STANDARD OPERATING PROCEDURE FOR OPTIV LITE

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Purpose

The purpose of this document is to understand the standard operating procedures for the Zeiss O-inspect - 543 in CMM lab in Bangalore, also to operates the machine at its maximum efficiency and safe in manner.

1. Application scope

This standard operating instruction applies to GDMC Bangalore location and specifically the Zeiss O-Inspect machine in the CMM laboratory. This is especially applicable for the metrology purpose of the machine.

2. Definition and abbreviation

GDMC

CMM

PCM

CAD

Tactile Sensor A tactile sensor functions on the principle of mechanical contact with the workpiece. The resulting signals are then derived from this contact for further processing.

Optical Sensor An optical sensor, is a non-contact instrument that uses images to perform measurements.

Glass-scale A Glass scale is very precise ruler attached to all the axes of the CMM, and on its surface, accurate divisions are equally marked.

Encoder A encoder is a device which works in combination with the glass scale which helps to read the graduation on the glass scale.

3. Machine specification

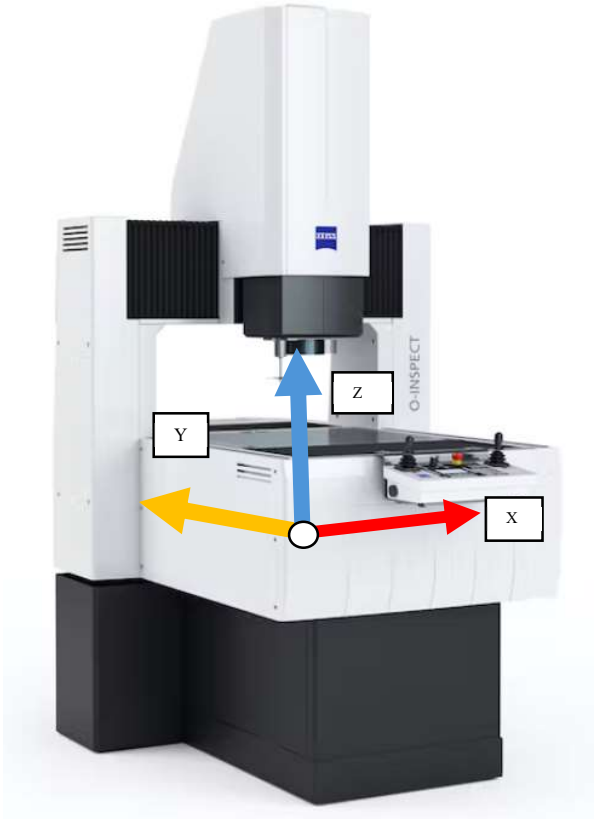
The Zeiss O-inspect is a multi-sensor CMM machine, which is having the optical sensor as primary and having tactile sensor as secondary. This machine working length is 500 mm, breath 400 mm and height is 300 mm.

This machine is a cantilever type machine, and the bed is a moving glass table is because of the optical sensor needs the back light to operate. The tactile probe head is VAST XXT with M3 with passive sensor.

4.1.Machine axis

All CMM's works on one principal called Coordinate system also right-hand thumb rule for co-ordinate directions. There are 3 axis X, Y and Z will exist in all CMM. The creation of geometric elements and all background calculations are processed based on X, Y and Z values we create on the software. Each axis contains a Glass-scale and an encoder along with guide vanes in-order to read the CMM movement values

to software. Since Glass-scale is extremely sensitive to outside environment, it cannot be seen outside as it will be covered by strong shields.



4.2.Components of machine

There are many important components there in co-ordinate measurement machine, there are

- Controller
- Machine bed
- Software
- Joystick
- Glass scale and encoder
- Stylus system
- MSR
- Rotary table

4.2.1 Controller

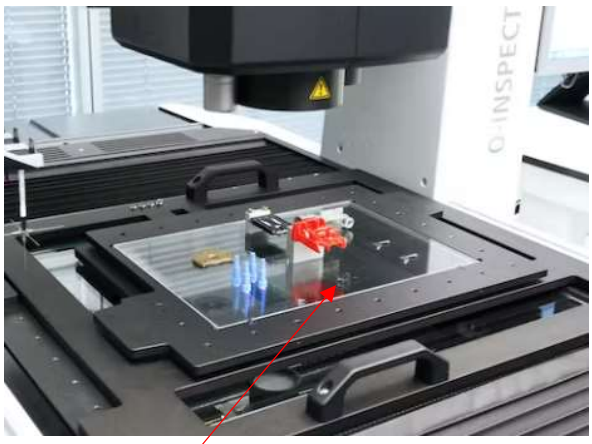
The controller is the brain of a co-ordinate machine because all the calculations and the encoder data will be processed in the controller. The controller of a coordinate measuring machine must fulfill many functions, which can be summarized under the heading axis control, object probing, programming, control of the measuring run, data acquisition and evaluation.

