USE OF GAMMA RAY COMPUTED TOMOGRAPHY (CT) AND COMPUTER AIDED RADIOACTIVE PARTICLE TRACKING (CARPT) IN MULTIPHASE REACTORS

This brief review focuses on the work performed at the Chemical Reaction Engineering Laboratory (CREL) at Washington University, St Louis, in using Computer Aided Radioactive Particle Tracking (CARPT) and Gamma Ray Computed Tomography (CT), in generating velocity and phase holdup profiles in different multiphase reactors. This data is used for validation of the Euler–Euler interpenetrating fluid model executed in the framework of FLUENT and CFDLIB. Data for holdup and velocity profiles, as well as for mixing parameters, obtained in liquid–solid and gas–solid risers, slurry bubble columns, and stirred tanks, are discussed. It is shown that Euler–Euler simulations are capable of predicting such data well for the cases studied. Extension of CARPT-CT to industrial systems is briefly discussed.

INTRODUCTION

Radioisotopes are used extensively in the chemical process industry as nuclear analytical techniques (e.g. neutron activation, x-ray fluorescence, ion beam (Garrison, 2001; Volkovic, 1993), in radioimmunoassays (Dali, 2000), gamma and x-ray densitometry and tomography and radioisotope tracing (Eyre, 1996; Dmitriev et al., 2001). In manufacturing radioactive sources are used to effect a desired reaction, to monitor product quality, to monitor the process (e.g. level control, etc.) and especially in trouble-shooting (e.g. densitometry and radiotracer injection response monitoring). In research they are used in identification of kinetic mechanisms and for imaging on molecular as well as reactor scale level.

The focus in this manuscript is on techniques based on radioisotopes that are used to identify and quantify phase holdup (volume fraction) distributions and velocity and mixing patterns in multiphase reactors with moving phases. Multiphase reactor technology contributes over 60 billion dollars to the US economy alone and is the basis of petroleum refining, synthesis gas conversion to fuels and chemicals, bulk commodity chemicals production, manufacture of specialty chemicals and polymers, and conversion of undesired products into reusable materials. Quantification of the reactor performance (i.e. the ability to relate reactor volumetric productivity and selectivity with feed conditions and operating variables) demands the description of: i) kinetics on a molecular scale, ii) effect of transport on kinetics on a single eddy or single catalyst particle scale and iii) phase distribution, flow pattern and mixing in the reactor on the reactor scale. It is critical to understand and predict at what rates can each reactant be supplied to the micro scale and how
do changes in reactor size or operating conditions affect these rates of supply. While progress has been made in understanding fundamental reaction mechanisms and in computing from first principles the effect of mass transfer on the reaction rate locally, the description of the reactor scale flow pattern and mixing is in general primitive and rests on the assumption of ideal flow patterns. Usually, either plug flow is assumed (i.e. all fluid entities of a particular phase that enter together stay together until they exit together) or perfect mixing is postulated, i.e. the feed losses its identity instantly and the composition in the vessel is the same as that of the outflow.

For multiphase reactors with two moving phases, such as depicted in Figure 1, the most frequently assumed flow patterns are shown in Figure 2. Plug flow of each phase is advocated for the liquid–solid riser, and complete ideal mixing for gas as well as liquid for the stirred tank. For bubble column some authors suggest plug flow of gas and liquid while others assume that the liquid is perfectly mixed while gas is in plug flow. When data, such as measured residence time distributions (RTDs) of the phases, are not in agreement with the assumptions of ideal flow patterns, as is frequently the case, modifications to reactor flow models are made. Most frequently the axial dispersion model (ADM) is assumed, which superimposes an eddy diffusivity flux on the plug flow motion. While ADM is often capable of fitting the RTD data there are no reliable ways of predicting the needed value of the axial dispersion coefficient a priori for most applications. Therefore, it is advantageous to develop physically based flow models that capture the physics of flow in the system of interest as this allows a priori parameter calculation with higher certainty. Ultimately, one would like to use CFD for computation of flow fields and phase distributions but at present the needed closures are subject to uncertainty. Hence, both for development of phenomenological models or for validation of CFD one needs accurate experimental data.
Investigated Multiphase Reactors

Figure 1. Schematic of investigated Multiphase Reactors

Examples of Reactor Scale Models for Contacting of Two Moving Phases

Ideal Reactor Concepts:
A) Plug Flow (PFR)

B) Stirred Tank (CSTR)

