Planning, preparation and performing complex maintenance projects in the process industry

As with all technical consumable products, the process plants of the chemical and petrochemical industry are subject to permanent wear caused by the process conditions themselves and by the prevailing ambient conditions. The influence of aggressive media inside the apparatuses and pipelines, high process temperatures and pressures or vibration loads are examples of process-related wear. Environmental factors that can wear down the process plants in a particularly strong way include atmospheric precipitations, wind and storm loads, UV radiation as well as major fluctuations in temperature.

Maintenance measures are supposed to counteract these deteriorations and ageing processes.

Maintenance is defined in the German Standard DIN 31051 »Fundamentals of maintenance«. The fundamentals of maintenance are defined as a combination of all technical and administrative measures as well as measures of the management during the life cycle of an item in a plant, a plant component or electrical equipment intended to retain an item in functioning state, or restore it to a state in which it can perform a required function» [1].

Figure 1: Start OPTIMIX 13: safety is topic number 1
Maintenance includes a preventive and corrective component.

Preventive maintenance includes all maintenance and inspection activities, corrective maintenance comprises all repair activities, e.g. repairs and elimination of faults.

Process plants are characterized not only by an extremely complex combination of equipment, piping, chemical substances, process parameters and control actions by operators [2], but in many cases also by very high safety requirements for staff and environment due to dangers that are inherent to the process.

Therefore, a carefully planned and exactly implemented maintenance concept must take into account the high degree of complexity and the existing hazards caused, e.g. by processing flammable substances, high pressures and temperatures, or electric energy.

Particularly for plants in hazardous areas, the European Directive 1999/92/EC of the European Parliament and of the Council on minimum requirements for improving the safety and health protection of workers potentially at risk from Explosive atmospheres, Annex II, Section 2.5 stipulates:

›All necessary measures must be taken to ensure that the workplace, work equipment and any associated connecting device made available to workers have been designed, constructed, assembled and installed, and are maintained and operated, in such a way as to minimise the risks of an explosion and, if an explosion does occur, to control or minimise its propagation within that workplace and/or work equipment. For such workplaces appropriate measures must be taken to minimise the risks to workers from the physical effects of an explosion.‹ [3].

The German ›Ordinance on Industrial Safety and Health (BetrSichV)‹, which represents the transposition of the Directive 1999/92/EC into national German law, stipulates under § 15: ›Recurrent inspections‹ that installations subject to monitoring and plants in hazardous areas shall be subjected to recurrent inspections, e.g. at certain intervals to ensure their proper condition. Intervals for inspecting installations in hazardous areas are maximum three years [4].

To this effect, the definition of maintenance defined above can be confirmed for these plants as a task with the goal to check and substantiate a sufficiently high level of protection against explosion hazards or to restore it to this level.

In the process industry maintenance work can generally not be considered in isolation for only securing and maintaining the explosion protection, but it must be embedded in a comprehensive concept, which on the one hand considers other hazards caused by provided working equipment (e.g. pressure tanks or lift systems), and on the other hand serves for maintaining and improving the productivity of the process plant.

Requirements concerning proper preparation and performance of maintenance of plants that are within the scope of the ›Ordinance on Industrial Safety and Health (BetrSichV)‹ are described in Germany in the Technical rules for operating safety TRBS 1112 [6]. TRBS 1112 Part 1 provides details of the requirements concerning hazard assessment and the safety measures that must be taken in the presence of explosion hazards during maintenance work and hazards caused by it [7].

In the following, the PCK refinery in Schwedt (Brandenburg) will be used as an example to show how a correct, efficient comprehensive maintenance concept can be implemented on the basis of these directives and regulations.

The refinery in Schwedt was built between 1959 and 1964 as one of the largest process plants for oil processing in the former German Democratic Republic (GDR). In 1970 the name was changed to ›Petrochemisches Kombinat (PCK)‹, and has since 1996 been renamed to PCK Raffinerie GmbH. After German reunification, the company, which was initially taken over by the German ›Treuhandanstalt‹ (escrow agency), continuously developed into one of the most modern and efficient refineries in Europe. This continuous increase of efficiency was facilitated by well qualified and committed employees along with modernization and qualified maintenance of the plant. Already in 1996, the international Solomon refinery ranking rated the PCK as the refinery with the lowest processing costs in Western Europe.
Today, the PCK Raffinerie GmbH is a contract processing refinery for international petroleum companies. The shareholders are:

- Ruhr Oel GmbH with 37.5% (BP and Rosneft)
- Shell Deutschland Oil GmbH with 37.5%
- AET-Raffineriebeteiligungsgesellschaft mbH with 25% (Eni and TOTAL)

The shareholders ensure delivery of crude oil to PCK and then market the products produced in the refinery.