Zeiss – O Inspect Controller

4.2.2 Machine bed:

The machine bed is made mostly made of granite table for more stability and good finish (mostly lapping surface), this is to maintain the better flatness of the bed. All our part locator or fixture should be clamped on the bed. In O-inspect machine, the machine bed is made of glass because the machine is multi-sensor machine. The table should be transparent for using the backlight in the machine to get proper illumination for the optical measurement.

The surface should be free from dirt and impurities as it is considered as the level for keeping components before doing inspection. Hence the bed should be parallel to ground and should have high surface finish.



Glass type machine bed

Granite type machine

4.2.3 Software

The metrology software used to interpret the data given by machine (mostly the discrete point data). The software allow us to do the measurement and present the data in the respective requirement. In market there are many software available for CMM and its with respect to manufacturer. For Zeiss o-inspect 543 machines in Bangalore facility has integrated with CALYPSO 2021 (Version 7.2.20). In this software, we have license basic metrology measurements, GD&T measurements, 3d curve and freeform surface for the profile measurements.

In market other software available like PC-DMIS, Mitutoyo, CMM Manager etc.,

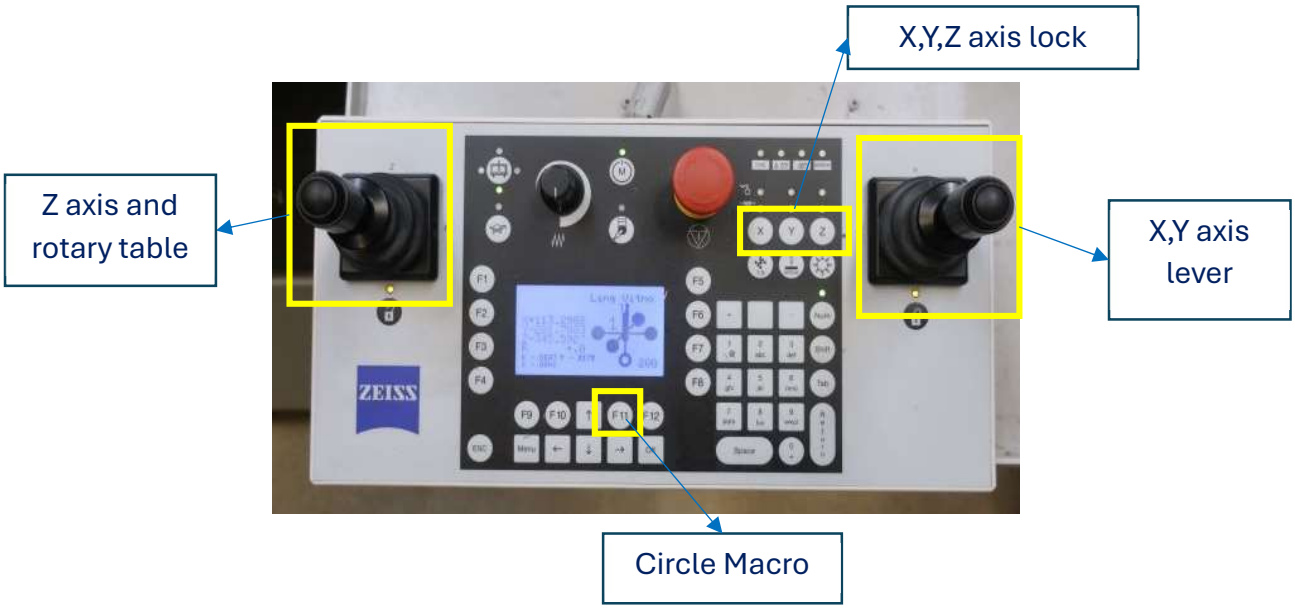
CALYPSO 2021

PC-DMIS 2017

Mitutoyo

4.2.4 Joystick

The joystick is used to control the axis movement of the machine manually. This will be used for the manual measurement or manual programming. This joystick consists of two levers for axis control, speed knob for speed control also the drive button (explained later in the document) also other function buttons for proceeding some action like homing, auto circle, program start etc.,



