Industrial Engineering Journal
ISSN: 0970-2555
Volume : 52, Issue 12, No. 3, December : 2023

DESIGN AND IMPLEMENTATION OF MACRO PROGRAM TO GENERATE PRINTED GEOMETRICAL DIMENSIONS

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Abstract:
In engineering and manufacturing industries, accurate representation of dimensions is essential for effective communication and precise product realization. However, manually creating and documenting geometrical dimensions can be time-consuming and error prone. This paper introduces a macro program designed to automate the generation of precise geometrical dimensions in engineering and manufacturing. The program employs advanced algorithms and data processing techniques to extract dimension information, ensuring adherence to industry standards. It provides flexibility in dimension styles and includes error-checking mechanisms to detect and resolve common dimensioning issues. Users can customize dimensioning rules to meet specific project needs. Case studies demonstrate the program's effectiveness in reducing dimensioning time, enhancing consistency, and maintaining high accuracy levels. Feedback from engineering professionals confirms its practicality and usability, offering a valuable solution for improving the dimensioning process in the manufacturing industries.

Keywords: Macroprogram, Green Carbide Inspection (GCI), Rhenium metal powder (RMP), PU 2 – Pressing, Shaping, Sintering, Automation, Simulation Model .

Introduction

In the contemporary, dynamic changing world, access to production data in real life is necessary to properly plan, simulate and supervise production. Companies operating in different sectors of the economy are more and more commonly using IT solutions to optimize logistic systems by improving the handling of materials and performance parameters. In today's ever-evolving and dynamic global landscape, the availability of real-time production data has become imperative for effective production planning, simulation, and supervision. An increasing number of companies across diverse industries are embracing IT solutions to optimize their logistics systems, thereby enhancing material handling and performance parameters. Automation macroprograms are potent tools that streamline and automate repetitive tasks. By eliminating the need for manual execution, macroprogram save time and effort. They are highly adaptable, allowing users to incorporate logic, conditionals, and variables to tailor the automation to specific needs.

Macroprograms integrate with various automation frameworks and tools, enhancing their capabilities. The benefits of macroprograms include increased productivity, reduced manual errors, consistent task execution, and the ability to focus on more strategic activities. However, they may require adjustments if the underlying system or application changes significantly. Overall, macroprograms empower businesses to streamline workflows, improve efficiency, and achieve higher levels of automation in their operations.

Queuing theory in simulation is a mathematical framework used to model and analyze the behavior of waiting lines or queues. It provides insights into the performance of systems involving the flow of entities, such as customers, data packets, or requests. Queuing theory considers factors like arrival patterns, service times, queue disciplines, and system capacities to understand queue dynamics. Simulation allows the practical application of queuing theory by implementing virtual models that replicate real-world queuing scenarios. Through simulation, queuing theory helps in evaluating performance metrics like queue length, waiting time, and system utilization. It enables system designers to identify potential bottlenecks, optimize resource allocation, and improve overall efficiency. Queuing theory simulations assist in capacity planning, allowing businesses to determine the optimal number of servers or service points required.

During the production process, most of the products undergo multiple operations, including pressing, shaping, and sintering. To carry out these operations effectively, green dimensions are required. These green dimensions are manually calculated by the GCI operator for each route card. Once a component is pressed, it is sent to the GCI for dimension verification, and the appropriate shrinkage percentage is determined. This shrinkage percentage is used in the calculation of green dimensions. When calculating green dimensions, several factors are considered, including the drawing dimensions (outer diameter, inner diameter, and height), shrinkage, prescribed grinding allowance, and sintering tolerance. Each specific grade requires specific considerations for grinding and sintering. However, the current manual calculation process performed by the GCI operator is time-consuming and prone to errors. This inefficiency leads to production delays and increased scrap rates. Moreover, in the absence of the GCI operator, machine operators lack the necessary calculation skills to proceed with further machining operations, causing further delays in production.

To address these challenges and improve efficiency, it is crucial to automate the calculation of green dimensions. By implementing automated software or tools tailored to this purpose, the process can be streamlined. The proposed solution aims to minimize manual intervention, reduce errors, and enhance productivity.

The following steps describe the process followed for products to achieve their targets.
a. Purchase Order & Technical Evaluation
b. Order Booking
c. Master Data
d. Release of Route Cards
e. Manufacturing Process- Pressing, Sintering.
f. Metallurgical Inspection and dispatch

a. PURCHASE ORDER & TECHNICAL EVALUATION:
The customer places an order at the sales department where the team simply collects the orders and sends it for technical evaluation. The team analyzes the order and evaluates whether the order can be taken for manufacturing, what might be the estimated LEAD TIME and the pricing of the order.

b. ORDER BOOKING:
The quotation is then sent back to the customer and if he agrees with the lead time and the pricing, only then the support team books the order.

c. MASTER DATA:
A production order is now created for this order and the LEAD TIME for production is estimated. The team tries its best to match with the lead time declared by the technical evaluation team to the customer. The start date and the end date are generated automatically on the SAP along with the various steps of manufacturing, the time for each step. A ROUTE CARD is generated which is distributed to the different processes in the plant.

d. RELEASE OF ROUTE CARDS:
The planning team releases route cards to the plant with the description of the tool to be manufactured, size, weight, composition, various steps the tool should undergo and time for each step. The route

cards are distributed to the respective processes. This way the people in the plant know if there is a delay in their manufacturing process.

e. MANUFACTURING PROCESS:
The RMP in the form of dry powder and granules from Production Unit 1 is brought to Production Unit 2 for further operations such as pressing and sintering.
Processes involved in Production of products are:
1. Pressing
2. Green Carbide inspection
3. Sintering
4. Metallurgical inspection and dispatch.

