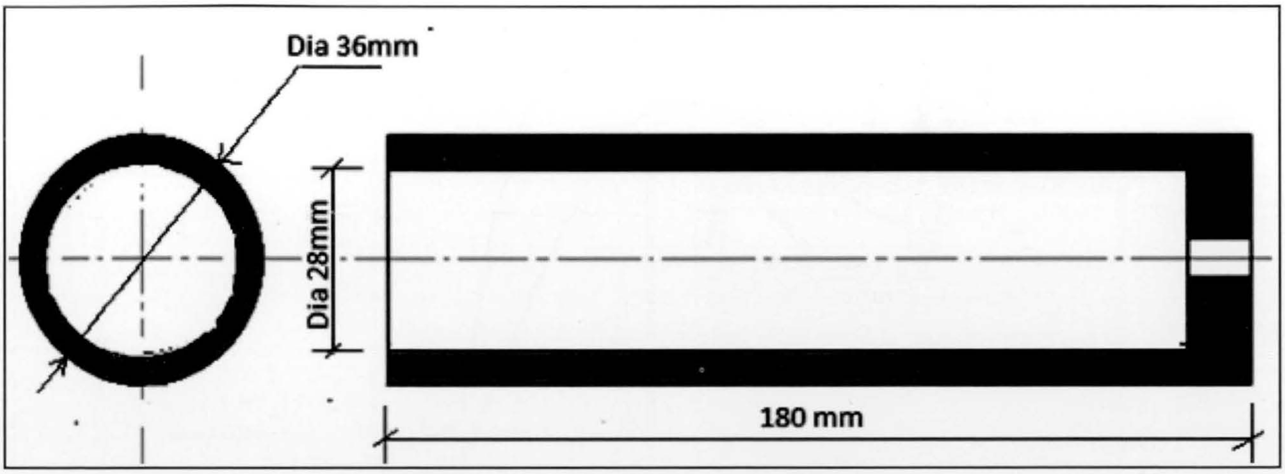


Fig 1. Dimensional details of work piece

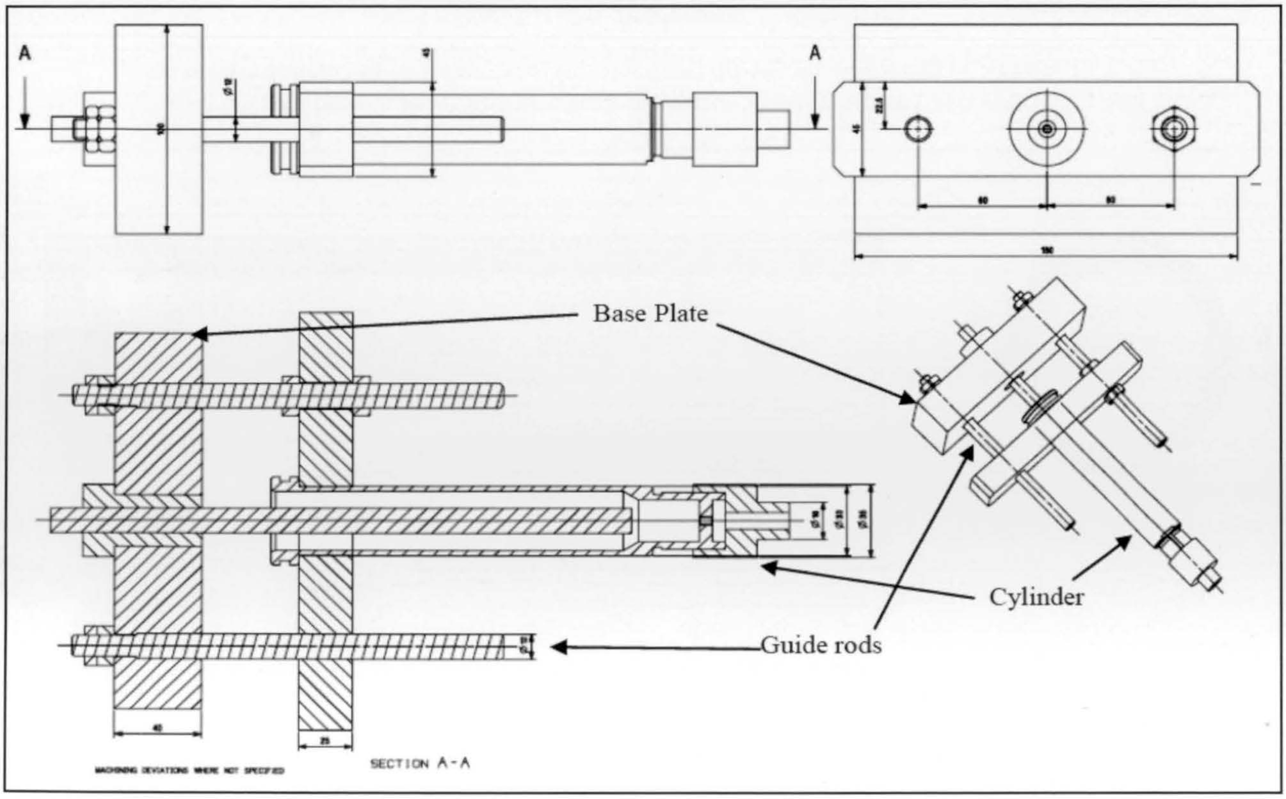


Fig 1. Schematic Details of Special Fixture with Cylinder Set Up

The finished job was inspected using two point contact bore gauge for dimensional accuracy including cylindricity and circularity. The surface finish was measured with Mahr, Germany make surface finish measuring equipment.

2.2 Design of Fixture

The fig- 2 & 2a shows the sectional view and 3 D model of the fixture along with the work piece.

