Analyzing and Improving Process of Assembly for AE and CE Type Chemical Reactors to Maintain Repeatability

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Abstract
A chemical reactor is an enclosed vessel in which a chemical reaction takes place. Agitator shaft is used to mix the ingredients inside the chemical reactors. To prevent the reaction of the ingredients with the material of the agitator and surface of reactor, glass lining is provided on the agitator and inner side of the reactor. To avoid the damage of glass lining the components used in chemical reactors must be precisely placed. This project is about maintaining repeatability in reassembling drive assembly of chemical reactors which reduces the cycle time required for resetting the parameters like coaxiality, concentricity and flatness.
Coaxiality and concentricity must be maintained to prevent damage of glass lining and mechanical seal. Flatness must be maintained to avoid leakage of ingredients during working condition. Therefore, each parameter like coaxiality, concentricity and flatness have to be maintained within the range of 20-50 microns. This paper contains the experiments carried out to analyse which components affect the parameters and the problems occurring due to the existing method of assembly along with their solutions.

***Key Terms* – Assembly, Parameters, Repeatability**

I. Introduction

Repeatability must be maintained to obtain ease of setting parameters and to reduce the time of reassembling the reactor. Following are the terms used,
Co-axiality: Axis of two or more components must be in same line.
Concentricity: Having same centres of circular parts.
Flatness: Levelled surface without any raised areas.

Fig 1.1: Coaxiality

Fig 1.2: Concentricity

Fig 1.3: Flatness

The problem is that when certain client demands for reassembling the entire drive assembly. The problem is that when the client reassembles the drive assembly the parameters which are set initially get totally changed and the entire process is to be repeated, also this method causes lot of dimensional errors in the component because of non-standard methods.
This paper deals with analysing the entire process and suggesting methods to improve the existing one so as to maintain the repeatability for each reactor.

II. FACTORS AFFECTING REPEATABILITY

RECOGNITION OF COMPONENTS AFFECTING EACH OF THE THREE PARAMETERS

- Muff coupling: In the untightened position the coupling is fitted onto the agitator shaft and then it is tightened with the bolts.
- Bearing sleeve: Untightened condition is the normal position in which the shaft is placed inside the bearing housing and in the tightened condition the bearing sleeve is tightened which holds the shaft tightly and together the coaxiality is achieved.
- Flatness is measured with reference to the agitator shaft and the bolts of the pad plate are tightened depending upon the reading obtained from the dial indicator (negative or positive). If the reading obtained is negative then the bolts near that region will be loosened and if positive reading is obtained then the bolts will be tightened.
- Concentricity is also measured with reference to the shaft and the pad plate is moved in order to achieve the concentricity.

TABLE 1: READING OF DRIVE ASSEMBLY IN THE UNTIGHTENED AND TIGHTENED CONDITION

Parameters (microns)	Component	Untightened condition	Tightened condition
Coaxiality	Muff coupling	250	150
	Bearing Sleeve	250	70
Flatness	Fasteners (of pad plate)	50	30
Concentricity	Pad plate	100	50

- Based on the above readings, three things can be noticed
  - Coaxiality depends on tightening of Muff coupling as well as bearing sleeve.
  - Flatness of base plate depends on the fasteners (applied torque on fasteners) which fastens pad plate with base plate.
  - Concentricity depends on the position of the pad plate with reference to the lantern stool.

MEASUREMENT OF VARIATION IN SET PARAMETERS WHILE REASSEMBLING THE DRIVE ASSEMBLY

- The lantern stool was lifted from its position by removing the bolts and again placed in its position.