4.2.5 Glass scale and encoder

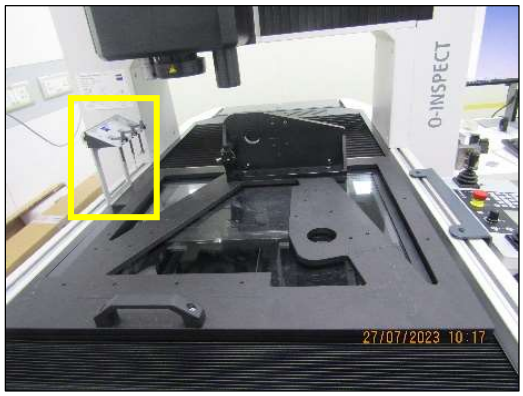
The glass scale and encoder are responsible for collecting location information about the current location of the machine in all three axes (for rotary table it works in different procedure). This setup is called the length measurement system, and this is directly coupled with the controller for seamless connection and data transfer.

4.2.6 Stylus system

The stylus system is the data collection mechanism in the CMM. There are many sensors available in the O-Inspect 543 but mostly we call the tactile sensor's stylus as stylus system. There are some stylus systems in the calypso we shouldn't delete. Those are Master probe and Tester Probe.
The stylus system needs to be created according to the requirement or we can reuse the stylus system which is been already created and calibrated.

4.2.7 Multiple stylus rack

The multiple stylus rack used to store the probe in ready condition for using in the program. It reduces the manual interventions of changing probes between the program and measurements. The MSR needs to be calibrated before using the MSR. The calibration steps been discussed later in the document.



4.2.8 Rotary table

The rotary table is acting as a fourth axis for the machine. This allows us to use the machine to inspect various side features in a single setup program. The part which is mounted on the rotary table will be rotated while collecting the points. This will help us to measure the parts in real time scenarios like runout measurements.

4.3.Operating specification

There are some specifications we need to maintain for installing the software and prerequisites of the computer. The requirements of the calypso machine computer is listed below

Necessary system requirements

- Intel Core i3 processor
- 4 GB RAM
- OpenGL compatible graphics card
- Windows 10 (64-bit 21H2) with current security updates

Recommended system requirements

- Intel Core i9/Xeon (16 Core) processor
- 64 GB RAM or more
- Windows 10 (64bit 21H2) with current security updates
- Certified graphics card for the use of ZEISS INSPECT

4.4.Software

There are two software for the Zeiss machines, these are CALIGO and CALYPSO, In the O-inspect 543 we have inbuilt with CALYPSO, In Bangalore premises we have calypso and software properties are

- Year of release 2021
- Version 7.2.20
- Licenses Basic, GD&T, Freeform surface, Curve
- Operating system Windows 10

4.5.Sensor availability

The Zeiss O-inspect is a multi-sensor machine it has three built in sensor for points collection these are explained below

4.5.1 Tactile sensor

In Zeiss o-inspect 543 the active tactile sensor model is used for physical part touch method. The sensor used is VAST XXT. This comes with TL3 – M3 threaded joints adaptor plate. Some main specifications are listed below

- Type: Scanning and single-point sensor
- Measuring speed up to max. 2.5 seconds per point and up to 500 points/s by scanning
- Stylus tip diameter of 0.3 to 8 mm
- Maximum stylus weight = 15 g

4.5.2 Optical sensor

This machine has discovery V12 2D camera with image processing functionality and autofocus. These images will be processed for dimensional analysis. This entire tactile, optical, dot scan setup mounted on

the single frame Z-axis so whatever the movement on Z axis will affect the movement of other sensors also the length measuring error on the axes will be same for all sensors. Some key specifications given below

- Measuring speed: 30 frames/s
- Working distance: 87 mm
- Zoom level: 10 fixed zoom level
- Zoom: 12x

4.5.3 Dot scan sensor

The dot scan is mounted in the right last on the sensor head. This is a pointer laser which can measure only z value of different levels in this machine. This is a white light distance sensor works in a principle of triangulation is mostly used in two cases which is groove deep point measurement and the high point intensity with shorter time. The key specifications listed below

- Measuring rate: 1000 points/s
- Working distance: 55 mm
- Resolution: 60 nm
- Measuring range: 10 mm

4. Sensors and qualification

These above sensors have its own method for qualification also the qualification tools. The sensor qualification should be done every day, and the results should be recorded accordingly.