The fixture consists of two parallel plates, top one made out of alluminium and bottom plate from carbon steel. Two guide rods ensure the parellality of base plates and perpendicularity of anode rod w.r.t base plates, thereby ensuring concentric position of lead anode inside the bore. Further the design has taken care of avoiding direct contact between top plate and lead electrode by inserting the Teflon bush.

2.3 Experimental Procedure

The apparatus for this experiment is depicted in

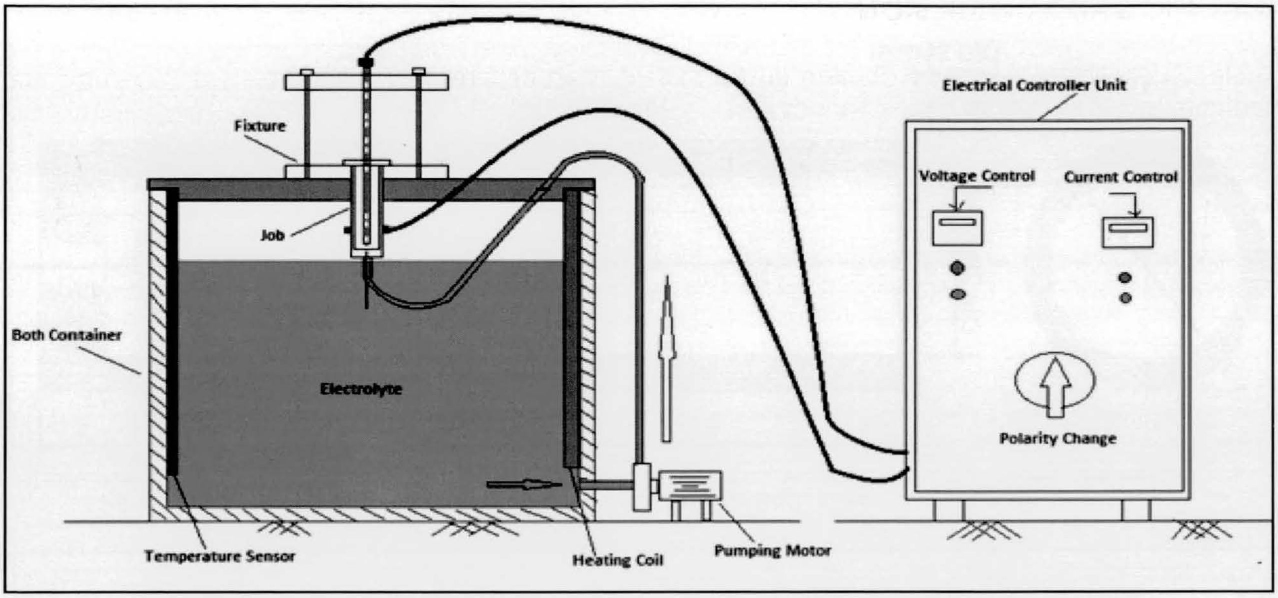


Fig 2. Schematic of Experimental Set-Up (with fixture) for Chromium Electrodeposition on Interior of Cylinder, Length: 250mm, Inside Diameter: 30mm, Anode Diameter: 12.5mm

