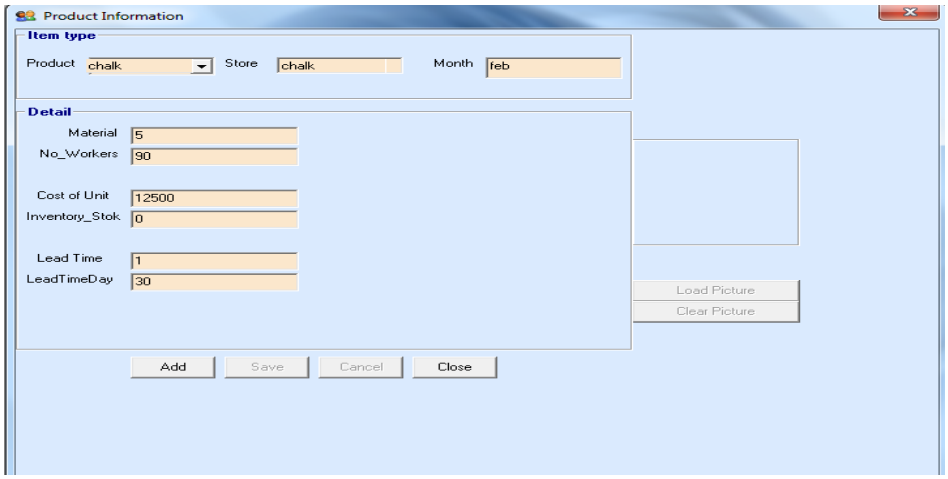

Figure (17): Add item information for Jordan Chalk.

>> Item report (Item calculations) as in figure (18).

Figure (18): Item calculation for Jordan Chalk.

In this window (Fig. 18) the demand was entered for only 5 months because they will give the same results for demand on 12 months (the demand amount is fixed and equals 28 ton). From the window in figure (18) will find the followings:

- Lead time in days = 30 because L_n = 1 month.
- Daily demand = 933.33kg.
- Number of cells to be filled = 5 cells.
- Average monthly demand = 28 ton.
- Average daily demand = 933.33kg.

- Standard deviation of monthly demand and daily demand both = 0.0 because the difference between demand amount and average demand amount equals zero.
- The SS value equals zero and this means the company doesn't have any safety stock quantity. This means that the company doesn't have any excessive amount of stock to meet the unexpected demand during the period of supply. This value indicates that the company really in a big problem especially when it receives additional demand (it is more than 28 ton) because the company will not provide any of these demands because it doesn't have any safety stock in its stores.
- The optimal order quantity = 28 ton.
- Reorder point = 28 ton, the amount of the product that when the inventory level reaches to a new request of the product which must be organized (Each month the quantity equals = 28 ton).

>> To calculate the total cost of producing 28 ton as illustrated in the Figure (19). Just by entering the demand quantity 28 ton with lead time = 30 days. In order to determine the situation type of this demand and calculating the total cost of production, press the generate key only.

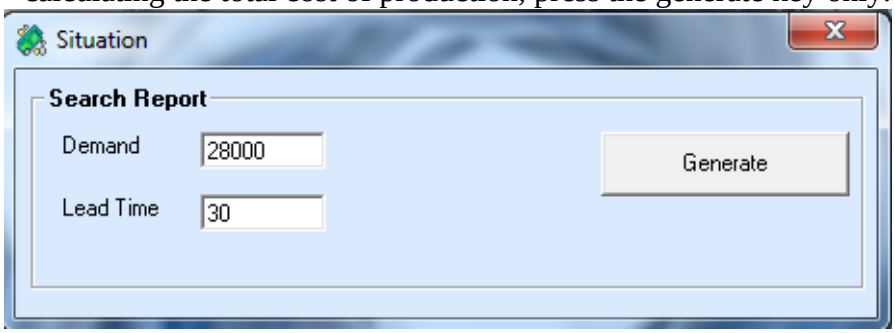

Figure (19): Situation type window for Jordan Chalk.

After pressing on the generate key, the following message will appear as in Figure (20).

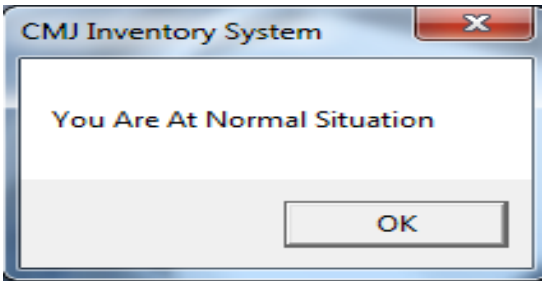

Figure (20): Situation of decision message for Jordan Chalk.