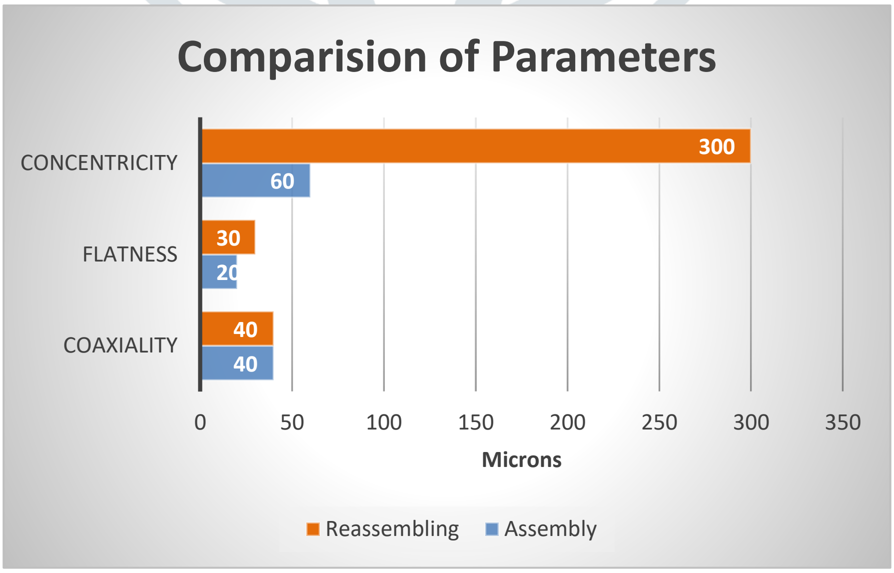


Fig 2.1: Effect of reassembly on parameters

- From the above graph it can be concluded that when the lantern stool is lifted during reassembly the major change is observed in Concentricity as the reference (the central axis on lantern) with which the readings were taken gets changed.
- The reason for the change in reference is that the bolts with which the lantern stool is fixed has a clearance of 1-2mm, so the lantern stool can shift by this much amount, translatory motion along x-y axis and rotatory motion along z axis.

DETERMINATION OF BENDING IN THE BASE PLATE DUE TO WELDING.

- When the base plate is welded with the supports as shown in the fig 2.2 it causes the base plate to bend.

Fig 2.2: Welding of base plate with supports

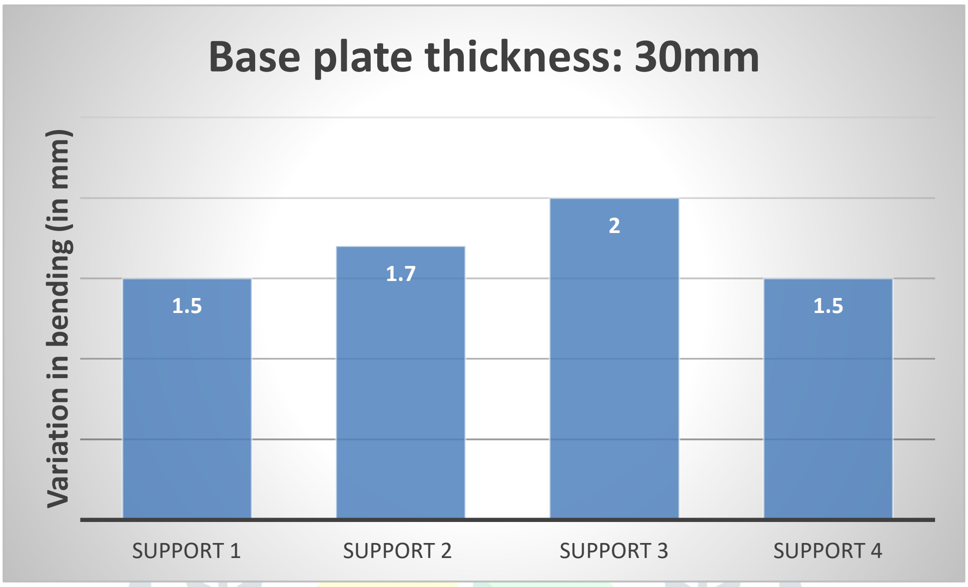


Fig 2.3: Amount of bending at welded supports for 30mm thick base plate

- It can be seen from the above graph that the variation observed in bending is very large for the 30 mm thick base plate. The reason for bending due welding is as follows:
  - Initially the base plate is at the room temperature, when welding takes place the base plate is heated to the welding temperature, now the base plate gradually cools from this welding temperature to room temperature after welding, hence internal stresses are generated in the base plate causing bending.[3]
  - The amount of bending depends upon the thickness of the plate, in the present thickness used (30mm) the bending ranges from 1.5-2mm.

III. SOLUTIONS

To overcome the above-mentioned problems the following solutions are suggested

DOWELING PROCESS

- In order to circumvent the problem of movement of the lantern stool along the three axes it became necessary to fix its motion along these axes. The following solution was used to fix the position of the lantern:
- Using the doweling process the motion of the lantern stool with respect to the base plate is eliminated.