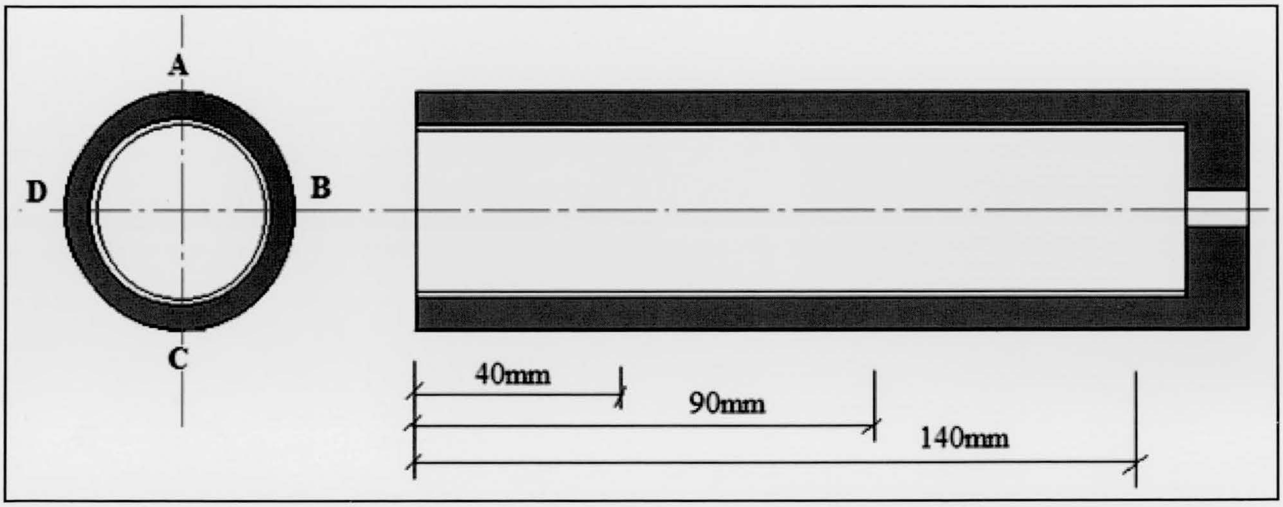


Fig 3. Thickness Measurement Circularly A, B, C and D Location and Axially at 10, 40, 90 and 140mm Positions

Fig. 02. The lead anode of size 12.5mm dia and 300mm long is used for the job size of 30mm dia and 250mm long. The electrolyte flow rate was controlled using a pump. The electrolyte storage of 250 liters capacity was connected to the circulation line, and the temperature was maintained using a water bath heater and thermo couple.

The major ingredient of the plating bath was chromic acid (250g/1it) with sulfuric acid (2.5g/1it) added as the catalyst. Before plating, cylinder was thoroughly cleaned with organic solvent and detergent. In addition to this surface etching is carried out by passing reverse current. The inside surface of the tube was then plated with chromium for 7 hours at constant parameter of current 30A, temperature 55^{0}C and flow rate 4 l/min. The plated tube was then washed with running water and stored for later testing. Experiment was conducted in two stages. In the first experiment the anode was mounted on the top plate and intentionally pulled on one side so that the anode is inclined in the bore making it nearer to AC plane and away from BD plane. In the second set of experiment anode was placed inside the bore such that it is concentric throughout the bore length. The measurement of plating thickness is carried out using Eddy/magnetic current dual scope as per test plan given in the fig. 03 and the values are reported in table 1 & 2.

3. RESULTS AND DISCUSSION

Table 1 Deposit thickness distribution on a cylinder at an apparent current density of 30 A/dm^2 and temperature of 55°C with inclined anode

Position of measurement 10 mm depth		Average coating thickness measured in microns			
		40 mm depth	90 mm depth	140 mm depth	
A section		87	85	95	111
B section		84.5	84	87	87
C section		90.5	86	78	71
D section		88	85	83	84
Avg. Plating thickness		87.5	85	85.75	88.25
Variation along the	Circumference	6.0	2.0	17.0	40.0
	Length	26.0	3.0	5.0	19.5

Observation:

1. Maximum observed variation in thickness throughout the cylinder is (Max thickness – Minimum thickness) 38 microns. The maximum variation along the cross section is 38 microns
2. Coating thickness is gradually increased along the length in A position and
3. gradually decreased in C position. Whereas the thickness is almost constant at B & C locations indicating that the anode was inclined during plating in one plane (along AC plane).