5.1.Qualification tools

The qualification can be done in different tool and the tools are

- Tactile Sensor – Ceramic spheres (Ø8 mm and Ø25 mm)
- Optical Sensor – Ring gauge (Ø16 mm)
- Dot scan Sensor – Matt finish ceramic sphere (Ø31 mm)

*Image here

5.2.Sensors for specific features

There are specific sensors to be chosen for the specific features. Small diameter features cannot be probed properly so for this kind of features the optical 2d measurement is the best choice for the measurement.

5.3.Optical illuminations

There are three types of illuminations in the Zeiss O-inspect 543

- Bright field incident light illumination
- Dark field incident light illumination
- Transmitted light illumination

For Dark field incident illumination, we have two set of lights to control the illumination on the part.

- Outer Ring light
- Mini ring light

*Image here

5.4.Qualification of sensors

The different tips of a stylus need to be qualified before they can be used in a part inspection process. The probe qualification typically comprises of finding the effective radius of the probe tip (Ruby ball radius - R), length of stylus and orientations of the stylus and errors associated with the probing system (coefficient of elastic bending of the probe).

The Standard variation (S) of the probe qualification sphere is critical for the CMM probe qualification process. The calibrated size of the sphere will be recorded inside the CMM software during the probe qualification process.

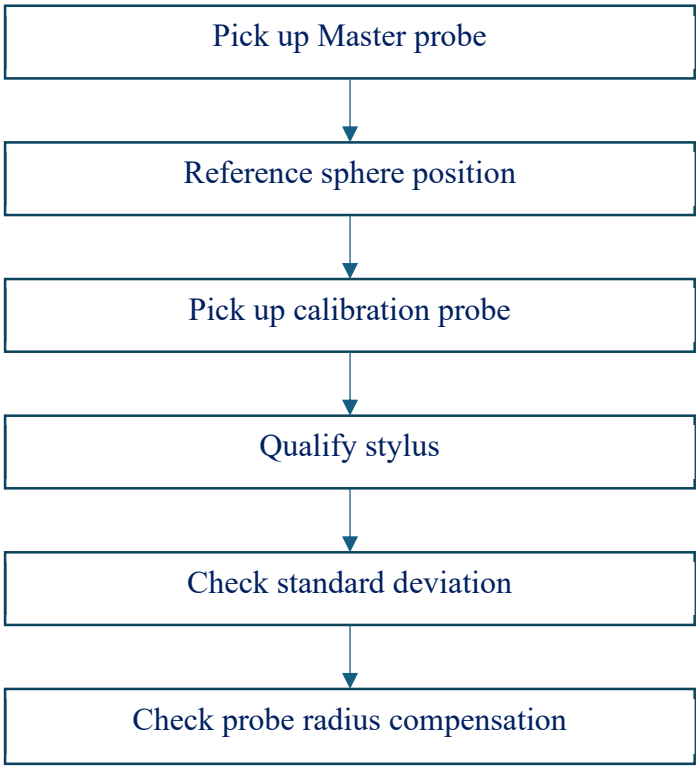
The selection of reference sphere is depending upon the size and type of the stylus system we need to qualify.

In Zeiss O-Inspect, The Master probe must qualify with all reference spheres first before doing any other probe qualifications. The selection of reference sphere was made according with the probes we are using for the measurements.

While doing the probe selection and its configuration to be used for the measurement we need to keep the below mentioned things for the consideration.

- Features can be feasible to take using the specific configuration.
- Choose the diameter of the probe, stem diameter and length of the probe feasibly
- Angles of the features and its probe numbers in the software
- The material of the part we are going to measure.

Tactile Sensor:



5.5.Probe camera offset

The probe camera offset is the X, Y distance offset between the master probe center in the tactile sensor to the optical sensor center. This will be more effective when doing program or measurement with multiple sensors in a combined manner.

