Hydroprocessing Associates – HYDROPAC® Catalyst Dense Loading System

a report by
Hydroprocessing Associates trading as HPA

General Company Description

Our prime business is in offering specialised equipment and personnel in providing niche reactor services to a broad range of industries, including oil & gas, exploration and refining, petrochemical, fertiliser, mining, power plants and utilities. The works are both disciplined and intricate, involving planning, blinds to blinds, inert entry vacuum (nitrogen loop) unloading/welding repairs & retrofits (HPA has our U&R stamp), packaging/screening/HYDROPAC® Catalyst Dense loading of high value catalysts from within reactors and vessels under nitrogen and normal atmospheres. Our works are usually required during plant shutdowns and also during emergencies and online reactor problems such as high delta pressure, etc.

The current environment within the global process industry is on the upward trend within all the major factions: oil & gas, petrochemical, fertiliser, etc. Good margins are again being realised, expansion of existing and new facilities are being erected and money is being well spent on existing plant maintenance. A recent quote from SK Corp Korea stated: "Asian refiners are now rushing to upgrade their plants to produce cleaner, more value-added products, but it requires a lead time of two to three years". These upgrades will include many reactors and opportunities for niche industrial service contractors.

The industry is continually looking for companies who have ability in providing niche expertise with well-renowned people, allowing comfort in expenditure. The industry is looking for alliances whereby companies remain loyal, to grow together in continued improvement, safety and value-added services.

Hydroprocessing Associates specialises in catalyst handling activities, while also having extensive environmental and waste management expertise. We have provided works within the industry in many countries throughout the world. Collective regions and countries of various experiences include Asia, Australia, New Zealand, Europe, South America, the US, the Far East and the Middle East. We understand the culture and environment of these very different countries and have grown an excellent network of clients and friends who assist in their respective areas in the culmination of providing and offering our services. Our name is well known within the industry, especially in terms of our skills and accomplishments in undertaking and successfully completing arduous activities. We have tackled the complexity in increased demand for planning, allocation and co-ordination of resources and control of performance in completing our set objectives.

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We believe our company plays a critical role within our society. We provide a source of identity and developmental opportunities for individuals. Our people are our business. With this concept, HPA has created a depth of experience within a pool of available reactor technicians from countries including the US, Singapore, Australia, New Zealand and South Africa. These technicians are employed as and when needed for projects, are aged between twenty-one and forty-six and have variable lengths of experience in our specialised work. This provides several advantages in respect to availability; response to projects, level of experience, country and culture selection, etc. HPA has established an essential base within the industry and is now fundamentally positioned to collaborate with global partners to combine resources to develop a successful business entity.

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Business Objectives

Vision Statement

"We are committed to the safety of our people, the environment, provision of excellence, sustainable growth and continued employment and development of our staff and surrounding communities. We will strive to maintain and develop our profile as a highly reputed, specialised catalyst-handling company."

In the words of Woodrow Wilson: "Nothing in the world can take the place of persistence. Talent will not: nothing is more common than unsuccessful men with talent. Genius will not: unrewarded genius is almost a proverb. Education will not: the world is full of educated derelicts. Persistence and determination alone are omnipotent!"

Mission Statement

Hydroprocessing Associates is well positioned within this unique industry; we plan to maintain our highly respected personal reputation with not

only our knowledge and skills, but also our loyalty and business ethics. We have a goal to continually broaden and pass on these skills we have learnt through our experience within the industry over the past 22 years and create a name for ourselves which will be associated with quality and care throughout the world.

Products and Services

The current services on offer to clients are as follows:

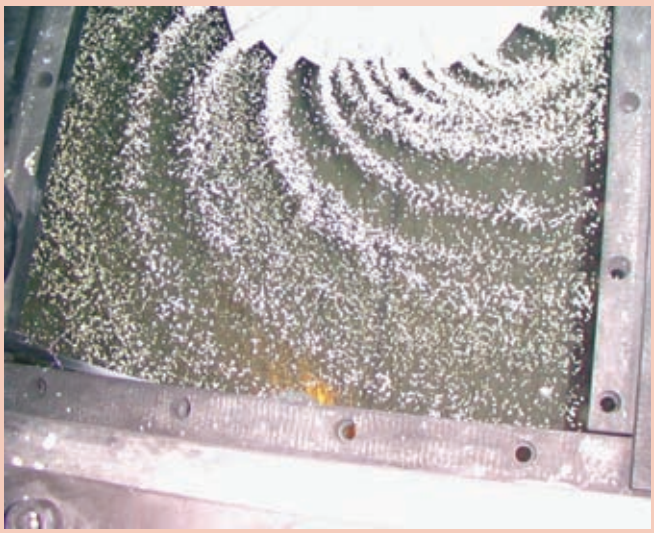
- Catalyst Handling;
- Inert Entry;
- Catalyst Screening;
- CCTV Inspection Services;
- Reactor Internal Repairs under Inert Atmosphere;
- Specialised Catalyst Dense Loading;
- Project Planning; and
- Blind to Blind Reactor Turnaround.

HYDROPAC® Catalyst Dense Loading System

Catalyst loading may be done in either of two ways: sock loading and dense loading.