Table 2 Deposit Thickness Distribution on a Cylinder at an Apparent Current Density of 30 A dm–2 and Temperature of 55°C without Inclination of Anode

Position of measurement 10 mm depth		Average coating thickness measured in microns			
		40 mm depth	90 mm depth	140 mm depth	
A section		87	85	95	111
B section		84.5	84	87	87
C section		90.5	86	78	71
D section		88	85	83	84
Avg. Plating thickness		87.5	85	85.75	88.25
Variation along the	Circumference	6.0	2.0	17.0	40.0
	Length	26.0	3.0	5.0	19.5

Observation:

1. Maximum observed variation in thickness throughout the cylinder is (Max thickness – Minimum thickness) 8.6 microns. The variation along the cross section is 1.7 microns
2. Coating thickness is fairly uniform on both the plane.

The coating uniformity is represented graphically as follows. The 'x' axis represents the depth at which the coating thickness is measured. And 'y' axis represents the coating thickness in microns. It is clear from the graph that the coating obtained (when the anode is inclined) is fairly uniform upto a depth of 60 mm and beyond 60 mm depth the coating thickness increases along A direction and decreases along C direction. The coating is fairly uniform throughout the bore length when the anode is placed concentrically with respect to bore.

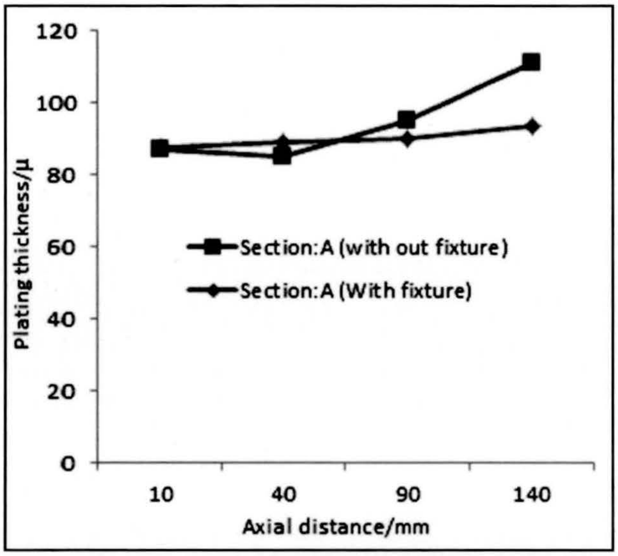


Fig 4. Thickness Distribution for Section A in Axial Distance

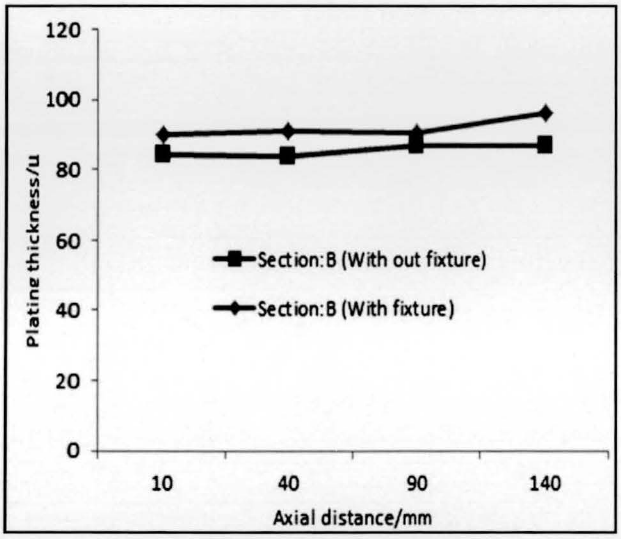


Fig 5. Thickness Distribution for Section B in Axial Distance

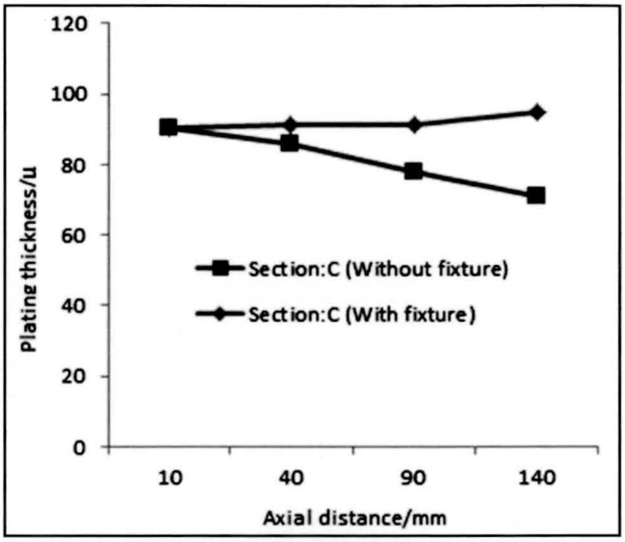


Fig 6. Thickness Distribution for Section C in Axial Distance

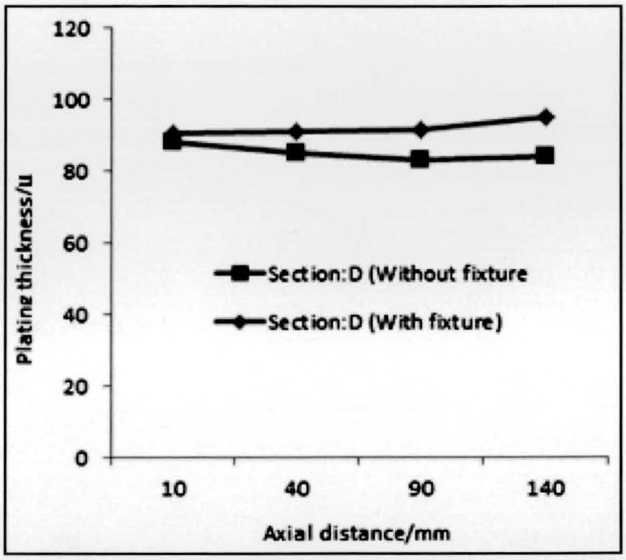


Fig 7. Thickness Distribution for Section D in Axial Distance

4. CONCLUSION