C) Axial Dispersion Model
D) Need More Accurate Flow & Mixing Description Via
   1) Phenomenological Models
   2) CFD Models (Euler-Euler Formulation)
   3) Model Verification: Holdup Distribution and Velocity Field

Figure 2. Ideal Flow Patterns used for Modeling Multiphase Reactors with Two Moving Phases

After conducting an extensive review (Chacuki et al, 1997a, 1997b) we decided that the best candidates for providing the needed flow visualization in opaque multiphase flows are gamma ray transmission computer tomography (CT) and computer automated radioactive particle tracking (CARPT) set-ups because both have been extensively described in the literature (Devanathan et al, 1990; Kumar et al, 1995; Kumar and Dudukovic, 1997). We then briefly review the application of CARPT-CT to a liquid-solid riser, gas-solid riser, bubble column and stirred tank.
Computer Tomography (CT)

\[
\frac{I}{I_0} = \exp (-\mu_{\text{eff}} L)
\]

Assemble over entire plane

Back project over entire plane

\[
\mu_{\text{eff}} \text{ (in each pixel)} = \rho_g \mu_g \varepsilon_g + \rho_L \mu_L (1 - \varepsilon_g)
\]

Time-averaged volume fraction of phases


CT Setup (Kumar, 1994)

Figure 3. Schematic and Photograph of the CREL CT Scanner

**CT-CARPT at CREL**

At CREL we have developed, designed, constructed and operated our own gamma ray based third generation computer tomography CT scanner (Kumar et al., 1995; Kumar and Dudukovic, 1997). The 100 mCi encapsulated Cs137 source is rotated 360° around the cylindrical vessel (column) being scanned together with the fan beam of collimated 2 inch cylindrical sodium iodine detectors facing the source. Spatial resolution better than 2 mm and a density resolution better than 0.04 g/cm³ are achieved with the original scanner. The schematic and photograph of the scanner are shown in Figure 3. The CT unit is used to obtain gas holdup profiles in bubble columns at high pressure and high superficial gas velocity as well as solids holdup profiles in risers. The improvement in the scanner allowing resolutions of 1 mm and its use in detecting gas holdup profiles in two phase flow through packed beds and in stirred tanks have also been accomplished.

The Computer Aided Radioactive Particle Tracking (CARPT) technique, introduced by Lin et al. (1986), has been further developed in CREL as a powerful tool for evaluation of the velocity field in opaque multiphase systems (Devanathan et al., 1990; Devanathan, 1991; Degaleesan, 1997; Larachi et al., 1994; Roy, 2000). In CARPT one monitors the motion of a single gamma ray emitting particle (Sc46 is used in CREL) by an array of sodium iodide 2 inch scintillation detectors located strategically all around the column. The schematic and photography of the CARPT set-up is shown in Figure 4. For monitoring liquid motion in bubble columns a neutrally buoyant tracer particle is used (a composite of polypropylene, air and scandium). For monitoring the motion of solids in fluidized beds, risers and stirred tanks, the tracer particle of the size and density representative of the solids in the system is prepared and used. CARPT results provide the ensemble averaged liquid and solids motion in bubble columns and liquid-solid risers, and numerous backmixing parameters. The wealth of information regarding turbulent stresses, eddy diffusivities, velocity auto-correlations and cross-correlations, residence time distributions, mixing, etc., is also contained in the CARPT data as illustrated below.

**LIQUID-RISER FLOWS**

A liquid-solid riser is a reactor of choice for production of linear alkyl benzene and other alkylates in a solid acid catalyzed reaction between olefins and paraffin in the liquid state. Since the solid catalyst deactivates it must be continuously removed, regenerated and recycled. The riser allows the liquid reactants and products to carry the catalyst. Riser reactor size and performance depend on the extent of backmixing in the liquid and solids phase. It is routinely assumed that both liquid and solids are in plug flow in the riser. The average slip velocity between the two phases is then correlated with mean solids holdup via a Richardson-Zaki type of correlation (Roy, 2000). Our task was to verify whether these assumptions are justified and if not, develop a better description of liquid and solids flow and distribution pattern.
We constructed the experimental set-up shown in Figure 5 which is explained in detail in the thesis of Roy (2000) and in the paper by Roy and Dudukovic (2001). In this experiment we were able to maintain the desired level of solids to liquid flux ratio S/L in the feed to the riser at each liquid superficial velocity. Liquid tracer studies revealed that the RTD of the liquid can be always matched with 10 or more stirred tanks in series which justifies the plug flow assumption (Roy, 2000). This is not surprising since liquid flow is clearly turbulent with Reynolds number exceeding 35,000 at the lowest liquid velocity used. CT scans revealed a quasi-axisymmetric solids volume fraction distribution, which was almost independent of axial elevation. When azimuthally averaged the radial solids holdup profile (Figure 6) revealed somewhat more solids at the wall than in the center.
The solids-to-liquid flow ratio fixed at 0.15. Scans are at 100 cm from the lower flange of the riser.