Literature
[1] According to the needs of the purchase department of the ABC Company, plan and formulae were kept to be the same but the manual operations from the report were totally removed. As in apropos of VBA, literature was reviewed in the context of automation in MS excel. Research was conducted by Kalwar and Khan (2020) in which acquisition reports and purchase orders were automated by the help of VBA in excel. Instead of 2097 seconds both requests took only 520 seconds after the automation.

[2] By using VBA in excel ZainulAbidin et al., (2015) summarized Air Pollution Index (API) and Water Quality Index (WQI). The VBA program was used with converted formulae and the application was programmed for calculating the indices. In order to climax the value of index coded details of the index was calculated by itself shown along with it.

[3] Ahmadi et al., (2018) accomplish as a Dairy model by using VBA in excel. The execution of the CTR Dairy Model was carried out in research by using VBA by Ahmadi et al., (2018). CTR dairy is an effective simulation model for grazing lactating dairy cows that is used to forecast the overall milk production and profits on numerous frameworks like under the irregular schedules of feeding the ruminal digestion it is used for the absorption of the nutrients.

[4] Yan and Wan (2017) created an application with the use of VBA excel for an automatic calculation and generation of bill of material (BOM) of transmission line. The application and design of the template and errors in the process of designing of total steel BOM were improved because Accuracy and efficiency were widely reduced.

[5] At the planning and costing department of ABC Company of Lahore research was accomplished by Kalwar and Khan (2020) in which the acquisition and purchase order reports were automated the report formation time was reduced from 2076.751 seconds to 516.578 seconds (Kalwar and Khan 2020).

[6] Belchior Junior et al., (2011) developed the new application for the results of post-processing the Reactor Excursion and Leak Analysis Program 5 (RELAP5) by using Microsoft Excel VBA. It is indicated to be quite a useful instrument to speed up the output data analysis.

[7] Cirujano and Zhu (2013) developed a new method for the automatic creation of manpower planning reports using VBA in Microsoft Excel. As per the new method, roles, and schedules of the engineers in various projects were collected. The collected information was compiled, analyzed, and organized. In this regard, the engineer`s information in various projects could be retrieved and the plans for the engineers could be made. The method was validated in a consulting firm with greater than a hundred

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employees. It was indicated that a power planning report could be generated automatically; by which a tremendous amount of time and cost will be saved.

[8] Lessa et al. (2016) automated a practical mathematical model for the calculation of packaging and the logic program by using visual basic for application (VBA) in Microsoft Excel. The graphic designs were automatically created for how the packages are being filled.

[9] Wettlaufer (2010) implemented mapping rules in the form of VBA macros in Microsoft Excel. For each report, one macro was programmed. Expected values were written by the macros in the separate spreadsheet i.e., expected values spreadsheet. Then it sends the patient's follow-up to the merline.net server for processing the data and the processed patient follow-up session was generated containing a reports package in the WinRAR file.