1. The study on chromium deposition in a confined space on the interior of a hollow cylinder of large aspect ratio indicates that maximum observed variation in thickness throughout the cylinder is 23 microns and along the cross section is 38 microns for the Process carried out without fixture (inclined anode), whereas variation in thickness throughout the cylinder is 8.6 microns and along the cross section is 1.7microns for the process carried out using special fixture.

2. Use of special fixtures for concentric positioning of anode inside a bore while plating hard chromium on internal surface with restricted opening at one end and hollow at the other end improved considerably the quality of plating especially with regard to non-uniformity of coating.

REFERENCE

1. R.A.F. Hammond, Trans. IMF 34 (1957) 83.
2. K.-M. Yin *, C.M.Wang, A study on the deposit

DESIGN OF SPECIAL FIXTURE FOR HARD CHROMIUM PLATING ON INTERNAL SURFACE OF HOLLOW CYLINDER OPEN AT ONE END AND WITH RESTRICTED OPENING AT THE OTHER END WITH L/D RATIO MORE THAN 4

SS Avadhani, Champuri Srinivas Rao and CJ Kumara

Total Prod. Maintenance (TPM) Dept.,
Central Manufacturing Technology Institute (CMTI), Bengaluru
E-mail: avadhani.cmti@nic.in

Abstract: *Hard chrome plating is widely used for various applications requiring wear and corrosion resistance. The quality of plating is influenced by applied current, relative position of anode & work piece, bath solution composition & concentration, temperature. The present work is focused on design & development of fixtures for holding anode with a view to produce uniform coating on internal surface of work piece made out of 17-4-PH steel. The plating was carried out with and without concentric position of anode. The quality of coating in respect of uniformity was assessed by measuring coating thickness. The results show that the uniformity in coating is achieved by the use of fixture for concentric position of anode.*