Figure 6. Examples of CT Determined Solids Holdup in the Liquid–Solid Riser

Azimuthally Averaged Time-Averaged Solids Velocity ($U_L = 23$ CM/S) and Solids Kinetic Energy

Figure 7. CARPT Determined Ensemble Averaged Velocity and Solids Kinetic Energy in the Riser

CARPT studies produces the ensemble average solids velocity profile which indicated that the flow was fairly well developed as the profile was not elevation dependent. This profile (Figure 7) revealed that solids flow upward in the middle and down by the wall. At constant liquid superficial velocity the ensemble averaged solids velocity increases with the increase in the S/L feed ratio while the "turbulent" fluctuating solids velocity (i.e., rms solids velocity) decreases (see Figure 7). Since the time of entry of the radionuclide into the riser and the time of exit for each visit of the tracer particle, was recorded by detectors specifically positioned for that purpose, the RTD of the solids is obtained as shown in Figure 8. The variance of these RTDs, taken at various operating conditions, confirms that solids are not in plug flow but are fairly backmixed, as 2 to 6 tanks in series are needed to match the observed RTDs. From the variance of the solids RTD an effective axial dispersion
solids residence time distributions

\[ \sigma_D^2 = 0.23 \]

\[ \sigma_D^2 = 0.26 \]

\[ \sigma_D^2 = 0.46 \]

\( \overline{2} \leq N_{\text{solids}} \leq 6 \)

Overall \( 0.18 \leq \sigma_D^2 \leq 0.61 \)

\[ \bar{U} = 15 \text{ cm/s}; S/L = 0.15 \]

\[ \bar{U} = 20 \text{ cm/s}; S/L = 0.10 \]

\[ \bar{U} = 23 \text{ cm/s}; S/L = 0.20 \]

Figure 8. Solids Residence Time Distribution in the Riser

Models for Reactor Flow Pattern in Liquid-solid Riser

- **a)**

- **b)**

- **c)**

Figure 9. Phenomenological Models for Solids Flow in the Riser

coefficient, \( D_{\text{eff}} \), can be readily calculated. CARPT, as shown earlier (Roy and Dudukovic, 2001) also provides directly the principal components \( (D_{zz}, D_{dd}) \) of the eddy diffusivity tensor for various components in the column.

The quantification of flow in our liquid-solid riser via liquid tracer, CT and CARPT provides the basis for the improved phenomenological of physically based flow models for the riser sketched in Figure 9. At the simplest level, we could use the plug flow model for the liquid and the axial dispersion model (ADM) for the solids phase (Figure 9a) with the axial dispersion coefficient \( D_{\text{eff}} \) calculated from the variance of the solids RTD. An additional improvement is to acknowledge that the solids can flow both upwards and downwards, while liquid is in plug flow (Figure 9b). The CARPT data for the time averaged solids velocity allow us to calculate the average solids velocity in the upflow, \( \bar{U}_{s1} \), and downflow region, \( \bar{U}_{s2} \). Super-imposed is the eddy diffusion flux of
solids with axial eddy diffusivities in each region, $D_{z1}$ and $D_{z2}$, available from CARPT data. The value of the exchange coefficient between the upflow and downflow solids, $k_{s12}$, can be calculated from the radial eddy diffusivity determined by CARPT. A more complete picture of the flow is captured by the 2D-convection diffusion model (Figure 9c) with liquid in plug flow and solids following the observed ensemble averaged solids velocity profile determined by CARPT with superimposed axial and radial eddy diffusivities $D_z$ and $D_r$, determined by CARPT.

