



Future of manufacturing  
**Chemical products plant  
and machine operators:  
Occupational report**

*[New tasks in old jobs: drivers of change  
and implications for job quality](#)*

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**Related reports:** This occupational report is one of the five occupational reports (Car assemblers, Chemical products plant and machine operators, Hand packers, Inspection engineers, Meat processing workers) conducted in the framework of the project Future of Manufacturing in Europe and produced by Martin Eggert Hansen (Danish Technological Institute) and Simone Rosini (Fondazione Giacomo Brodolini).

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## Introduction

### About the study

The overall purpose of the study is to provide a comparative, qualitative, contextualised and detailed analysis of five specific manufacturing occupations, listed below with their International Standard Classification of Occupations (ISCO-08) code:

- meat processing worker (ISCO 8160);
- chemical products plant and machine operator (ISCO 8131);
- hand packer (ISCO 9321);
- car assembler (ISCO 8211);
- inspection engineer (ISCO 2141).

The study is based on a comparative, qualitative analysis of five key occupations in four countries (Germany, Italy, Sweden and the UK), each covering different European regions (continental Europe, the Mediterranean, Scandinavia, and Ireland and the UK). The study focuses on how job content, tasks, applied technologies and working conditions are changing the jobs and their contents.

The five occupations were selected as case *examples* of classical occupations in manufacturing, and how the occupations and their content are changing due to many different factors at contextual and company level. Many other occupations in manufacturing could have been chosen. Hence, the main purpose of these comparative occupational studies is not to analyse the occupations as an end in themselves, but rather to use them to illustrate how manufacturing in Europe is changing and how this affects European jobs.

Each case study combines a contextual level and a company level. This means that each case study analyses the occupation in a given country (for example, chemical products plant and machine operator in Germany) and how industry developments, company strategies and other contextual factors affect the work tasks and job content of the occupation. In each country, the case study is based on desk research and interviews with employees in the occupation and employers in a case study company. In addition, interviews were conducted with relevant trade associations.

At company level, the main focus of the interviews was to analyse the contents and work tasks of the occupation. This analysis is based on a framework developed by Eurofound, which divides the job content and tasks of occupations into three generic categories (Eurofound, 2016):

- physical/manual tasks;
- intellectual tasks – such as processing and transformation of information;
- social tasks – such as interaction with other people (colleagues, customers and so on)

The information gathered from the case studies suggests that the framework is robust and applicable across all the occupations of this study.

### The occupation of this working paper

This working paper focuses on the occupation ‘chemical products plant and machine operator’. This occupational group monitors and operates units and machinery to blend, mix, process and package a wide range of chemical products. They work in the chemical industry, using chemical processes such as chemical reactions and refining methods to produce a wide variety of solid, liquid and gaseous materials. Their tasks usually include operating and monitoring machines and equipment that blend, mix, package and otherwise process chemicals and chemical products to give them the desired properties for further industrial production or to make finished products. The workers may also supervise other workers.

## **Comparative analysis of the case studies: Contextual factors**

This chapter discusses the main findings of a comparative analysis of the four case studies of the occupation, one from each selected country. It analyses the contextual factors and drivers of change in the chemical industry, and how they influence the occupation's job content and working conditions. Contextual factors include:

- industry developments;
- policy context;
- market conditions;
- technological developments;
- industrial relations.

## **Market changes: International competition forces specialisation**

In all four countries, the chemical industry faces the market challenges of internationalisation and competition from the low-cost capacity that has developed in Asia over the past decade. These challenges have forced European companies to adopt new strategies that focus on their core competences, product specialisation and product innovation. The 2008 financial crisis accelerated this trend.

The companies now tend to outsource their production of basic chemical materials to low-wage countries abroad and keep the production of advanced chemical products in their home country. The competition from low-cost countries implies that the pursuit of efficiency and price competition may no longer be a suitable business strategy. Instead, the key to future competitiveness and value creation in high-cost countries is to focus on innovation and the development of complex products requiring knowhow in production and application. To create values, the companies focus on advanced, knowledge-based products where they can develop services and offer consultancy to their customers.