1. INTRODUCTION

Chromium possesses special properties such as wear & corrosion resistance and low coefficient friction. These properties make it a choice of plating especially for hydraulic cylinders where the life of seals mounted on reciprocating components can be greatly enhanced. K.-M. Yin & C.M.Wang, have carried out work on coating of rifle bore "A study on the deposit uniformity of hard chromium plating on the interior of small-diameter tubes, Surface and Coatings Technology 114 (1999) 213– 223 [2] and reported that plating of internal surfaces, particularly with aspect ratio is difficult due to the problems associated with control of bath solution, excessive air bubble formation and the relative positioning between anode and work piece. There has been little work done on chromium plating on internal surfaces. Twomethods of plating have been found in the open literature, i.e. full immersion with the aid of natural convection induced by gas bubbles produced from cathode and anode, and forced convection driven by a fluid-pumping system [1,3–6]. The first type of technique has several draw backs, including a low current efficiency, severe axial deposit non-uniformity, and health damage to the operating personnel. For the forced circulation plating system, equipment can be configured in a series of possible stages for automation, and the aforementioned draw backs of the open free convection plating bath can be avoided effectively [4].

The surface properties of coated layer such as thickness of coating, porosity, adhesion, surface finish etc are dependent on many factors. The coating uniformity i.e variation in coating thickness mainly depends on variation in anode cathode distance as the rate of deposition especially while plating internal surface has direct relationship with the distance between the anode and cathode.

The purpose of the present study is to evaluate the uniformity of chromium deposition in axial and circular directions on the interior of a small diameter hollow cylinder of aspect ratio more than 4 under constant operating parameters in a closed flow plating system. The influence of lead electrode concentricity on the axial and circular uniformity was assessed w.r.t internal surface of hollow cylinder.

2. EXPERIMENTAL

2.1 Work Piece

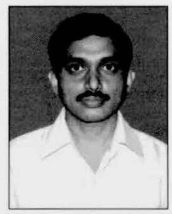
The work piece is made of 17-4-PH material. The main ingredient of this material is C Mn Si Cr Ni Cu The hardness of the material is HRC. The Fig-1 shows dimensions of the work piece. The 17-4-PH material was proof machined on a Horizontal machining center DMG80H, Germany with allowance for grinding ID & OD. Further finish machining was carried out on internal grinding machine Voumard, Switzerland make.

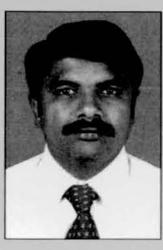
uniformity of hard chromium plating

3. on the interior of small-diameter tubes, Surface and Coatings Technology 114 (1999) 213– 223.
4. V.P. Greco, G.. D'Andrea, J.Walden, Recent Findings and Devel- opments in Chromium Plated Gun Tubes ARLCB-TR-83010, ARRADCOM, Benet Weapons Laboratory, Watervliet, NY,
5. E.S. Chen, G.P. Capsimalis, G.R. Weigle, J. Appl. Electrochem. 17 (1987) 315.
6. M. McCormick, S.J. Dobson, Trans. IMF 65 (1987) 24.
7. S.J. Dobson, M. McCormick, Trans. IMF 66 (1988) 92 ◘

SS Avadhani, Scientist - E, has obtained masters degree in Physical Chemistry in 1983. He has 35 years work experience in the area of material characterization and surface finishing. He is currently holding the post of Scientist E in Central Manufacturing Technology Institute, Bangalore and presently working on development of metal matrix composites (Cu/SiC) for electronic application. He is involved in evaluation of engineering components through NDT technique for determining the presence of flaws. Developed processes for electropolishing of pressure cooker parts and hard chrome plating on internal surface with high l/d ratio. Representing NABL. New Delhi he has visited several test laboratories for evaluation of competency of laboratory. He is a faculty for various training programmes organized at CMTI. Published 10 papers in National & International journals.

Champuri Srinivasa Rao, Scientist - C, in Central Manufacturing Technology Institute, Bengaluru. He has obtained BE (Mechanical) from J N T U Hyderabad and M. Tech in Metallurgical Engineering from IIT Roorkee in 2008. He has 10 years work experience in the area of material characterization and heat treatment. He is presently working on development of diffusion aluminization process. He is involved in evaluation of engineering components through NDT technique for determining the presence of flaws. Involved in development of processes for and hard chrome plating on internal surface with high l/d ratio. He is a faculty for various training programmes organized at CMTI. Published papers in National & International journal and conference.





CJ Kumar, Sr Tech Assistant-I, in Central Manufacturing Technology Institute, Bengaluru. He has obtained masters degree in General Chemistry in 1983. He has 22 years work experience in the area of material characterization. He is involved in development of hard chrome plating on internal surface with high l/d ratio, and in document preparation and control for implanting ISO/IEC 17025-2017 in material testing laboratory.