

PC BASED POTENTIAL LEVEL CONTROLLER

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To provide efficient monitoring and control of electrochemical dissolution process, a PC based controller was developed at EEI division, CECRI. Details of hardware and software package of the controller are discussed in the paper.

Key Words: Data acquisition, electrohydrometallurgy, and Potential level controller.

INTRODUCTION

Amalgam metallurgy, which is based on the affinity of metals with mercury, is a useful technique for the extraction of metals from lean and impure solutions. The ability to separate closely related metals is a noteworthy feature. Metals, which either dissolve in mercury forming a true solution or form a suspension of metallic particles in mercury, can be separated from those, which do not get reduced at mercury cathode. Amalgam metallurgical process does not require stringent control of pH of the electrolyte that may be necessary in electrowinning practice. Since, room temperature and aqueous solutions are involved amalgam metallurgy forms part of electrohydrometallurgy.

Metals dissolve in mercury according to the individual affinity towards the latter. Metals closer to mercury in the periodic table both horizontally and vertically have in general greater affinity towards mercury, though some exceptions are found. In solid phase cementation, the process is effective only when the potential difference between the two metals is sufficiently great. Then the metal cemented out virtually disappears from the solution. This is also true in case of amalgam cementation. The standard electrode potential of a particular amalgam differs from the standard electrode potential of the metal by about 1000 mV in case of alkali metal amalgam type and by about 50 mV in case of cadmium amalgam.

The main difference between the solid metal cementation and amalgam cementation is that the cemented out metal does not form a separate solid phase but dissolves in mercury. Because of this, cementation with amalgam can be

compared with liquid - liquid extraction. The presence of dissolved oxygen as well as the passivity of metal surface due to the formation of insoluble oxide in case of metals like aluminum are some of the hindrances in solid cementation process though the potential difference between the two metals is great.

To provide on-line monitoring and control of an electrochemical dissolution process, a PC based potential level controller was developed. The electrochemical dissolution process is employed to separate out noble metal constituents present in an amalgam obtained by amalgamation, which is a common metallurgical process. The potential level controller is useful to control any amalgam dissolution process by fixing the desired potential to an accuracy of ± 1 mV. In the electrochemical dissolution process employed to separate metal constituents present in the amalgam, when there is no control over the electrolytic process incorporated, it encounters a problem of mercury getting dissolved in to the electrolyte and reforming the amalgam with the separated metal constituent. The instrument is reliable and fast enough to resist the attack of mercury by suitably providing control over the dc power supply unit, which delivers electrical energy to the electrolytic process. With its high speed data acquisition add-on card to monitor continuously the electrochemical potential of the dissolution process incorporated in the hardware package when the entire quantity of this constituent has been dissolved it is essential to switch off at the characteristic potential.

PC based data acquisition is carried out on the three electrode electrochemical dissolution process to enable on-line

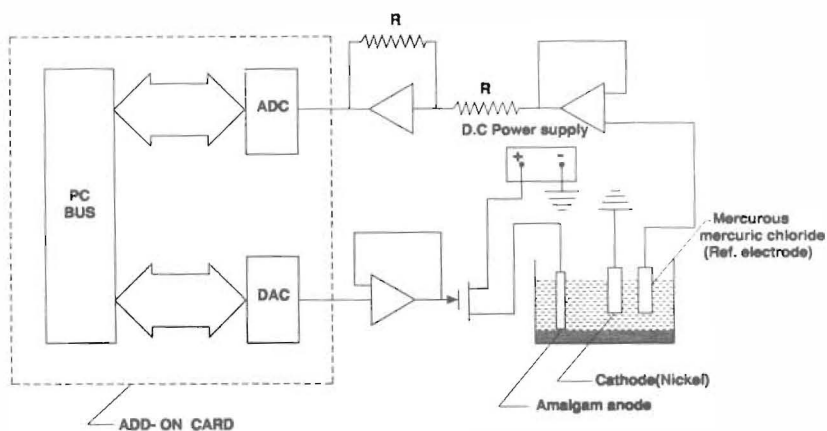


Fig.1: Schematic diagram for electrochemical potential level controller.

monitoring of electrochemical potential. The control system with its DAC channel set to drive the dc power supply unit through high power MOSFET. The personal computer controlled instrument with its hardware and software package, provides effective monitoring and control over the electrolytic dissolution process. The different potential levels of different dissolution processes can be monitored and controlled independently and simultaneously using multi channel process control system. The instrument is reliable and fast enough to resist the attack of mercury which occurs, when the electrochemical potential of the dissolution process reduces to a region in the vicinity of zero potential.

The instrument is capable of continuously monitoring the amalgam dissolution process and stopping the flow of dc current at the point of complete dissolution of the constituent metal. Its response is fast as compared with manual operation and hence mercury attack is prevented. It needs no foreign component and is useful for a wide - range of current requirements.

EXPERIMENTAL

Hardware description

The Block diagram shown in Fig.1 explains the hardware used to construct the PC based instrument which provides the control over the acquired potential or the electrochemical cell. The PC based instrument consists of blocks such as IBM PC / AT, Add on card, voltage follower or buffer, low pass filter and control element.

The PC based instrument together with its elegant hardware and software package, enables the electrochemical dissolution process to obtain noble metal constituent from an

amalgam. With its high speed 12 bit data acquisition card, the instrument is capable of measuring the electrochemical cell potential with +2 mV accuracy. The LPF and voltage follower in the signal conditioner section of the interface unit enables the instrument to measure electrochemical cell potential free supply mains frequency influence and other industrial noise.