→ **Dowel positioning:**

- First hole on 45° and second hole on 195° with the reference to X- axis of lantern based on 3-2-1 principle of location.[4]
- The holes will be at the PCD of 135mm radii. The diameter of the hole will be 10 mm through from lantern and up to half the thickness of the base plate. The Dowel pins can be positioned in the area between 480mm to 580mm diameter as the main purpose of dowel pins is to fix the location of the Lantern stool. But, the distance (or angle) between them must be maintained such that all the Degree of freedoms are constrained as per 3-2-1 principle.

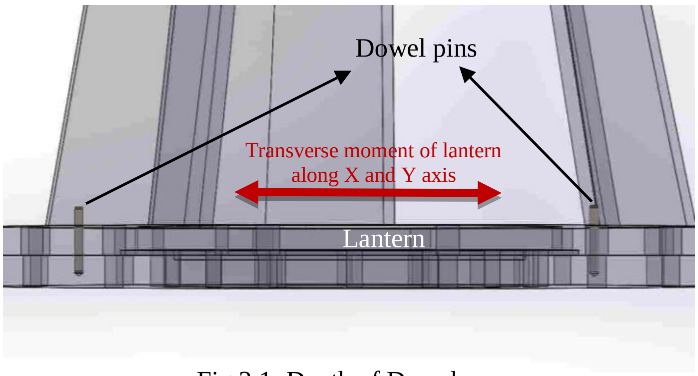


Fig 3.1: Depth of Dowel

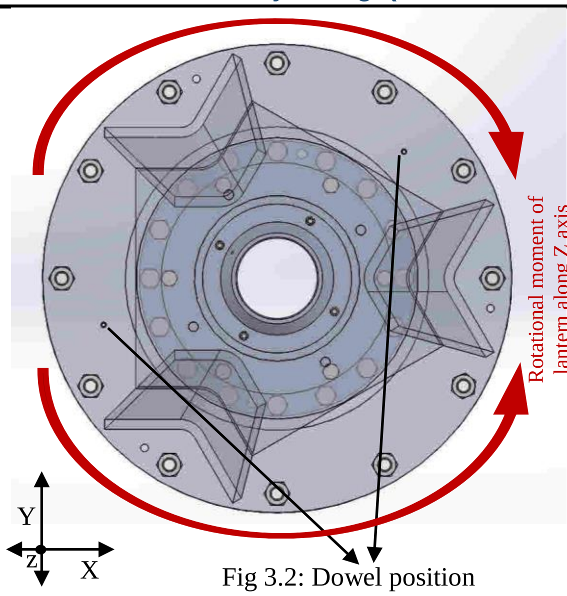


Fig 3.2: Dowel position

Spring pins for doweling:

- Reason for using spring pin for doweling is that these pins are flexible such that they can be easily pressed to fit in the drilled holes for positioning.
- Also, when there is need to lift the lantern after the doweling process it will become easy to lift.
- As per ISO 8752, for the chemical reactor of capacity 5KL with shaft diameter 100mm spring pin of diameter 12mm was selected.

Fig 3.3: Spring pins [9]