Over the past 20 years, these shareholders have invested 2 billion euros in PCK, primarily for cutting-edge technologies and for environmental protection [5].

For many years, the so-called major turnarounds took place every three years. During this time, about 50% of the plant stops for about three to four weeks and the relevant parts of the plant and equipment are comprehensively cleaned, maintained and inspected. As the refinery in Schwedt has two crude oil distillation plants and only one of them is stopped during the maintenance period, the operation can be continued in the other part of the plant. This eases considerably the restarting of the maintained parts of the plant, but it also causes some special requirements which will be explained below.

The major turnarounds are extremely challenging for the planning and performing divisions. All employees of the refinery are involved in the preparation, performing and post-processing of these turnarounds. One could recognise the outstanding events in the operation of the plant already by their individual names. The turnaround in 2007 was denominated ‘007’, the next in 2010 was named ‘Start 10’, and the turnaround at the beginning of 2013 named ‘OPTIMIX 13’ indicates the last preparation phase.

A special challenge for the employees in Schwedt is to use the major turnarounds on a regular basis also for major plant expansions and for replacing obsolete parts of the plant. During ‘Start 10’, e.g. one of the two crude oil distillation columns that had been in service since 1964 was replaced with a new 200 ton column.

Considering the complexity of such comprehensive maintenance work and measures for expanding the plant, it is easy to understand that the planning of the turnaround, that takes place three years later, starts directly after the completion of the current turnaround.

The advantage of using the three-year maintenance cycle is that the organisation and every employee involved maintain their skills and gather considerable wealth of experience over the years.

Preparation for the forthcoming complete maintenance, which traditionally began during the first week after Easter 2013, started already in summer 2010. Since that time, the turnaround team, consisting of all company divisions, structures and all persons responsible for the plant (plant engineers), meets every 2 months, preparing and improving the plan for the forthcoming turnaround, and creating a report on it.

TRBS 1112 in section 3.2 stipulates the following steps for preparation of maintenance in process plants:

- Define type, scope and sequence of the maintenance work,
- Identify and assess hazards, and define the required measures,
- Before awarding the contract to external firms, define the safety requirements and requirements in regard to the qualification of the maintenance personnel.

The German Law on the occupational safety and health requires in § 5 that the employer performs a hazard assessment and documents the results prior to commissioning of the plant. The Ordinance on Industrial Safety and Health in section 3 provides detailed explanation for plants subject to monitoring, e.g. hazardous areas.

This hazard assessment is a living document and must be adapted to the changes in the companies on a continuous basis. The results must be documented in the relevant plant documentation, e.g. in the explosion protection document. Major interventions, e.g.
The refinery’s own employees are also trained in due time for proper training. The technical rules for operating safety TRBS 1112: Maintenance in section 4 define that hazard assessment must be carried out and documented for every activity performed and for every workplace under maintenance. Special hazards posed by plant parts to be maintained and the work equipment used require special attention. Subsequently, measures required for eliminating the identified hazards must be defined. Annex 2 of TRBS 1112 contains a detailed list of hazards and proposals for avoiding them. In terms of explosion protection and hazards that must be considered during installation work, technical regulation for operating safety TRBS 1112-1 must be observed.

Due to a lack of time during turnaround of the plant, the hazard assessment and definition of appropriate countermeasures are performed in PCK Schwedt to a large extent during the planning phase. The comprehensive safety concept is documented in the so-called turnaround manual, which is available to all internal and external persons involved.

One of the special challenges in Schwedt, aside from the scope of the maintenance and expansion work, is also a high share of external firms. While during normal operating time about 1200 predominantly refinery own employees work in the refinery, during the turnaround over 2500 additional external employees of cleaning and maintenance companies and different specialized firms work there.

The TRBS 1112 requires the operator of the plant to provide close coordination of different internal and external organizational units; the operator thus has the immediate responsibility for the operation ... of the plants [6]. The operator is also responsible for comprehensive training and instructing of all employees.

During the turnaround phase, the planning staff meets every day and discusses the progress of the maintenance and installation work. The responsible maintenance engineer is assigned to every part of the plant as a part project manager who is responsible for the correct performance of the maintenance work, and work coordination of the internal and external employees. Central project management runs expansion and modernization projects. Cooperation of partner firms with many years of PCK experience and new external firms and their employees also results in close organizational interdependencies.