2.1Methodology

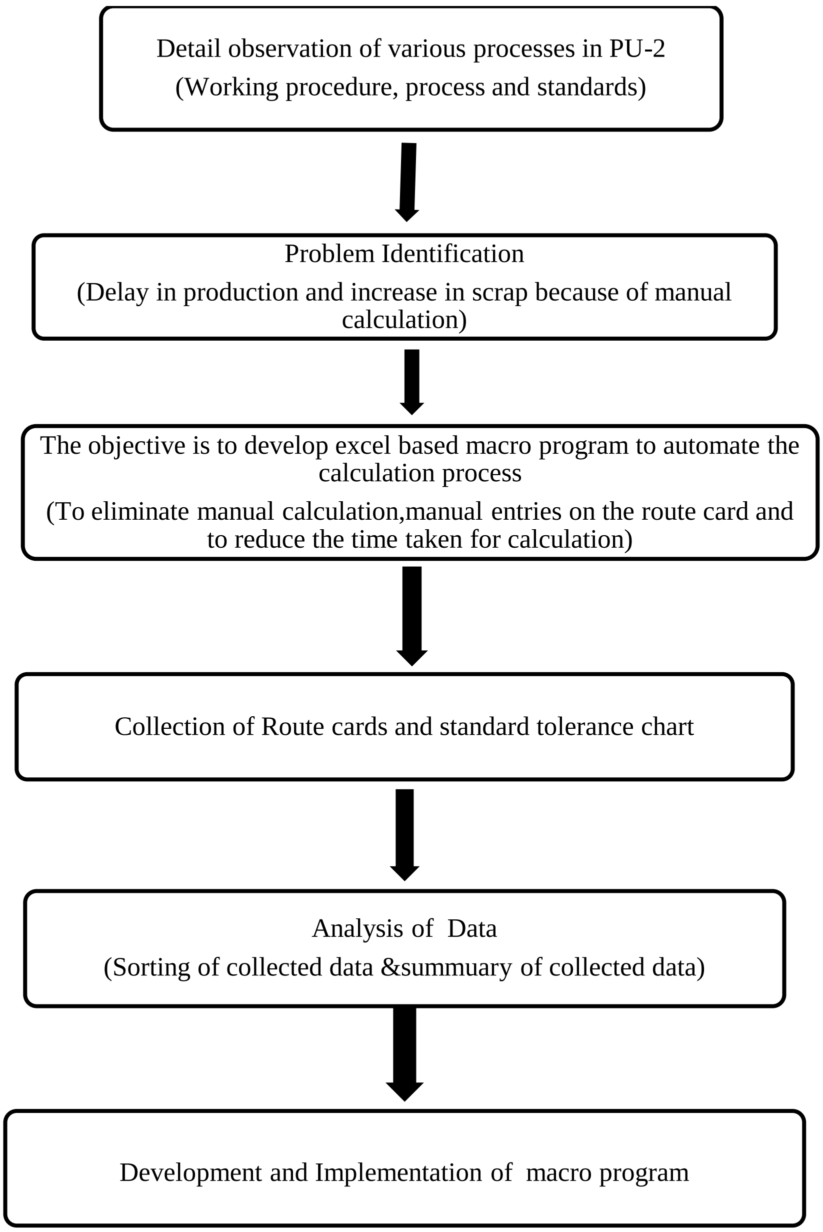

Fig - 1: Project Methodology

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The objectives accomplished are:
1.To develop Macro program which will generate a printed output for shaping conditions to eliminate the manual calculations and manual entries on the route cards.
2.To achieve proper green dimensions of Outer diameter, Inner diameter, Height along with L/D Ratio, Packing and Sintering Condition and to ensure the final products after sintering are within the tolerance limits (STD chart).
3.To reduce the scrap due to calculation errors at the Green Carbide Inspection area by improve the previous calculation process which will in turn improves the productivity through process improvement.
4.To eliminate the manual calculations which will reduce the waiting time of the machine operator for getting the green dimensions which are required for the further machining operations.
5.To ease the calculation process for the Green Carbide Inspection Operator by automating the manual calculation process

2.2 Calculations

CALCULATION OF GREEN DIMENSION ALONG OD, ID, and HT

For calculating the green OD, we need to refer to the tolerance chart to calculate the grinding and sintering tolerance (GA+ST). The required tolerances are specified by the customer according to requirements.

- Green dimension along OD
  = (Drawing dimension OD + Tolerance of OD) *(1+Shrinkage/100)

- Green dimension along ID
  = (Drawing dimension ID - Tolerance of ID) *(1+Shrinkage/100)

- Green dimension along HT
  = (Drawing dimension HT + Tolerance of HT) *(1+Shrinkage/100)

Example:
Consider a product with drawing OD of 40mm, and HT of 25mm and by seeing the tolerance chart we get 1.8 as the tolerance for OD, if planner is planning for 23% shrinkage, then the green OD will be
(40+1.8) *(1+23/100) = 51.41mm

Consider a product with drawing HT of 25mm, and OD of 40mm and by seeing the tolerance chart we get 3 as the tolerance for HT, if planner is planning for 23% shrinkage, then the green HT will be
(25+3) *(1+23/100) = 34.44mm

Consider a product with drawing ID of 10mm, and HT of 25mm and by seeing the tolerance chart we get 0.68 as the tolerance for ID, if planner is planning for 23% shrinkage, then the green ID will be
(10+0.68) *(1+23/100) = 11.46mm.

SIMULATION MODEL USING QUEUING THEORY:

For the purpose of analyzing the data we first collected the required 10 days data i.e., necessary for queuing model like time the machine operator arrived at GCI, time the GCI operator took for the calculations, waiting time of the machine operator and total time spent by the machine operator were all collected by time study method. Later we plotted the graphs for the individual days to understand the delays that were happening which are leading to the delay in production.

- 10 Trails were done to estimate the required analysis.
- After conducting 10 trials more time is taken for the calculations by the GCI operator due to which delays are formed in the production.

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• According to the above trails an overall summary is made for the clear understanding of the bottleneck formed.

Days	No of operators	service time(min)	Time spent in system(min)	waiting time (min)
1	7	57	85	28
2	9	117	198	81
3	6	78	107	35
4	7	106	185	88
5	8	113	172	59
6	7	100	146	46
7	7	85	138	53
8	8	116	149	33
9	7	96	135	39
10	8	134	191	57