For example, the Swedish chemical industry tends to focus on complex and advanced products that require considerable research and knowhow in production as well as in application. The Swedish case study company is a good example of this. Its products, ultraviolet-cured finishes for wooden floors, are high-technology products with long-term markets, whereas simpler products such as cleaners have a shorter lead time. For simple products, the success is more dependent on marketing efforts whereas advanced products 'sell themselves'.

The UK chemical industry has adopted the same strategy of focusing on advanced knowledge-based products. According to the UK trade association, the Chemical Industries Association (CIA), a key factor in the business strategy of the chemical industry in a high-cost country is to produce complex products that require knowhow, which can be used to develop consultancy services on how to apply the products. Instead of merely selling paint, for example, the chemical industry now supplies 'painting systems', which require consultancy, knowhow and other services that can be spun off the product itself. In contrast, simple commodity chemicals such as polymers, bulk petrochemicals and other intermediates do not have the same potential for value creation in a high-cost country like the UK.

The international competition from low-wage countries is also an important driver of the increasing outsourcing of production of simple commodities. For example, the Italian chemical industry has moved its production of simple commodities to low-wage countries, while concentrating production of advanced products in Italy (that is, products where innovation is the main competitive leverage). Similarly, German chemical companies tend to focus on core competences and pursue being competitive on well-defined single product markets, and not the integration and optimisation of different products and processes. Pharmaceutical companies increasingly focus on new products protected by patents guaranteeing high profits, while the production of standard products with low rates of return is outsourced to other companies.

## **Technology changes: Digitalisation increases efficiency and decreases labour intensity**

In recent decades, the business strategy of the chemical industry in general has focused mainly on achieving value and competitive advantages through economies of scale, cutting costs, speciality lines and production streamlining. Many companies have invested in automation and information technology leading to enhanced reliability, reduced costs and improved operational efficiencies in production and supply chain management.

The automation and digitalisation of production increase productivity as each operator can produce more. This enables the company to make work organisation leaner, with more responsibilities for the operators employed in the production. For example, the Swedish case study company described how a chemical plant operator now handles the production of 15–20 different recipes. Ten years ago, each operator typically handled fewer than five recipes.

Over the past decades, the chemical industry has experienced decreasing labour intensiveness in production in all four case study countries. The main factors explaining this development are:

- increasing use of mechanisation and automation technology;
- the outsourcing by companies of some of their production of simple, basic products to low-wage countries in eastern Europe and Asia.

The use of automation technology, besides reducing the demand for personnel, has improved working and safety conditions for line operators. In the Italian case study company, for example, the automated bottling and labelling lines are equipped with optical and weight sensors, which allow for automatic elimination of non-compliant products. This technology has reduced the demand for labour, and improved working conditions because operators no longer have to monitor the lines continuously and eliminate non-compliant products manually.

## **Policy and regulation: Sustainability is an important driver**

The growing political focus on sustainable solutions and the climate change agenda is an important driver for innovation and the development of new products and markets for knowhow and services related to environmental issues in connection with the chemical products. Hence the chemical industry can create value by developing collaboration with other industries that use their products.

In the UK, for example, collaboration with the automotive industry sees paint and other advanced chemical products being used in production processes, requiring deep insight into the regulations related to health and safety, and sustainability. The chemical industry is also collaborating with the construction industry, helping to develop energy efficient products that enhance sustainability and are friendlier to the environment. Likewise, the chemical industry provides products to the energy industry such as polyester resin for wind turbine blades, monocrystalline silicon for solar cells, high density polyethylene for gas pipes and fatty acid methyl esters for biodiesel.

Similar trends are seen in Swedish chemical companies, which have competitive strengths in terms of product innovation and production processes to become more sustainable and environmentally friendly. This trend is evident in the case study company, which produces chemicals for the treatment and preservation of wooden floors. Over the past decade, the company has innovated its products so that they are now water-based rather than solvent-based substances that can be harmful to health and the environment. The company made this strategic choice because it expects water-based products to be more successful in the future. It is also keen to ensure healthy working conditions for its employees, and the shift to water-based substances benefits the workplace environment. As part of the company's business strategy, its salespeople have a deep insight into its products and are able to advise customers properly. Its customers are mainly businesses that provide wooden floors, although selling to end-users is becoming more important.