According to the machine specification by the manufacturer the offset been defined, with respect to the tactile probe, the optical is 74 mm in the right side of the machine and dot scan (white light sensor) is 176 mm in same direction.

5.6.Offset calibration

From above information we get the offset which is been defined by the manufacturer but the value the manufacturer provided is not micron level accurate for doing compensation with the value. So, an internal calibration and evaluation has been a necessary requirement in multi-sensor machines.

In calypso the PCM coded program used for the offset calibration and the validation. This is due to the machine parameters can be altered inside the code. Run the below mentioned program with master probe and optical.

Reference: file location in reference

5. Work procedure

The O-Inspect 543 has a set of work procedure consists of multiple steps includes machine initialization, fixture setup and measurement etc.,

6.1.Machine Initialization

This machine initialization starts with turning on the power and before turning on the power ensure the input voltage and power of the socket. This can be done by ensuring with internal maintenance team.

After turning the switch there is a power button in the joystick, Turn this ON. Wait for a minute the controller will get fully started and later, Turn the M button in the joystick which powers the drivers of the machine.

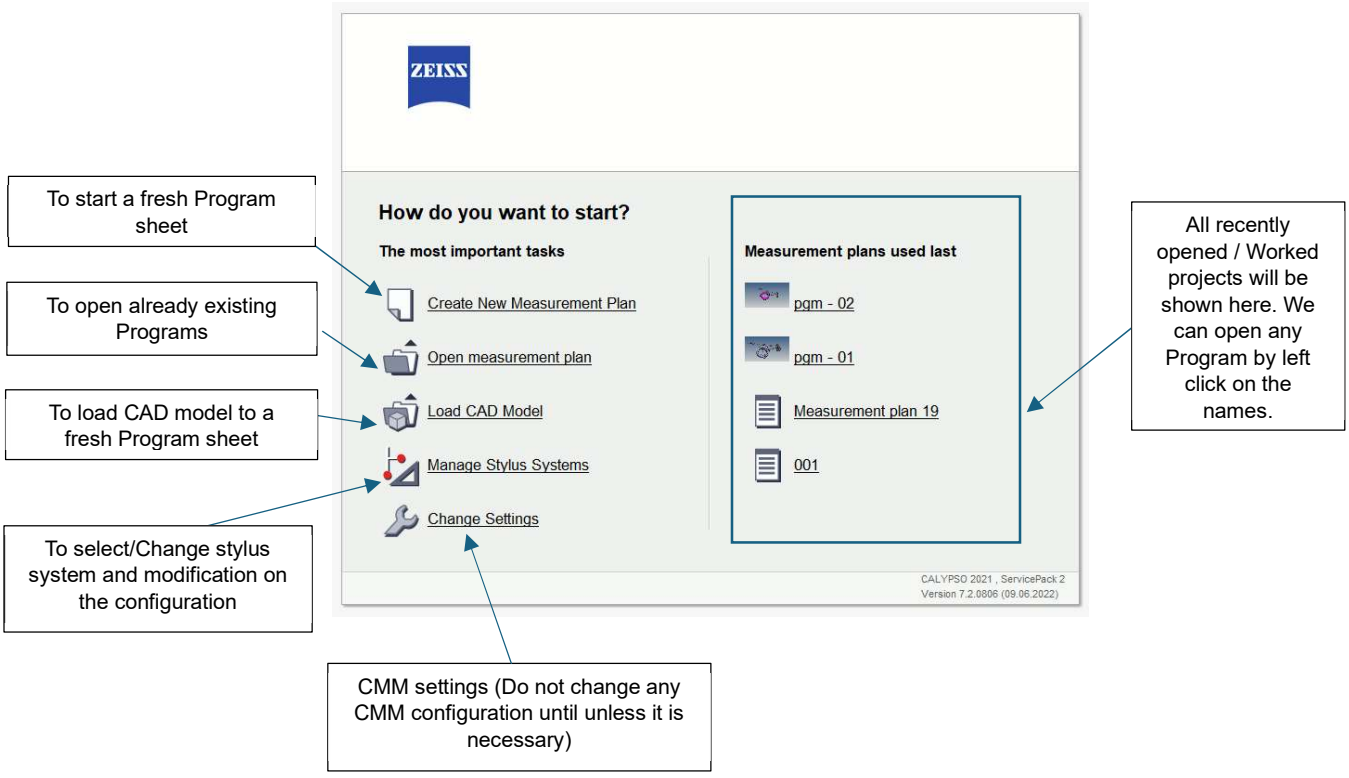
The above-mentioned process should be followed in the correct order else the software will pop up many random errors in the system also the connection between the machine and computer will be lost. This will lead to require complete restart of the machine and computer.