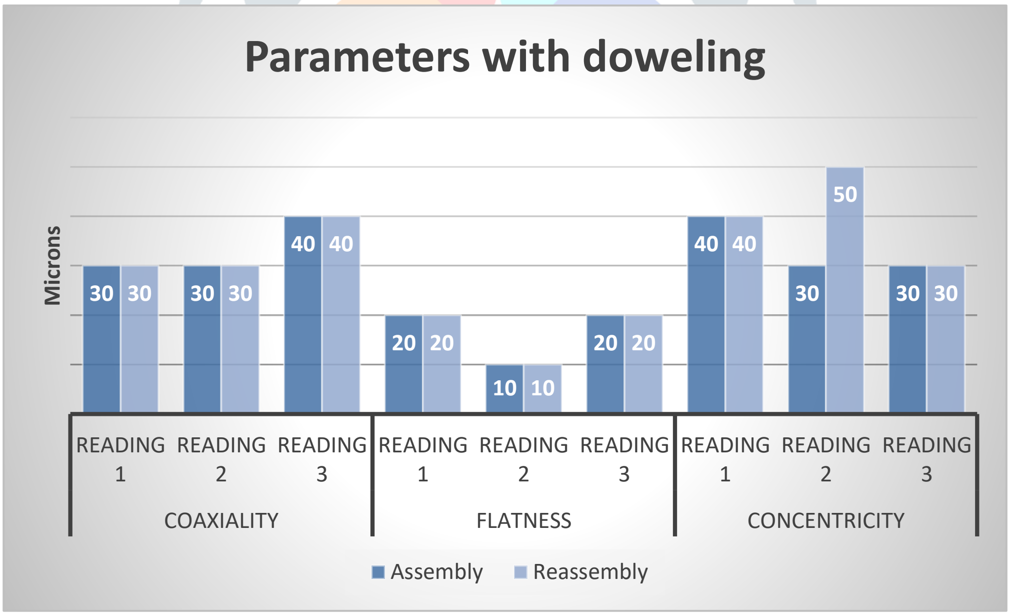
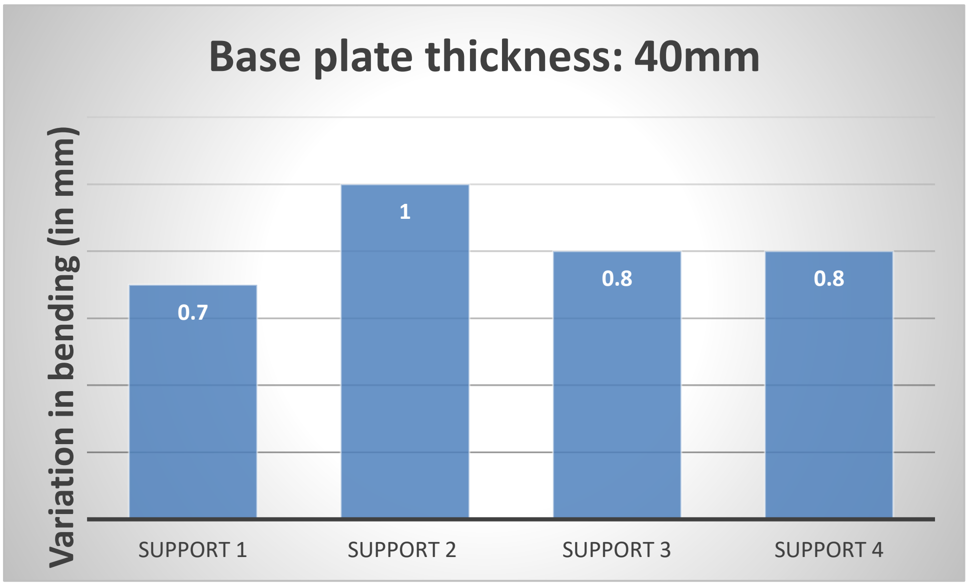


Fig 3.4: Effect of reassembly with doweling on parameters

BASE PLATE THICKNESS:

- We increased the thickness of the plate by 33% (i.e. from 30mm to 40mm).
- By increasing the thickness of base plate, the bending is reduced to 0.7-1mm.
- But, on the other hand material cost will increase.
- The material cost will increase as per the below calculation (for 5kL capacity reactor).



CALCULATION:

- Increase in volume (ID: 271mm, OD: 690mm)
    - $V = \pi[345^2 - 135.5^2](10)$ (thickness increased = 10mm)

      $= 3162476.39mm^3$
- Increase in mass
    - $M = 3162476.39 \times 7.85 \times 10^{-3}$ (density of MS=7.85×10^{-3})

      $= 24825.46$ g

      $= 24.83$ kg
- Increase in material cost.
    - $P = 24.83 \times 35$ (cost of Mild Steel = 35 ₹/kg)
    - $\boldsymbol{P}$ **= ₹869**

CONCLUSION:

1. Using spring pin for fixing the position of lantern stool will reduce the variations obtained in parameters during reassembly and are brought in limit up to 50 microns each time.
2. Bending in the base plate was reduced to 0.7-1.0 mm by increasing thickness of base plate, this increase in cost is 0.54% of the total cost of the reactor (i.e. 16 lakh/reactor for 5kL reactor). Thus, this solution is feasible.

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[9] Photo courtesy

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