The question then arises as to how can these parameters, needed for implementation of any of the models depicted in Figure 10, which are currently available from CARPT and CT experiments, be obtained for the equipment of different size (diameter). The answer is provided by computational fluid dynamics. If one can show that, without tweaking any knobs specific of the current application, CFD can produce results in agreement with experimental evidence, then it is fair to base the evaluation of the needed parameters of models depicted in Figure 9 on CFD calculations. We have employed the Euler–Euler interpenetrating fluid model and executed it in the Fluent framework. Upon choosing the appropriate descriptions for liquid turbulence, liquid-solid drag and employing the granular-temperature idea to describe solids interactions among themselves and with the liquid, we obtained a good comparison with the CARPT–CT data (Roy, 2000; Roy and Dudukovic, 2001). As Figure 10 indicates not only that the mean solids velocity profile and mean solids holdup profile were predicted well, but the agreement between experimentally observed and computed solids turbulent kinetic energy (i.e., rms velocity or granular temperature) was remarkably good. Since no major scale-up factors are expected in liquid-solid risers, this means that CFD and the developed CARPT–CT data provide a good basis for design.

**GAS–SOLID RISER–SOLIDS RECIRCULATION FLUX**

There is a considerable interest in gas–solid riser flows due to their major application in catalytic cracking. We are in the process of calibrating a system shown in Figure 11 for CARPT studies so that we can obtain a detailed description of the solids velocity profile and backmixing in the riser. This is part of a major cooperative effort between the Department of Energy Office of Industrial Technology (OIT), national laboratories and universities called Multiphase Flow Dynamics Research Initiative (MFDRC). As indicated in Figure 11 solids are in the closed circulation system, as they are picked up and carried by the gas in the riser, collected in the hopper and recycled via the downcomer. It is important to determine the solids flux in the riser at each superficial gas velocity. Since solids recirculate in a closed system, this is a nontrivial task, as

Three-Dimensional Simulation

$U_i = 20 \text{ cm/s, } S/L = 0.15$

![Axial Solids Velocity](image1)

![Solids Holdup](image2)

![Granular Temperature](image3)

**Figure 10. Comparison of CFD Predictions for Solids Mean Velocity and Holdup Profiles and for Solids Kinetic Energy with CARPT–CT Data**

clearly shown by Naor et al. (1988). The solids flow rate cannot be uniquely determined by measurements of tracer impulse responses at one, two or even three locations. At the same time there are no reliable in-line flow meters. In order to find an accurate estimate of the solids circulation rate we identify the section of the
Overall solids flux - Time-of-flight measurements

- Cross-correlation of time series of the two detectors:
  \[ R_s(t) = \frac{1}{T} \int_{-T}^{T} C_1(t) \cdot C_2(t - \tau) \, d\tau \]

- Mean velocity can be calculated as:
  \[ \langle v_s \rangle = \frac{\Delta H}{\langle \tau \rangle} \]
  \( \langle \tau \rangle \) average time of flight obtained for number of particle visits

- To select the distance between the detectors:
  \[ \rho_s(t) = \frac{R_s(t)}{\sqrt{R_s(0) \cdot R_{s,0}}} > 0.9 \]

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**Figure 11. Gas–Solid Riser and Time of Flight Measurement Set-Up**

Results: Densitometry Experiments

**Radial Solids Hold Profile (Downcomer)**

![Diagram of radial solids hold profile](image)

- Solids hold-up lie within the 95% confidence intervals after the modification
- Radial solids hold-up profile is flat even near the wall regions
- Mean value = 0.59 (with a STD = 0.001)

**Figure 12. Solids Hold-up Profile in the Downcomer as Determined by Gamma Densitometry**

downcomer in which we expect the solids to form a dense packing of uniform holdup across the pipe and be close to plug flow. In such a situation the cross-correlation between solids fluctuating velocity and fluctuating solids holdup can be neglected, and solids flux in the downcomer is given by the product of solids density, average solids velocity in the downcomer and average solids holdup in the downcomer. The needed mean solids velocity is determined from the time of flight measurement (using two detectors distance L apart that view the downcomer) and the mean holdup (which is shown to be uniform by Figure 12) is obtained from the gamma densitometry measurement along several chords. As a bonus in these measurements, from the detectors located at the entrance and exit of the riser we also obtain the RTD of solids in the riser (not shown here...
Results after secondary air introduction: Time of Flight Experiments

Figure 13. Solids RTD in the Downcomer and Estimation of Solids Flux in the Riser

for brevity). In Figure 13 we show the solids RTD in the downcomer and clearly the solids flux can be determined with reasonable engineering accuracy (see Table in Figure 13). Interestingly, even in the downcomer the solids RTD indicates less backmixing at higher gas superficial velocity (Figure 13), i.e., at higher solids recirculation, which is expected.