Table 1: Simulation Model using Queuing theory

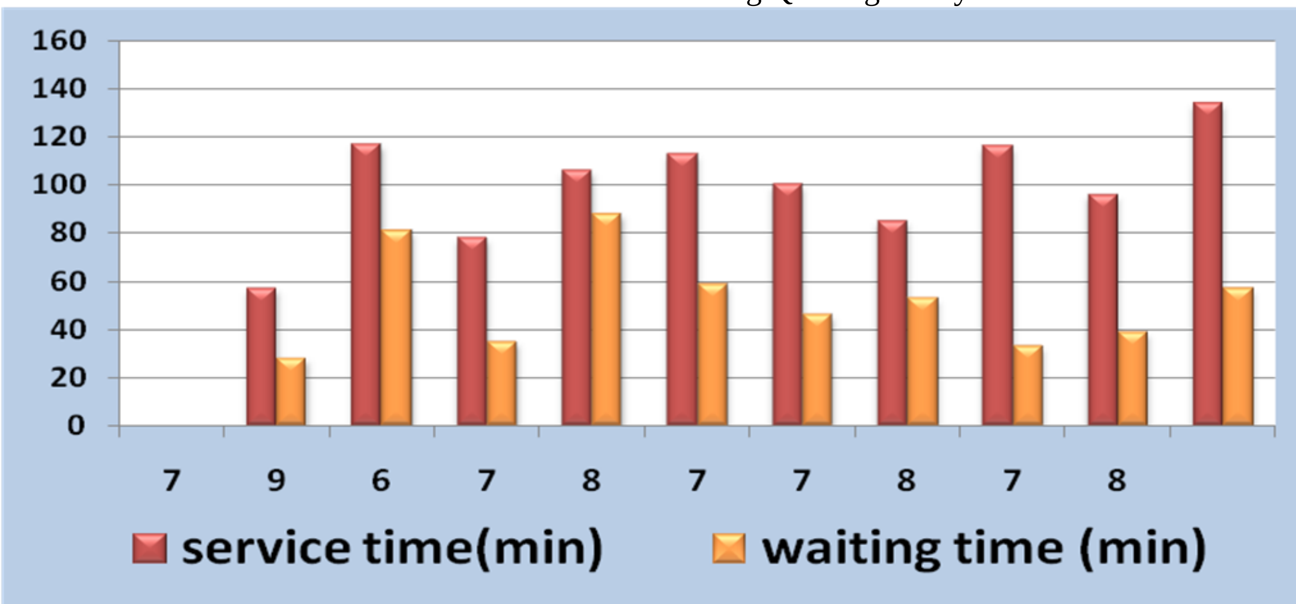

Fig-2: Graph of the simulation model

2.4 DEVELOPMENT OF MACRO PROGRAM

2.4.1 Automating the green dimension calculation process involves the following steps:

1. Development of Green Dimension Calculation Software: Design or acquire software capable of automatically calculating green dimensions based on input parameters, such as drawing dimensions, shrinkage percentages, grinding allowances, and sintering tolerances. The software should be user-friendly and adaptable to the different presses and product types used in Production unit 2.

2. Integration with the Route Card System: Integrate the green dimension calculation software with the existing route card system. This integration allows the software to automatically retrieve relevant parameters and perform the necessary calculations. The calculated green dimensions can then be directly populated onto the route card, eliminating the need for manual entry by the GCI operator.

3. Quality Control and Validation: Implement quality control measures within the software to ensure accurate calculations. The software should include built-in validation checks to identify any inconsistencies or errors in the input parameters. Additionally, it should generate reports or alerts for review by supervisors or quality control personnel to address discrepancies effectively.

4. Training and Support: Provide comprehensive training to GCI operators and machine operators on how to utilize the new automated system. Familiarize them with the software interface, input parameters, and interpretation of the calculated green dimensions. Ongoing technical support should be available to assist with any queries or issues that arise during the transition and implementation phases.

By automating the calculation of green dimensions, the process becomes more efficient, reducing the time required and minimizing the risk of errors. This automation enables smoother production flow, lower scrap rates, and eliminates the dependency on the GCI operator for manual calculations.

2.4.2 Process Automation in GCI Area for Shaping Conditions

The production produces various customized products and it invests a major part in metal cutting tools. Mainly they produce metal working tips, bushes, rolls, rings, and buttons etc. The functions performed are Pressing, Shaping, Dewaxing, Sintering and Hipping. After pressing, the B class components must be shaped as per the green dimensions, and then these components will be sent to the sintering operation. After sintering the sintered components should match with the drawing dimensions defined by the customer. While performing the operation cycle one drawback has been noticed i.e., before performing shaping operation for the required green dimensions, the machine operator needs to know the green dimensions and details for that shaping operation.

From the observation, we analyzed that previous process of calculation can be improved. Hence, decided to develop an Excel based macro program which will be user friendly and ease the procedure for the GCI operator to make the calculations.

The first step is to analyze the previous calculating process, how is it? How are the calculations made? What are all the formulas used for calculations? How does it work? How can we improve this?

First the machine operator will bring the route card to the GCI operator to get the required green dimensions for shaping the condition of the component. Then, the GCI operator must write the dimensions for the drawings, by doing calculations manually by referring to the standard tolerance chart (KIL) for the dimensions and tolerance of the drawings mentioned in the route card.

Here the important aspect is shrinkage which changes according to the powder grade, specific gravity of the powder and wax content in the powder. The major procedure of this program is to get the required green dimensions of (OD, ID, and Height), L/D ratio, Packing condition and Sintering. Condition for the operation because a certain amount of shrinkage will be there after sintering. So before pressing and shaping the component shrinkage percentage will be added to the calculation.

Format of the program

The developed “Excel Based Automation Program” consist of following sheets,

1. Data sheet
2. Main page
3. Input sheet
4. Output sheet

DATA SHEET

There are different data sheets for each grade and the data sheets consist of following parameters,

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MM. No. → Master Material Number
PO. No. → Production Order Number
O.D (mm) → Outer Diameter in mm
I.D (mm) → Inner Diameter in (mm)
H.T (mm) → Height in (mm)
N/A → Not Applicable
L/D Ratio → Length / Diameter Ratio

Formulas used in the Data Sheet for calculations

A. GREEN DIMENSION

- OD (mm) = If (Shrinkage = 0, "N/A", ((drawing dimension OD + tolerance of OD) × (1+ (shrinkage ÷100))))
- ID (mm) = If (Shrinkage = 0, "N/A", ((drawing dimension ID - tolerance of ID) × (1+ (shrinkage ÷100))))
- HT (mm) = If (Shrinkage = 0, "N/A", ((drawing dimension HT + tolerance of HT) × (1+ (shrinkage ÷100))))

B. TOLERANCE

- OD (mm) = If (HT=0, "N/A", If (OD=0, "N/A", INDEX (select the array in OD tolerance chart, MATCH (OD, select the OD row in OD tolerance chart,1), MATCH (HT, select the HT column in OD tolerance chart,1)))
- ID (mm) = If (HT=0, "N/A", If (ID=0, "N/A", INDEX (select the array in ID tolerance chart, MATCH (ID, select the ID row in ID tolerance chart,1), MATCH (HT, select the HT column in ID tolerance chart,1)))
- HT (mm) = If (HT=0, "N/A", If (OD=0, "N/A", INDEX (select the array in HT tolerance chart, MATCH (OD, select the OD row in HT tolerance chart,1), MATCH (HT, select the HT column in HT tolerance chart,1)))