## **Workforce changes: Digitalisation increases demand for skilled workers**

As described above, the chemical industry in Europe is undergoing increasing digitalisation and automation of its production. At the same time, the competition from low-wage countries means that European chemical companies are tending to focus on advanced, knowledge-based products and increased customisation of products and development services. The increasing focus on sustainability and environmental issues related to products and production processes is also a factor in creating new markets for knowledge-based services.

The digitalisation of production processes and the customisation of advanced products have increased the skill needs of chemical products plant and machine operators. The monitoring of digital production equipment means that operators increasingly need to have competences and analytical skills in information and communication technologies (ICT) related to problem-solving and quality management.

The chemical industry in the four case study countries is finding it increasingly difficult to recruit skilled workers. Moreover, the need for ICT competences is a challenge and requires the retraining of production workers, in particular older ones. In addition, the ageing workforce in the chemical industry means there is an increasing need to attract greater numbers of young, skilled people to the business. The chemical industries in the case study countries are therefore developing new recruitment and upskilling strategies to enhance the future provision of skilled workers, who are seen as a key factor for future growth.

In Germany, for example, the occupation of chemical products plant and machine operator has undergone a trend of upgrading the qualifications necessary to enter the occupation. Today, most of the employees recruited for the occupation are either a ‘chemist’ (*Chemikant*) with three and a half years of vocational training or a ‘machine operator’ with two years of vocational training.

In the UK, the chemical industry has established a long-term growth strategy based on an industry–government collaboration in the Chemistry Growth Partnership (CGP) launched in 2013. The CGP puts emphasis on addressing the need for more professionally accredited technicians and apprentices through an employer-owned, demand-led system facilitated by the sector coming together around a bid to develop a Science Industry Partnership (SIP). The CGP also believes it is important that school children are made aware of the potentials of working in manufacturing through programmes such as See Inside Manufacturing, Children Challenging Industry and the Catalyst Science Discovery Centre.

Similarly, the Italian case study company is considering adopting a future recruitment strategy aimed at recruiting young staff with the qualifications required for its production processes from local technical high schools.

## **Industrial relations: Centralised bargaining and consensus**

The increasing need for skilled workers in the chemical industry means that employers need to develop stable employment relationships in which operators develop experience over time. This need is reflected in industrial relations, which are characterised by cooperation and consensus at industry level as well as at company level.

At company level, negotiations on wages and working conditions reflect that common interest of the employers and employees in developing the company’s competitiveness and growth. At the same time, good working conditions are vital to ensure a stable, experienced workforce and a low staff turnover. The consensus-based relations mean that employers and employees cooperate to evolve the company and bring it safely through crises and redundancies. When the Swedish and UK case study companies, for example, have experienced major crises and redundancies, the employer and employee representatives have made joint plans on how to handle the redundancies and retrain those made redundant.

The chemical industry is a complex and heterogeneous sector with many different subsectors, company sizes, market dynamics and production processes. This complexity may explain why the organisational representation of chemical products plant and machine operators has been concentrated

in large umbrella organisations. This means that the interests and working conditions tend to be negotiated in collective bargaining alongside many other categories of production workers in the chemical industry.

In Sweden, most chemical products plant and machine operators are members of the Union of Metalworkers (IF Metall). The union is an affiliate of the Swedish Federation of Trade Unions (LO), which organises many other categories of workers. The key level for collective bargaining in Sweden is industry level, and the overall level of coverage of collective agreements is high (estimated at 90%). Workplace representation for employees in Sweden is through the local union in the workplace. Industrial relations at the Swedish case study company are characterised as based on cooperation and consensus between management and employees. The parties have a common interest in ensuring the company's competitiveness, while creating attractive jobs in production so that staff turnover is low. Similarly, in Germany, industrial relations and the negotiation of collective agreements are centralised in large umbrella organisations on both the employers and employees' sides. On the employers' side, the Federation of Chemical Employers' Associations (BAVC) is one of the most centralised umbrella employer associations in Germany. At company level, the working conditions of chemical products plant and machine operators are represented and negotiated in work councils along with other production workers. The relationship at work councils level is characterised by consensus and cooperation. For example, in the German case study company, the main issues dealt with are 'soft issues' such as shift work problems or issues pertaining to work clothes or parking facilities at the plant.