6.2.Software Initialization

Once the machine coupled correctly with the computer the software is ready to open. Open CALYPSO 2021 from the start menu. It will load three different windows to the screen. The windows are Main window, Status window, machine interface window. If these windows are showing without any error the software and the machine is coupled and communicating good.

Between this the homing popup will come and click OK for homing the machine at top left corner in the machine.

Once this all done, we will be end up in the main window and looks like this and the explanation provided in the image



6.3.Creation of Measurement Plan

In main window there are options to create new plan or open the saved program are in specific request folders if saved before or recent programs in main windows.

This process includes creating alignment, create features and characteristics.

6.4.Creation of Alignment

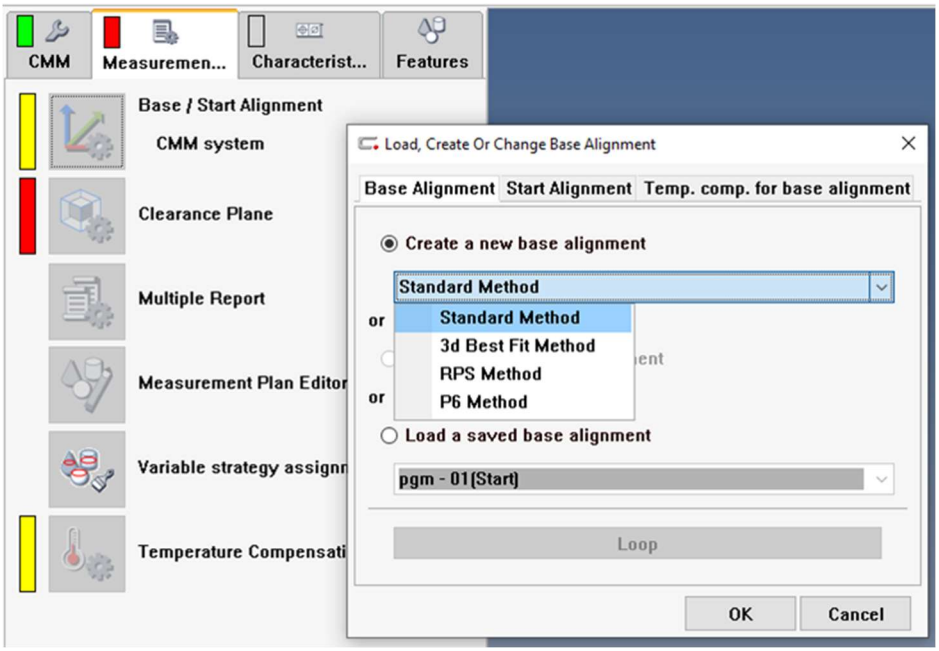
The alignment is the most important process for creating alignment in the part. This will create the part co-ordinate system in the measurement plan. Most of the elements were created with basis of base alignment which is created in the beginning.

Base Alignment is an inevitable part of CAD programming.

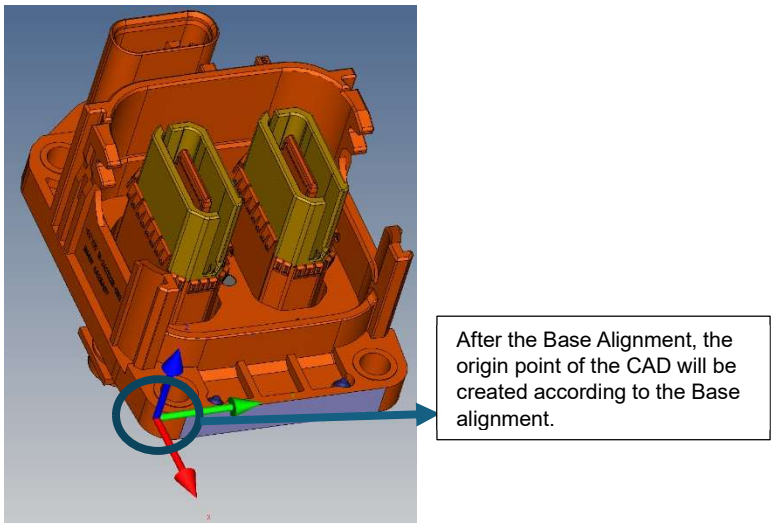
We can create as many other Sub-alignments later, but base Alignment is mandatory to do programming and measurements.