C. L/D RATIO

- L/D Ratio = If (OD=0, "N/A", If (HT=0," N/A", (HT÷OD)))
- PACKING = If (OD=0, "N/A", If (HT=0," N/A", If (L/D Ratio< 2.3, "VERTICAL PACKING", "HORIZONTAL PACKING"))

D. SINTERING CONDITION

- SINTERING CONDITION FOR NORMAL GT55

= If (HT=0," N/A", If (L/D Ratio>=2.25, If (ID>10, "BIG GT55", "NORMAL"), If (L/D Ratio >= 1.5, If (Theoretical Green Weight >= 1.5, "BIG GT55", "NORMAL"), If (Theoretical Green Weight >= 1.5, "BIG GT55", "NORMAL")))

- SINTERING CONDITION FOR UPASANA GT55

= If (HT=0," N/A", If (L/D Ratio>=2.3, If (ID>10, "BIG GT55", "NORMAL"), If (L/D Ratio >= 1.5, If (Theoretical Green Weight >= 1.5, "BIG GT55", "NORMAL"), If (Theoretical Green Weight >= 1.5, "BIG GT55", "NORMAL")))

- THEORETICAL GREEN WEIGHT

= [(13.2 × (0.785 × (HT × ((drawing dimension OD × drawing dimension OD) - (drawing dimension ID × drawing dimension ID))) ÷ 1.32]

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2. MAINPAGE

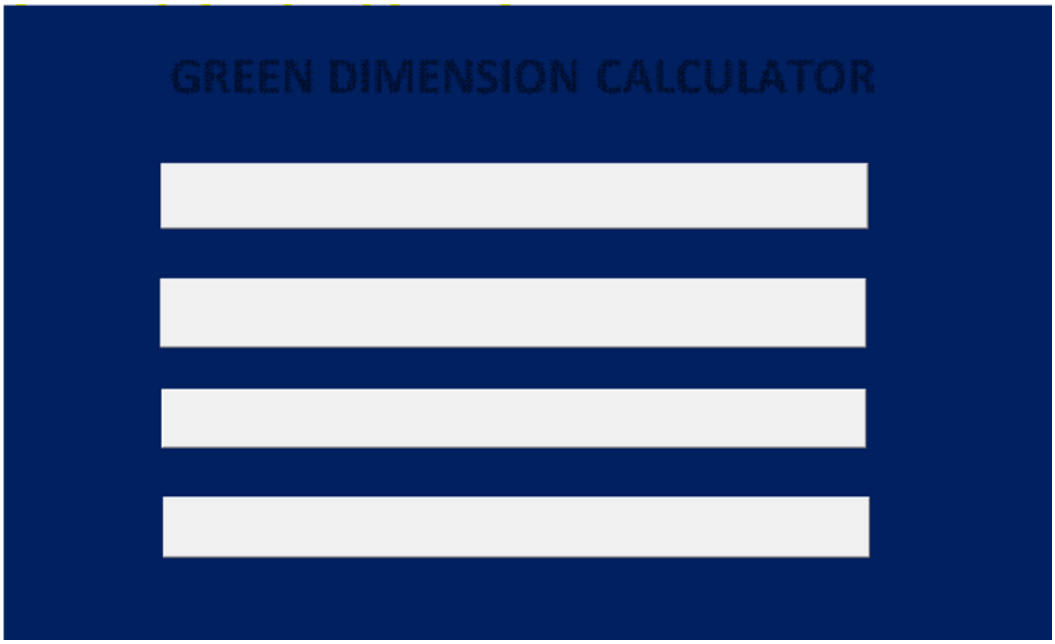


Fig 3: Program Format– MAINPAGE

The first page or main page of the program will be as show in below fig. We have inserted some buttons and recorded (macro recording) each operation, then we have assigned each button for the respective grades. Here the operator must choose the grade (as per the route card) for which they need to calculate the green dimensions by clicking on the grade button.

3.INPUT SHEET

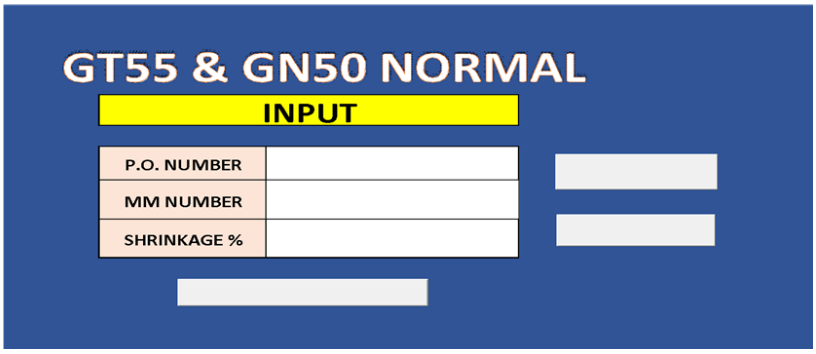


Fig 4: Program Format – INPUT SHEET

After clicking on the grade, the input sheet will be displayed as show in the below figure.