The turnaround manual contains the required training and instruction content. Before starting work, any external firm is obliged to properly train its own employees and provide written proof thereof. The manual is available online via a portal for external firms. On the one hand, it allows a widespread, but nevertheless an intensive training, on the other hand, it saves valuable working time during the plant shutdown. The compulsory ›gate training‹ on entering the refinery, for example, is completed in advance and the reception of external firm employees is thus limited to handing out passes.

The refinery’s own employees are also trained in due time before the start of the maintenance work on the basis of documentation in the turnaround manual.

To optimise the scope of the maintenance work, the results of the permanent plant monitoring between the turnaround periods are also taken into account. The pipelines, for example, are regularly checked in a non-destructive way; this measure makes it possible to decide prior to the turnaround whether the entire pipeline must be replaced as will be done during the maintenance action ›OPTIMIX 13‹. As it is not possible to exactly plan the entire maintenance requirements in advance, all shut down parts of the plant are fully opened within the first week. At this early stage, additional spare parts can still be ordered if they are required. As the remaining few weeks are definitively too short to first project and then order special electric equipment, e.g. explosion-protected distributions or control stations from the manufacturer, the most important products have been specified and standardized in advance with selected manufacturers. R. STAHL, for example, has defined in a principle offer specifications for standard control units including complete technical documentation (specification, assembly drawing, circuit diagram) and respective prices. These units can be supplied at very short notice if required.

As already mentioned, many parts of the plant continue to operate, which means that hazards caused by these operating parts must be considered and separated from the maintenance work by means of appropriate technical and organizational measures. In PCK Schwedt, conventional gas alarm equipment is distributed around the active plants and, in addition, laser-based infrared gas detectors type Searchline Excell by Honeywell are used.

They monitor very accurately border zones between stopped and active parts of the plant. Coordinated organisation plans regulate fast cessation of activities and evacuation of personnel in case of alarm by gas alarm equipment.

Before performing maintenance work in the stopped plants, the combustible media are completely removed and incoming lines are separated using sliders. This allows maintenance work to be performed under safe conditions, which leads to considerable improvement and facilitation of work (special protective equipment is no longer required, conventional mobile phones can be used, etc.). Conventional construction sites and workshops can be placed in the immediate vicinity of the maintained parts of the plant, allowing very effective work processes.

All explosion-protected equipment is maintained and, if required, replaced or repaired by specially trained qualified personnel. The Ordinance on Industrial Safety and Health stipulates in section 14.6: Where equipment, protective systems, or safety devices, controlling devices and regulating devices ... on which explosion protection depends, has been repaired it shall not be put back into service unless the approved body has determined that the essential features of explosion protection comply with the requirements of this Ordinance... The inspections pursuant to the 1st sentence may also be performed by competent persons of an enterprise if these per-
sons have been recognized by the competent authority… During the extensive maintenance and repair work, the refinery in Schwedt deploys both an approved body (ZüS) in the form of TÜV Rheinland and in-house recognized experts (recognized persons according to §14 [6] of BetrSichVO). The TUV specialists inspect, among other things, approx. 1200 pressure containers, 600 safety valves and the effectiveness of the lightning protection equipment.

As mentioned above, the turnarounds in Schwedt are also used for extension and modernization of the complete parts of the plant. Due to a very narrow time frame, certain assembly work is performed in advance, if possible. For example, the complete lighting, consisting of 140 Zone 1 linear fluorescent luminaires 36 watts, is installed in advance by R. STAHL on the new oven in the aromizer part of the plant. The comprehensive inspection of the explosion protection concept according to section 15 of the Ordnance on industrial safety and health and the first operation of the new plants are generally performed during the turnaround of the plant. This ensures that the new plants can immediately operate at full capacity when the maintenance phase is complete.

The stop of the refinery for a four-week intensive and complex maintenance means that all persons involved are under extreme physical and mental stress. Besides performing the work in a safe way, meeting the deadlines is top priority. Not all developments during the turnaround phase can be foreseen even with the most thorough planning and preparation.

The management of the PCK Raffinerie GmbH is therefore certain that the deciding factor for the success of the maintenance projects is an effective, flexible and well-trained team, directed during the work process by professional project management. A large celebration for all persons involved, including the employees of external firms, traditionally completes the project. One of the highlights of this event is a documentary film, which contains the highlights of the recent weeks. The next day, the employees continue their normal work and begin already the first preparations for the next turnaround in 2016, because:

After the turnaround is before the turnaround…