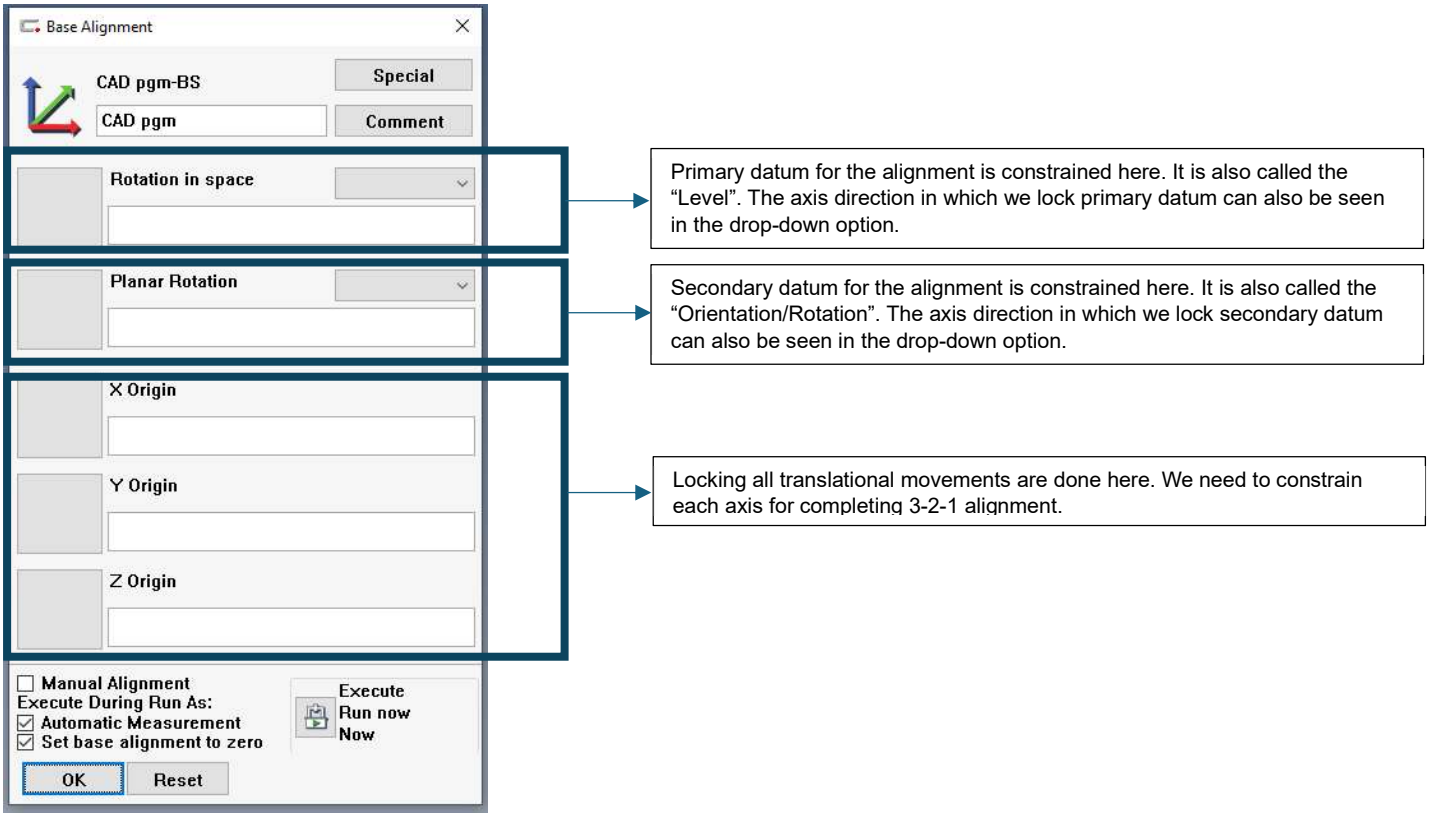
Go to Measurement tab > Select "Base/Start Alignment" > Select appropriate alignment type > Click "OK"

Standard Method: This type of base alignment is widely used. This is also called 3-2-1 Alignment.