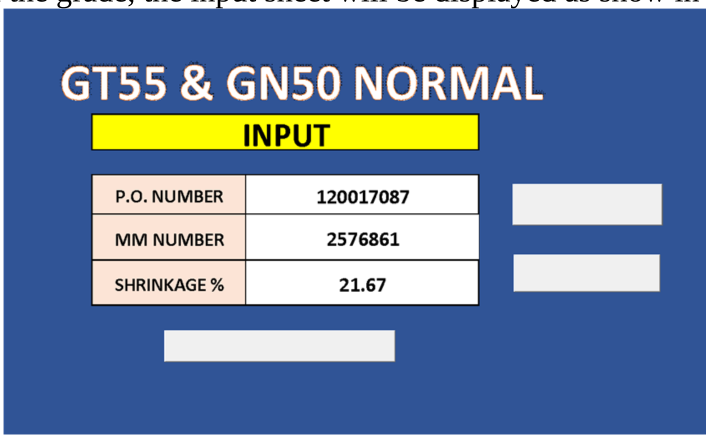
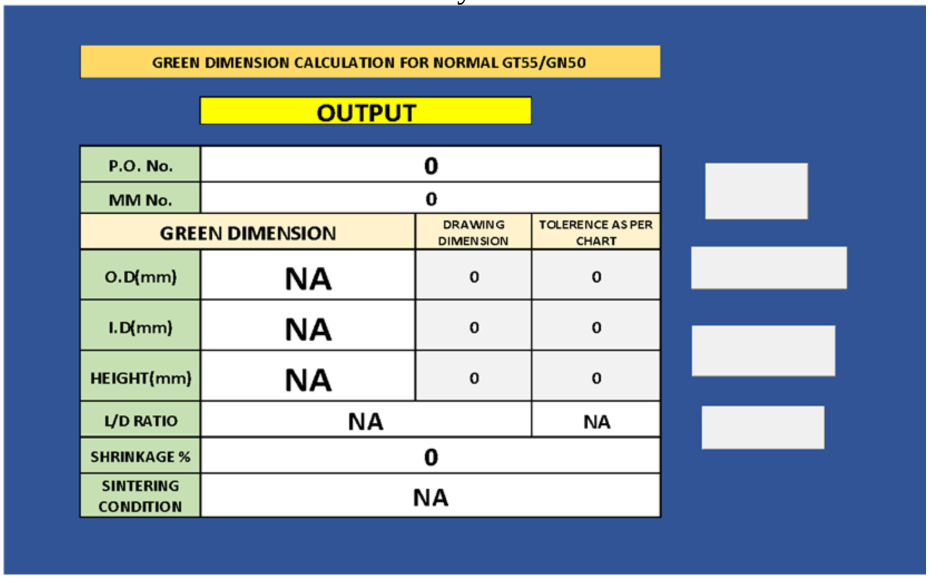


Fig 5: Program Format – INPUT SHEET with input parameters

Here, the operator must enter the P.O. number, MM. number and shrinkage % as the input parameters (as shown in below figure) to get the required output. Then click on "Green Dimension Calculation."

OUTPUT SHEET

After clicking on the green dimension calculation button on the input sheet it will be directed to the output as shown below, here the output from the background data sheet is obtained by using the VLOOKUP formula where calculations are already done in the data sheet.



GREEN DIMENSION CALCULATION FOR NORMAL GT55/GN50

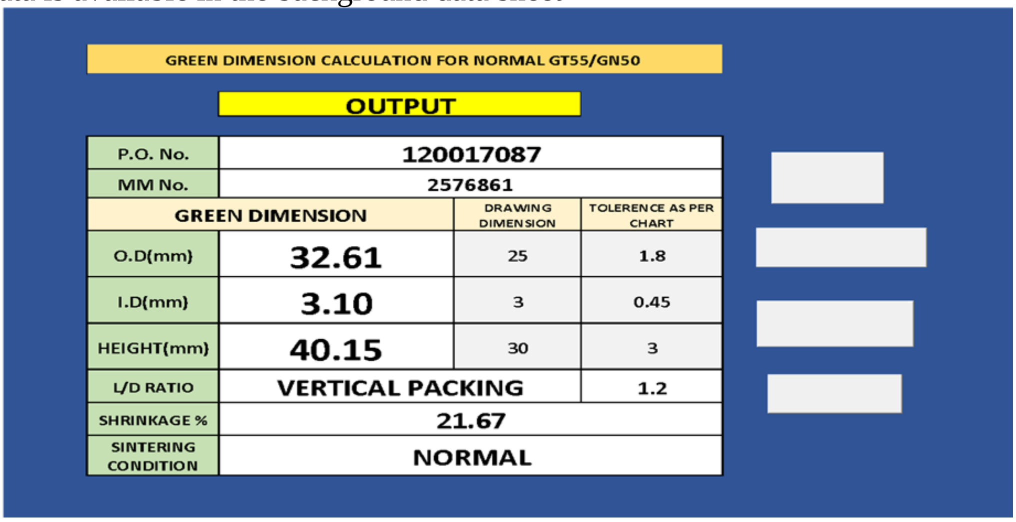
OUTPUT

P.O. No.	0		
MM No.	0		
GREEN DIMENSION		DRAWING DIMENSION	TOLERENCE AS PER CHART
O.D(mm)	NA	0	0
I.D(mm)	NA	0	0
HEIGHT(mm)	NA	0	0
L/D RATIO	NA		NA
SHRINKAGE %	0		
SINTERING CONDITION	NA		

Fig 6: Program Format – OUTPUT SHEET

There are two cases of output: -

CASE I: Here we get the required output by using the VLOOKUP formula from the data sheet, this is when the data is available in the background data sheet



GREEN DIMENSION CALCULATION FOR NORMAL GT55/GN50

OUTPUT

P.O. No.	120017087		
MM No.	2576861		
GREEN DIMENSION		DRAWING DIMENSION	TOLERENCE AS PER CHART
O.D(mm)	32.61	25	1.8
I.D(mm)	3.10	3	0.45
HEIGHT(mm)	40.15	30	3
L/D RATIO	VERTICAL PACKING		1.2
SHRINKAGE %	21.67		
SINTERING CONDITION	NORMAL		