SLURRY BUBBLE COLUMN FLOWS

Slurry bubble columns are used in numerous industrial applications and are of particular interest as reactors of choice in syngas conversion to fuels and chemicals. Market demands for high volumetric productivity increasingly require that these reactors be operated in the churning turbulent flow regime. In this regime very high superficial gas velocities (30 cm/s and larger) are used, and hence it is the gas that dictates the fluid dynamics in the system as it is rather immaterial, from the hydrodynamic point of view, whether liquid is processed as a batch or flows continuously in co-current or counter-current flow at low superficial liquid velocities (order of 0.01 cm/s). Very little information was available about this flow regime since large volume fraction of the gas phase prevents the use of conventional laser based diagnostic techniques. In a multi-year effort sponsored by the Department of Energy and industry, we at CREL have been able to provide a better quantitative description of churn turbulent flows. Since the two-phase fluid dynamics in bubble columns is driven by the buoyancy force differences, we have focused on quantifying the cross-sectional holdup distributions in the columns using our CT equipment (Kumar et al., 1995; 1997; Chen et al., 1996; 1999). It was established that in churn turbulent flow the radial holdup distribution is almost parabolic and that the holdup increases with superficial gas velocity and pressure. Using radioactive particle tracking (CARPT), it was clearly shown that the liquid establishes, in a time average sense, a single circulation cell, rising in the middle of the column and flowing downwards by the wall (Devanathan, 1991; Degaleesan, 1997). The circulation rate increases with the increase in superficial gas velocity and with the increase in pressure, and it is not affected much by internals, such as heat exchanger tubes that occupy up to 6% of the open area. However, this apparently smooth time average behavior of a single recirculation cell is the result of averaging helical and spiral motion of liquid, which seems almost chaotic. Fortunately, the components of the eddy diffusivity tensor are obtained directly from CARPT data and the application of chaos theory (Cassanello et al., 2001) reveals additional information about the flow structure.

The collected new information regarding bubble column hydrodynamics suggests that the convective-diffusion model shown in Figure 14 may be suitable. Theory suggests that \( u_\text{g} \) is the CT measured holdup profile and \( u_z \) is the CARPT ensemble averaged velocity profile. Assumptions are made that the cross-correlation between fluctuating velocity and fluctuating concentration can be closed via Boussinesq approximation and that the diffusivities are those
CARPT-CT Experimental Evidence Indicates For The True Time-Averaged Flow and Backmixing Patterns

\[ \frac{\partial}{\partial t} (\varepsilon_L C) + \frac{\partial}{\partial z} \left( u_z \varepsilon_L C \right) = \frac{1}{r} \frac{\partial}{\partial r} \left( r \varepsilon_L D_{rr} \frac{\partial C}{\partial r} \right) + \frac{\partial}{\partial z} \left( \varepsilon_L D_{zz} \frac{\partial C}{\partial z} \right) \]

\[ \overline{\mu_L C} = -D_{zz} \frac{\partial C}{\partial z} \]

\[ \overline{u_z C} = -D_{rr} \frac{\partial C}{\partial r} - D_{rz} \frac{\partial C}{\partial z} \]

**CARPT Experiments Indicate** \( D_{zz}, D_{rr} \sim 0 \)

- \( u_z \) Ensemble Averaged Liquid Velocity Measured from CARPT
- \( \varepsilon_L \) Time Averaged Liquid Holdup from CT Measurements
- \( D_{zz}, D_{rr} \) Assumed to be CARPT Measured Diffusivities

**Figure 14. Suggested Phenomenological Model for Liquid Flow in Bubble Columns**

Comparison of Computed (CFDLIB) and Measured \( D_{zz} \)

**Figure 15. Comparison of CFD Predicted and CARPT Measured Axial Eddy Diffusivity**

measured by CARPT. Since CARPT data shows that the off diagonal terms of the eddy diffusivity are negligible (Degaleesan, 1997) these are dropped. We have shown (Degaleesan, 1997, Degaleesan et al, 1997) that this model, based on experimentally determined \( \varepsilon_L \) and \( u_z \) profiles, predicts exceedingly well the independently measured tracer exit age density function, \( E(t) \). We have also shown that using the developed methods to estimate gas holdup profiles and liquid recirculation, this model, and its extension to the gas phase, predict well tracer responses in an industrial pilot plant unit (Degaleesan et al, 1997, Gupta et al, 2001). Liquid and gas phase tracer responses are predicted well for the Advanced Fuels Demonstration Unit (AFDU) in LaPorte, Texas at very different sets of operating conditions of methanol, dimethyl ether and Fischer-Tropsch
synthesis. We have also shown that CFD computations are able to generate the needed model parameters successfully, as illustrated in Figure 15 where CARPT determined and CFD calculated axial eddy diffusivities are compared.