Sock loading is the simpler loading method, requires both less equipment and less operator training. Catalyst is delivered to the bed being loaded through a flexible sock and is spread and raked to a level condition during loading. The sock loaded catalyst forms a more open bed structure and has both a lower density and lower initial start-of-run (SOR) pressure drop. Over the course of a run, the sock loaded bed tends to slump to a more dense structure. At end-of-run (EOR), a sock loaded bed will often have a pressure drop equal to that of a dense loaded bed. Dense loading fills a reactor with less open volume in the catalyst beds.

Figure 1: HYDROPAC® Loader



The basic principle is to allow the individual catalyst particles to free-fall to the bed where they bounce around, settling in their lowest energy state. This means that the particles fall onto their long axis and form a horizontal mat with the long dimension of the particles aligned with the bed diameter.

The main advantages of dense loading are:

- tighter and more uniform catalyst packing, resulting in better reactant flow distribution in the trickle flow regime as is used in hydroprocessing;
- catalyst beds do not sag/change flow patterns during the course of a run; and
- more catalyst is loaded into each bed because of the higher loading density, resulting in longer runs.

HYDROPAC® Loader

HPA is using a dense loading method that is referred to as HYDROPAC® loading. The loader receives catalyst into its internal feed bin by sock from a hopper external to the reactor. The loader channels catalyst to the attached distributor disk, which distributes catalyst evenly across the reactor. Disk speed determines the radial velocity of the particles, while gravity determines the axial velocity. As the bed fills with catalyst, the distance between the distributor and the top of the catalyst bed decreases. The distributor's rotational speed must then be increased to maintain even catalyst distribution across the reactor.

The HYDROPAC® Loader sits on top of the support screen just above the bed being filled with catalyst. An air motor rotates the distributor. An integral tachometer that has a continuous ½ inch LED display ensures that close speed monitoring can be easily achieved. An integral bubble level has been mounted to the top of the HYDROPAC® Loader catalyst drum, to provide a means to set

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and ensure that the drive shaft is plumb. The collar can be moved up or down and sets a primary catalyst flow gap. The adjustment position is on a set of stepped adjustment slots and is secured with the hand knob. The drive shaft is encased in a delrin sleeve where catalyst contacts the shaft, to prevent catalyst grinding and attrition by the rotating shaft. A bearing within a bronze bushing has been used on all of the shaft support spiders. This ensures a smoothly turning shaft in a possible dusty environment. The disk speed can be easily adjusted while the air motor operates at high speed, where it generates its greatest torque. It has a second asymmetric disk below the primary asymmetric disk to improve the uniformity of catalyst distribution. A pair of adjustable slots at the bottom of the compound disk allows continuous adjustment of the centreline catalyst flow. Knurled knobs are provided to permit hand tightening and to avoid the need for tools.

Catalyst Flow Through the Distributor

Catalyst is delivered to the HYDROPAC® Loader by sock. An integral drum retains a feed supply of catalyst to the disk. Catalyst falls through the annular slot formed by the adjustable sleeve and the primary cone of the disk. Vertical fins on the primary disk throw catalyst outward to the wall and fills an annular region adjacent to the wall. The centre of the cone is hollow and some catalyst falls through the support spider to a second smaller disk below the first. Again, a set of fins is used to throw catalyst to an annular region adjacent to the area covered by the primary disk. The vertical gap between the two asymmetric disks is adjusted to control catalyst flow to the second annular region. The centreline of the HYDROPAC® Loader is fitted with a pair of sliding gates that allow catalyst to fill the centreline of the reactor. The gaps are adjusted to maintain a flat and level catalyst bed throughout the loading process. The clearance between the bottom tube of the HYDROPAC® Loader and the surface of the disk is used for primary flow adjustment.

Loading Program Calculations

HPA uses a HYDROPAC® Loader program for the PC to aid loading personnel in establishing a loading schedule (rpm versus bed outage). Inputs to the HYDROPAC® Loader program are:

- reactor geometry;
- catalyst types, sizes and quantities to be loaded; and
- distributor to be used.

The HYDROPAC® Loader program is based on simple physics and a few empirical correlations. As the bed fills and makes the vertical distance shorter, the rotational speed will have to increase to throw the particles to the wall in less time. This then sets the rotational speed of the distributor. The compound disk has three annular zones of catalyst flow. The relative openings of the slots for each zone determine the loading rate in each zone. Each zone is adjusted to give as flat a catalyst bed as possible and to prevent catalyst from forming a mound and then avalanching into an adjacent hole. Avalanched catalyst will not have the dense orientation of non-avalanched catalyst.

Homogeneous Horizontal Bed Profile

The catalyst is distributed evenly over the cross-sectional area. There will be no repose angle and consequently no rolling of the catalyst, it is therefore homogeneous. The catalytic bed is made up of horizontally even layers of catalyst. This promotes linear reactive flow without channelling.

Non-attrition

Due to the free-fall of the catalyst individually downward, there will be minimal contact between the catalysts. This prevents breakage and attrition from occurring. Since the mass of the individual catalyst is so small, the free-fall speed is never great enough to damage that particular piece of catalyst.

The HYDROPAC® sits just below the trays (6"), enabling the bed to be loaded to its maximum potential height. A droplight can be lowered past it when working to view the bed profile, which is very important when monitoring that the catalyst bed is homogeneous. There is no centre shaft obstructing the catalyst flow to the centre of the bed, which can cause a dip in the bed profile, which will cause the catalyst in the centre to be angled continuously throughout the loading, resulting in the product taking the easiest route through the centre. The HYDROPAC® also has a reversible rotation, critical for loading around transfer tubes and thermocouples. ■