Another window will pop-up, for selecting features and registering alignment on the CAD model.





6.5.Feature Extraction

The Feature extraction includes different strategy assignment to features and providing clearance and the retract information storing inside the feature. This also includes the evaluation of the features such as UPR, association technique and filters.

We all know a greater number of points in the feature increases the accuracy, but it also leads more measurement time for the individual feature extraction. Having in the mind we must extract the features with good number of points and quicker as possible

6.5.1 Tactile

The O-Inspect 543 contains the passive sensor which can scan the surface of the part to get multiple points in minimal time compared to trigger probes. The strategy will differ for feature to feature

Here is the list of different approaches for the features

Plane: Probing points, Polyline scan, Grid scan, Multiple poly line scan, circle path scan.

Cylinder: Probing points, Circle path, Helical path scan, Linear line scan.

Circle: Probing points and circle path scan

Cone: Probing points, Circle path, Helical path scan, Linear line scan

Line: Probing points, Linear scan.

After the extraction of points from the actual sample, these points been processed and constructed by the evaluation and its settings. CAD is used to define the points very accurately in the feature for the extraction. This also provides the accessibility to nominal features to define its orientation and size accurate in manner.

6.5.2 Optical camera

The Optical Feature extraction is not like the tactile. Since the optical camera is the image extraction and processing technique the accuracy always depends on the quality of the image as well as the expertise of the operator.

In this the illumination also plays a major role for a good image extraction. Once the illuminations set in perfect, the grey scale values will be determined in each the pixels of the image, once we use any of the technique below accordingly the grey scale calculations and its transmission been recorded for the feature data collection.

Autofocus – Searching the better contrast image to get the surface points

Two-point scan – Starts searching the point from start point to finish point, a sudden threshold will be triggered.

Circle Scan – This also uses the threshold method in different direction within the scan area to detect the edge points

Templates – The templates are the manual extraction, it allows us to draw the lines circle, points. This also allows us to find the between angles without creating features.

Since the templates are manual extraction the influence of the operator is very huge compared to other techniques.

6.5.3 Dot scan

The dot scan has a similar quality such as tactile has but in limited projection angle features, this allow us to take planes and points, but the vector should be always same to the Z+ to the machine coordinate system.

Plane: Probing points, Polyline scan, Grid scan, Multiple poly line scan, circle path scan.

6.6.Measurement

The good measurement requires the alignment system, the features with appropriate points and parameters and callout technique. There are few callouts explained below for the understanding

6.5.1 Distance

The distance is the most usable callout when it comes 2d drawing measurement because most of the feature controls will be there in the distance controls between the feature to the feature. In Calypso we have numerous options to callout for the distance controls, The most using distances is explained below.

Cartesian distance:

In this cartesian distance the distance callout contains four inputs which is two features and two datum features for Spatial and planar rotation. In this measurement the second feature will also act like the rotational lock for the measurement. This second feature must be a line or planar element, this cannot be a point element because the point cannot be used for orientation purpose. Attached screenshot for the better understanding

Caliper distance:

This caliper distance used to calculate the max-to-max distance between the circles/radii this will also help us to quick measure the distance between the elements with respect to base alignment or sub alignment which we have created in the plan.

6.5.2 Angle

The angle measurement is for the between features, The complimentary angle, supplementary angle also the projection angle with respect to projection planes.

Angle between the feature: This will provide the different angles such as the opposite, adjacent, supplementary, complimentary angle between the features such as planes and lines or cylinder as well.

Projected angle: The projected angle can be called out for the single feature, and it is always represented with respect to the alignment system, which is been created for the selected feature, for e.g.: the projections can be for a X/Y plane and Y/Z plane as well.

6.5.3 True position

True position callout c

6. Safety measures

There are many etiquettes to be followed inside the lab environment.

Change Date (yyyy-mm-dd)	**New Revision**	**Chapter**	**Changes** (short description)	**Name**
2023-08-xx	1	All	Initial Release	Ajesh George E