Fig 7: Program Format-OUTPUT SHEET with the data

CASE II:

When the MM. No is not present in the background data sheet then the output sheet shows as N/A, then the operator needs to click on the manual calculator button

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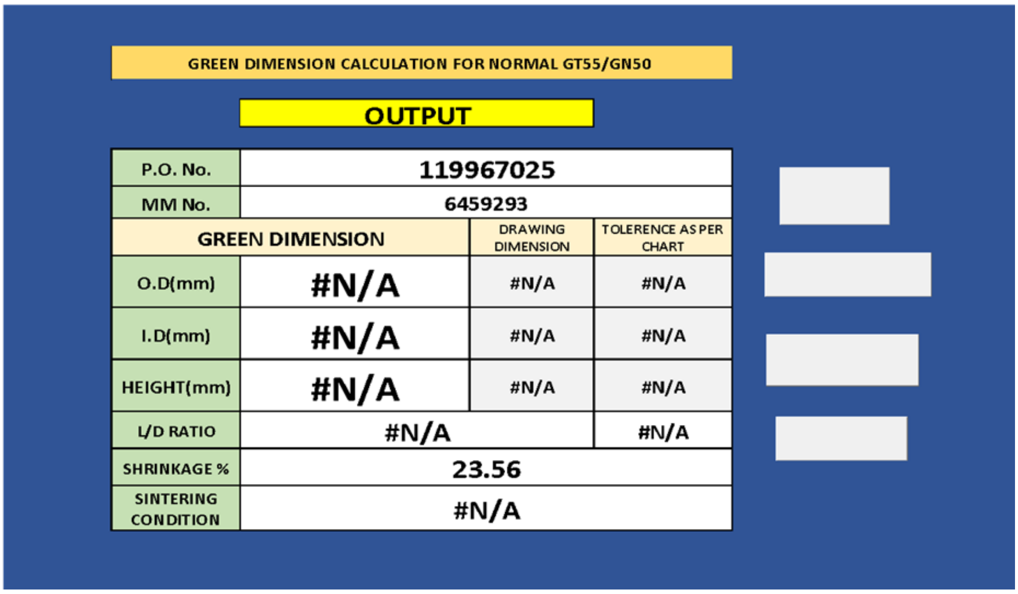

Fig 8: Program Format-OUTPUT SHEET without data

After clicking on the manual calculator button, a new input sheet will be opened as shown below

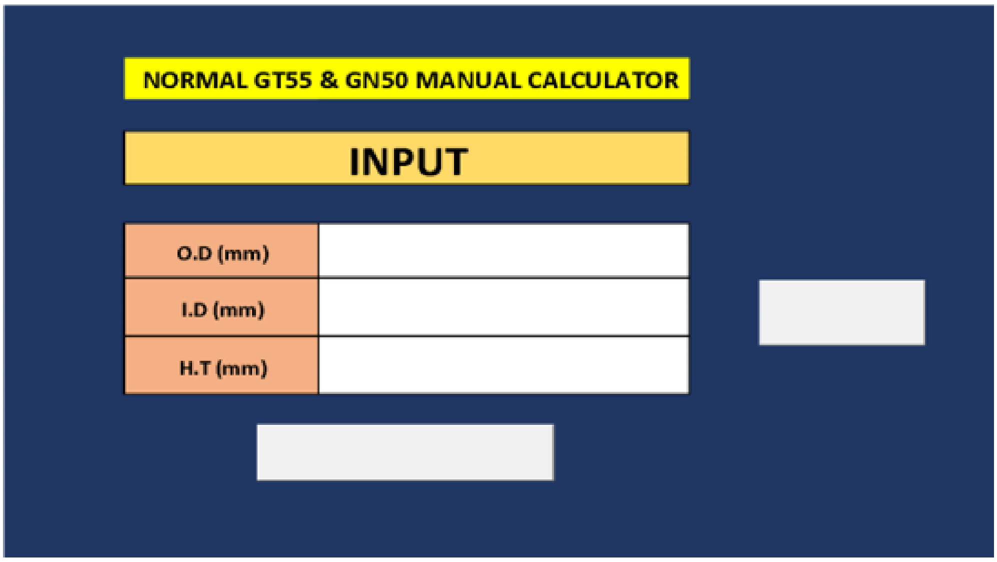

Fig 9: Program Format- INPUT SHEET for manual calculation

Here the operator needs to enter the drawing OD, ID, and HT as the input parameters to get the required output, and then click on the "Check for Green Dimension" button.