Pressing on ok key the following window will appear as shown in Figure (21) which indicates that the demand quantity which = 28 ton in the normal area .

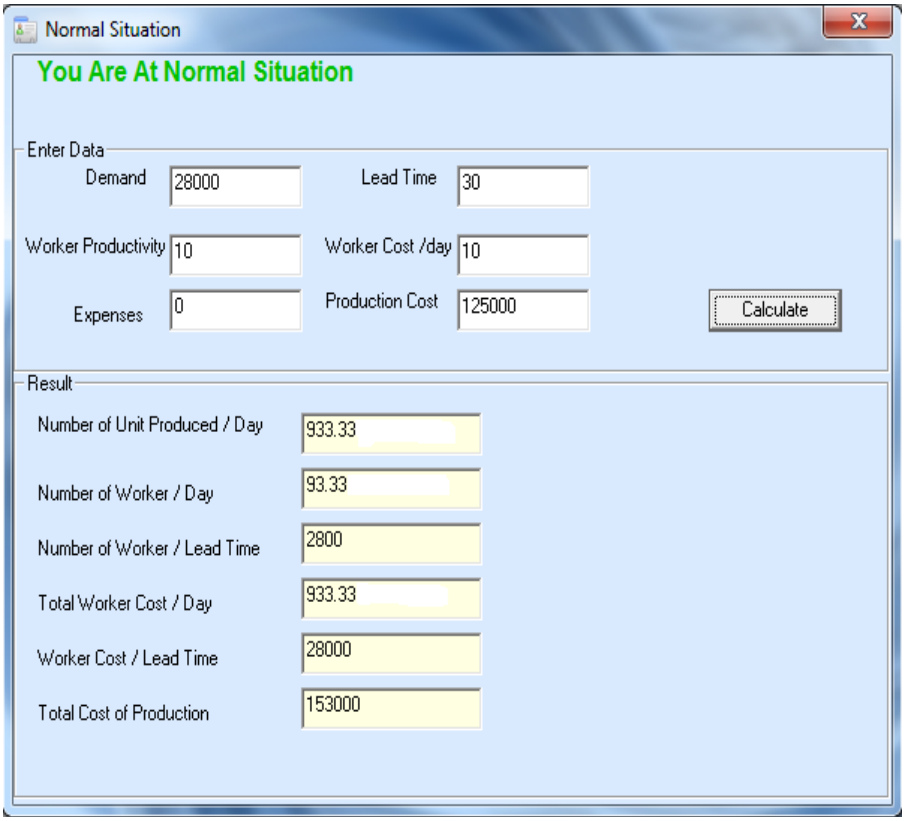

Figure (21): Normal situation for Jordan Chalk.

From this window (Fig. 21): For the demand quantity = 28 ton with lead time = 30 days were entered in data part in addition to the productivity of the employee = 10 kg each day, employee cost for each day = 10 JD, the expenses = 0.0 (because it is included in the production cost for this case) and the production cost = 125000JD for 10 containers of chalk.
In the result part will be as in Figure (21):
* Quantity produced each day = 933.33kg.
* Number of employee each day about 93 employees.
* Total cost of the employee for the total lead time = 28000 JD.
*Total cost of production (10 containers) = 28000 + 125000 = 153000 JD.

If the company receives an additional demand (1 additional container of chalk), this means the company must produce 28 ton + 2.8 ton = 30.8 ton and it deals with this as emergency situation (cost increasing) as in Figure (22).