Clearly, the use of radioisotopes has been instrumental in providing a better understanding of bubble column reactors and has enabled us to validate the CFD codes for a range of operating variables.

**STIRRED TANKS**

Stirred tanks are probably the most frequently used reactor in industry. While the flow of stirred liquids has been examined extensively in single-phase systems, hardly any information has been available on multiphase systems due to the opaque character of the flow and the inability of optically based techniques to provide the needed information. Here in Figure 16 we show the ability of CARPT to generate data in a single-phase liquid system rapidly. With careful analysis and comparison with LDA obtained data (Rammohan et al, 2003) we have shown that CARPT can capture the properties of flow up to 30 Hz and thus provide full information on the mean flow, kinetic energy and large to meso scale mixing. Use of CT and CARPT has been able to generate for the first time a complete picture of gas-liquid flow in a stirred tank. Detailed results have been presented in the thesis by Rammohan (2002).

**OTHER USES**

We have used CARPT-CT successfully to characterize flows in ebulated beds (Chen et al., 2001), bubble columns with draft tubes, photo reactors for algae growth, slowly moving packed beds and numerous other applications. These techniques clearly offer a great potential for numerous additional industrial applications.

**CONCLUDING REMARKS**

The CARPT-CT techniques described in this brief review provide us with the unique opportunities to assess holdup and velocity fields in opaque two-phase systems. The resolutions of both techniques allow reliable information to be generated for large-scale motion at lower frequencies. While CT provides the time averaged density distribution, CARPT in addition to time averaged velocities, allows estimation of a number of turbulent quantities, e.g., kinetic energy, stresses, eddy diffusivities, etc.,

The wealth of information provided by CARPT-CT allows us to quantify the flow fields in systems like liquid-solid risers and bubble columns which leads to improved and more detailed reactor models. CFD computations, based on the Euler–Euler interpenetrating two fluid model have been shown to be capable of producing information in good agreement with data which renders hope for CFD based scale-up in the future. (Pan, et al, 1999; Pan and Dudukovic, 2000; Sanyal et al., 1999). It is fair to conclude that CARPT-CT are indeed a valuable measurement tool for opaque multiphase systems and that the Euler–Euler model has potential in simulation of reactor scale multiphase flows at conditions of industrial interest.
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REFERENCES


IZVOD

PRIMENA METODA KOMPUTERIZOVANE TOMOGRAFIJE (CT – GAMMA RAY COMPUTED TOMOGRAPHY) I KOMPJUTERSKI PODRŽANOG PRAĆENJA KRETANJA RADIOAKTIVNE ČESTICE (CARPT – COMPUTER AIDED RADIOACTIVE PARTICLE TRACKING) KOD VIŠEFAZNIH REAKTORA

(Pregledni rad)

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Pregledni rad usmeren je na prikaz istraživanja kompjuterizovane tomografije (CT) i kompjuterski podržanog praćenja radioaktivne čestice (CARPT) u cilju analize profila brzina i zadržavanja faze u različitim višefaznim reaktorima. Ove metode su razvijene i realizovane u Laboratoriji za hemijsko inženjerstvo (CREL) Vašington Univerziteta u Sent Luisu. Podaci koji se dobijaju njihovom primenom koriste se za potvrdu Ojler-Ojlerovog modela višefaznog fluida sprovedenog preko softverskih paketa FLUENT i CFDLIB. U radu se analiziraju podaci koji definisu profil brzina i zadržavanja faze i razmatraju parametri koji definisu mešanje u višefaznim sistemima razdela (tečnost–čvrsto i gas–čvrsto), barotaznim kolonama sa suspendovanim čvrstom fazom i reaktorima sa mešanjem faze. Pokazano je da su Ojler-Ojlerove simulacije pogodne za predskazavanje navedenih parametara u svim slučajevima koji su do sada analizirani. U sažetom obliku se diskutuje mogućnost proširenja primene CARPT–CT tehnike na analizu rada industrijskih sistema.

Ključne reči: Kompjuterizovana tomografija (CT) • Praćenje kretanja radioaktivnih čestica (CARPT) • Reaktori • Višefazni sistemi • Profil brzina • Zadržavanje faze • FLUENT • CFDLIB • Key words: computed tomography (CT) • Radioactive particle tracking (CARPT) • Reactors • Multiphase systems • Velocity profile • Heldup • FLUENT • CFDLIB •