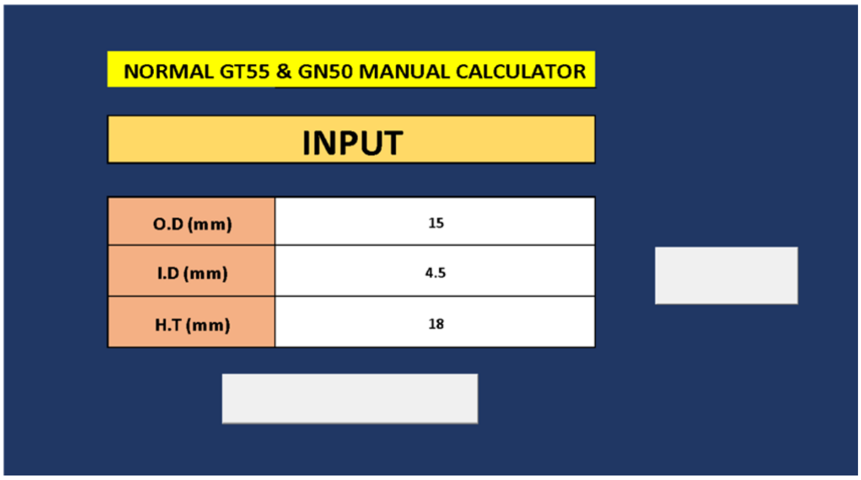

Fig 10: Program Format – INPUT SHEET with input parameters

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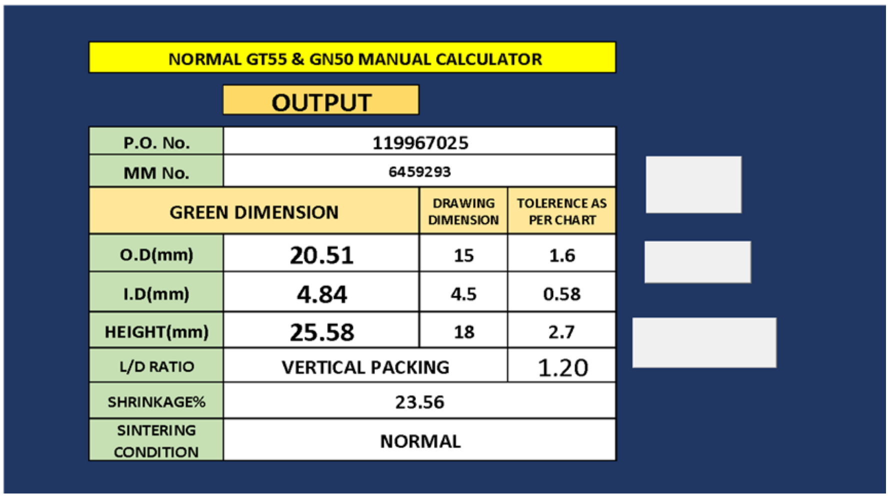
After clicking on the "Check for Green Dimension" button it will be directed to the output sheet as shown below



NORMAL GT55 & GN50 MANUAL CALCULATOR

OUTPUT

P.O. No.	119967025		
MM No.	6459293		
GREEN DIMENSION		DRAWING DIMENSION	TOLERENCE AS PER CHART
O.D(mm)	20.51	15	1.6
I.D(mm)	4.84	4.5	0.58
HEIGHT(mm)	25.58	18	2.7
L/D RATIO	VERTICAL PACKING		1.20
SHRINKAGE%	23.56		
SINTERING CONDITION	NORMAL		

Fig 11: Program Format-OUTPUT SHEET

After obtaining the required output click on the "PRINT" button to get the required print of the output, which is then pasted on the route card so that the machine operator can get the green dimension which is need for machining the components.

Results

To verify and validate the above analysis an experiment was conducted with the help of the guide. This experiment was done by comparing the Green dimensions obtained from the developed Excel based automation program with the manually calculated Green dimensions which has written on the route cards.

This experiment was done continuously for every single route card around 15 days. And the results which we got was as follows.

Table 2: comparison b/w manual calculation and calculations from program

DAY	No. of Route Cards checked	No. of route cards found with variations
1	180	0
2	120	0
3	150	0
4	104	0
5	115	0
6	198	0
7	120	0
8	58	0
9	92	0
10	61	0
11	46	0
12	52	0
13	86	0
14	43	0
15	118	0

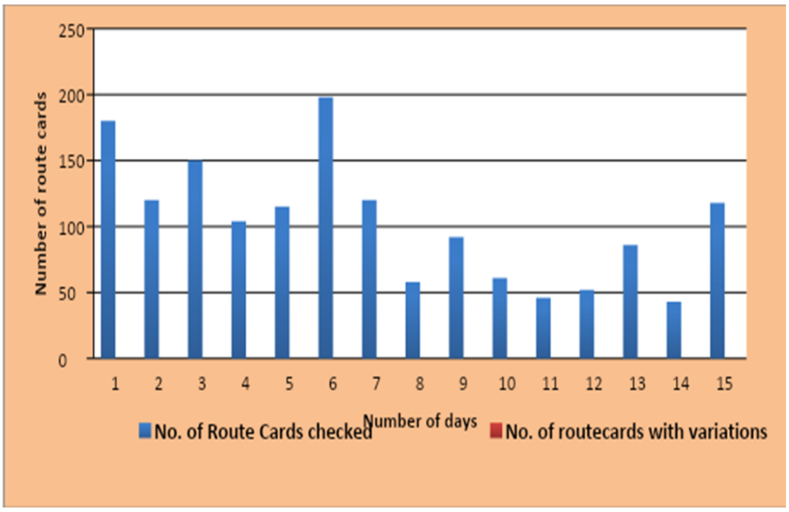


Fig 3: Graph showing comparison b/w manual calculation v/s calculations from program

Conclusion

In order to solve the problems of diminishing arable land and the rising demand for food brought on The implementation of the Macro program has sparked a revolution in the calculation process for GCI operators, markedly enhancing its efficiency. Through the automation of calculations, the Macro program has eradicated the necessity for manual computations and data input on route cards, thereby substantially diminishing errors in the calculation process. As a result, production delays have been reduced, and scrap rates have been minimized, due to precise predictions of green dimensions.

The effective deployment of the Macro program has integrated essential validation factors for rectifying green dimensions in both Grade "A" and Grade "B" materials. This program, combined with parameters like L/D Ratio, Packing Condition, and Sintering Condition, has successfully guaranteed precise green dimensions.

The creation of the Macro program has facilitated the attainment of printed green dimensions, obviating the need for manual entries on route cards. Additionally, this program empowers machine operators and individuals with limited calculation expertise to acquire green dimensions for the machining process, even in the absence of a GCI operator.

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