The DAC channel with 12 bit resolution can be able to provide control voltage ranging from 0 to 10V. The DAC output connected to high power MOSFET which functions as the final control element is programmed to output either 0V to +5V for switching OFF the MOSFET gate voltage or switching ON the gate voltage respectively. The PC continuously monitors the dissolution process potential and provides control to the Gate input of the MOSFET which in turn enables a control over the dc supply unit which electrolyses the electrochemical dissolution process.

Software description

The algorithm for complete details about the software design has been explained as per the flow diagram shown in Fig.1. The control logic has been explained in the flow diagram shown in Fig.2. The characteristic dissolution potential of the electrochemical cell is applied to the Add-On card through a signal conditioner.

Here we set the higher voltage as the threshold level1 (V_{th1}) and lower voltage as the threshold level2 (V_{th2}). Initially the rectifier status flag is reset. The system must switch ON when the acquired voltage (V_{ac}) is greater than V_{th1} and the rectifier status flag is reset. The system must switch OFF when V_{ac} is less than V_{th2} and the rectifier status flag is set. These are the two invariable conditions.

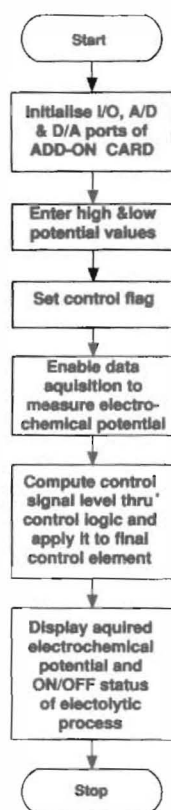


Fig.2: Electrochemical potential level control

When the system is in the OFF state and the electrochemical potential value I is higher than the V_{th1} the control system will switch ON the final control element and reset the rectifier status flag. If the electrochemical potential changes in the forward path, the system will retain the state of the final control element. If the control system senses the electrochemical potential to be controlled falls below the lower limit, the final control element is switched OFF and the rectifier status flag is set. If the electrochemical potential changes in the reverse path, the system will retain the state of the final control element.

As the control system is designed to prevent the passage of rectified current on reaching V_{th2} and is retained in the reverse path, jittering effect on the final control element is prevented. This results in the extraction of high quality Gallium, otherwise even when the system is switched OFF on reaching V_{th2} and is not retained in the reverse path, jittering of final element occurs. This may lead to the dissolution of mercury in the electrolyte which is hazardous.

So if there is no control over the electrochemical potential of the process, the limitations envisaged are contamination, jittering and dissolution of mercury. Our developed system

overcomes all those limitations explained before, by providing control over the electrochemical potential of the process.

RESULTS AND DISCUSSION

To evaluate the performance of the developed instrument, it was applied to extract different metal constituents from their respective amalgams, such as sodium, zinc and iron. A weak alkali solution. (Na OH) of 0.01 moles forms the electrolyte of the cell. Nickel acts as cathode. Sodium Gallate Amalgam having 0.5% of Sodium and 0.4% of Gallium acts as anode. Mercurous mercuric oxide is taken as reference electrode. Experiments with various amalgams like Iron amalgam, Zinc amalgam were carried out with the instrument for extracting Gallium from the amalgams. The initial concentration of amalgam is noted before the dissolution process and initial anode potential of amalgam Vs Hg / HgO reference electrode are noted down. The other parameters like Set potential levels, Impressed current density, duration of electrolysis are also noted during the dissolution process. These observed values are recorded as below for different amalgams.

EXAMPLES:

CASE 1.

With Sodium amalgam:

Initial concentration of the amalgam	: 0.08%
Initial anode potential of amalgam Vs Hg / HgO reference electrode	: -1.92V
Impressed current density	: 400A/m ²
Value of the Set potential in the controller	: -0.1V
Duration of Electrolysis	: 20 min
Final concentration of sodium in the amalgam	: Nil
Attack of mercury	: Nil

CASE 2.

With Zinc amalgam:

Initial concentration of the amalgam	: 0.1%
Initial anode potential of amalgam Vs Saturated calomel electrode	: -1.3V
Impressed current density	: 400A/m ²
Value of Set potential in the controller	: -0.2V
Duration of Electrolysis	: 10min
Final concentration of Zinc in amalgam	: Nil
Attack of mercury	: Nil

CASE 3**With Iron amalgam:**

Initial concentration of the amalgam	: 0.09%
Initial anode potential of amalgam Vs	
Saturated calomel electrode	: 0.19V
Impressed current density	: 100A /m ²
Value of the Set potential	: -0.12V
Duration of Electrolysis	: 52 Min
Final concentration of Iron in the amalgam	: Nil
Attack of mercury	: Nil

CONCLUSIONS

The following are the conclusions:

- * From the experimental results obtained, the on-line potential level controller performs well within its operating specifications.
- * Fluctuations found in the electrochemical cell did not cause any disturbance over the normal instrumental operation as it could not influence the final control element.
- * The instrument can have extended features such as capability for simultaneous and independent monitoring and controlling of multi-channel electrochemical systems.

- * With the use of other transducers, various parameters like temperature, pressure flow etc. can be monitored and controlled.
- * It can also facilitate on-line multi-channel monitoring control of array of electrochemical cells.
- * The instrument is applicable wherever hysteresis control is required.
- * As it is a PC based control system, through suitable hardware package incorporated, it can provide data-logging and remote monitoring of the system parameters.

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1. *Indian Patent No 169587* (1987).
2. J S Newman, *Electrochemical Systems*, Prentice Hall (1973).
3. *Electrochemical Engineering*, (Ed) C L Mantel, McGraw Hill, New York (1960).
4. Application of Polarization measurements in the control of Metal Deposition Ed I H Warren, Elsevier Science Publishers Amsterdam, Netherlands (1984).