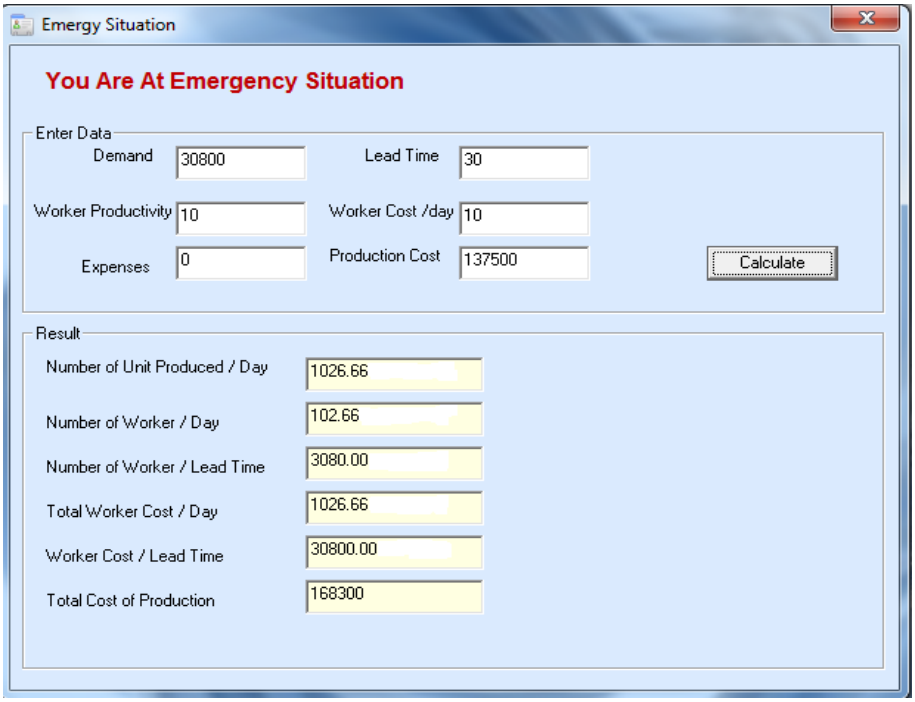

Figure (22): Emergency situation for Jordan Chalk.

From this window (Fig. 22):-

- ☒ The demand quantity is increased compared with the quantity in normal situation.
- ☒ Production cost of the demand (137500JD) is increased compared with the normal situation (125000JD).
- ☒ So that the total production cost (137500 +30800 =168300 JD) which is increased compared with normal situation (153000JD) because the worker cost is increased from 28000 JD for a demand = 28 ton to 30800 JD for a demand = 30.8 ton. This increasing is due to the overtime work. It is worth to mention that the company rejects a large amount of demand because it can't deal with them (there is no inventory in its store). So, the present work program will help the company in managing inventory and it will provide a value for safety stock, reorder point and the ordered quantity that is required to deal with unexpected demands, preventing stock out case or inflation inventory, also the program will help the company in calculating the total cost of production.

Drawbacks:-

The program was tested on only one item the final product in Chalk Manufacturing Company because this company didn't give any information

about the other items stored in their stores (such as raw material, spare parts and semi finished) but it gave general information about the final product only. This information was considered as confidential. While the present work designed program can be implemented to all item types (raw materials, spare parts and final product).

Conclusion:-

The main points which can be concluded from this works are:-

1- An inventory management controlling program was designed and tested in this work by implementing it on a case study which is the Jordan Chalk Manufactory company.

2- The main objectives of the program are to keep the inventory within the acceptable level for the business sector (any type of production) and to deal efficiently with emergency cases to predict the time or the additional cost due to these critical situations.

3- The present work program can help any company in solving the inventory problems and can deal with uncertain demand of product, by entering the required demand quantity for each month, so the program can manage the company's inventory as follows:-

(I)-Safety stock amount: Depending on the average demand on product the program can determine the excessive amount of stock that the company keeps it to meet the unexpected demand.

(II)-Reorder point: Also the program can calculate the amount of the product that when the inventory level reaches to it, a new request of the product must be organized in order to ensure that it can arrive before the stock reaches to the safety stock level. Determining it can help in minimizing the chance of stock out and reducing the amount of money tied up in inventory.

(III)-Order quantity: The program will provide the amount of product in each order.

(IV)- The value of the service level can be determined, which represents the probability of being able to service incoming order (or demand) during one lead time. Also it is an important variable for calculating the appropriate safety stock (SS). When its value increases the safety stock value also increases.

(V)- Any additional demand in any month with any quantity can be managed depending on the value of SS, R and Q taking the desired service level value into account.

(VI) -In case the company doesn't have any stock in it stores (i.e. Inventory stock = 0.0) .So that, this situation represents an emergency situation (challenge) for the company and in order to provide it to the

customer must carry on additional cost (overtime cost) of the actual cost for each container which must be produced in the emergency time.

(X)- By using this program, the company can meet the demand safely because it will has the required safety stock quantity and has the perfect amount of the reorder point that help the company to avoid the stock out case or inflation in inventory. Also keeping historical data about this quantity of demanded will help the company to predict how it can deal with situations like this in future.

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