In general, industrial relations in the chemical industry are characterised by consensus, and trade union conveners work closely with company managements to grow businesses and bring them safely through crises. The orientation towards consensus means that employee representatives are willing to accept redundancies – even mass redundancies – if they are considered necessary for the long-term survival of a company. For example, a few years ago, the German case study company underwent a major restructuring due to market challenges, with major job losses among production workers. The trade union representatives and company managers worked closely together throughout the process, and established a support plan for those employees who left the company to help them find a new job. They also launched a plan to retrain those workers who had been made redundant.



## The occupation's job content and tasks

The contextual factors discussed in the previous chapter affect the strategies, manufacturing processes and work organisation adopted at company level, and hence the content and work tasks of the occupation. Overall, the contextual analysis indicates that companies in the chemical industries adapt to market challenges by:

- focusing on advanced, knowledge-based and customised products;
- increasing efficiency based on digitalisation and automation.

The focus on advanced customised products suggests that discontinuous batch production remains the dominant manufacturing approach in the chemical industry. In batch production, more specialised products are produced in smaller amounts according to a recipe.

Based on interviews in the case study companies, this chapter examines how the contextual changes are affecting the job content and tasks of the occupation. The approach taken is to look at the four case study companies to deduce the main generic tasks and job content. Table 1 presents a summary of the occupation's tasks, following the task framework developed by Eurofound researchers, which distinguishes between physical, intellectual and social tasks (Eurofound, 2016; Fernández-Macías and Bisello, 2016).

*Table 1: Summary of job content and tasks performed by chemical products plant and machine operators*

Category	Tasks content and subcategories
<b>Physical/manual tasks</b>	<p><b>Physical strength</b></p> <ul style="list-style-type: none"> <li>• Moving the substances needed for production into place</li> </ul> <p><b>Dexterity</b></p> <ul style="list-style-type: none"> <li>• Onsite inspection of the production equipment</li> <li>• Preparation and blending of base products</li> </ul>
<b>Intellectual tasks</b>	<p><b>Information processing</b></p> <ul style="list-style-type: none"> <li>• Reading the weekly production plan</li> <li>• Reading instructions on production equipment and production processes</li> <li>• Taking test samples of the mixed substances for quality control</li> <li>• Documentation of all stages of the batch production process</li> </ul> <p><b>Problem-solving</b></p> <ul style="list-style-type: none"> <li>• Controlling the presence of the substances for production</li> <li>• Monitoring and controlling the process of adding and mixing substances, and intervention in case of problems</li> <li>• Running machinery through electronic and computerised terminals</li> <li>• Performing chemical and physical analysis on the base and finished products</li> </ul>
<b>Social tasks</b>	<p><b>Serving/attending</b></p> <ul style="list-style-type: none"> <li>• Cooperating with technical staff responsible for maintenance</li> <li>• Participating in meetings on health and safety procedures</li> </ul> <p><b>Teaching/training/coaching</b></p> <ul style="list-style-type: none"> <li>• Mentoring and coaching colleagues and newly recruited operators</li> </ul> <p><b>Managing/coordinating</b></p> <ul style="list-style-type: none"> <li>• Participating in meetings and cooperative action in case of problems</li> <li>• Communicating and cooperating with colleagues to ensure quality and continuity in production</li> <li>• Providing shift information on the production for the next shift</li> </ul>

Category	Tasks content and subcategories
	<ul style="list-style-type: none"> <li>• Changing working position and helping colleagues where needed</li> <li>• Teamwork and social interaction</li> <li>• Developing good relationships, team spirit and cross-cutting skills</li> </ul>

The following sections analyse the different task categories in more detail.

### Physical/manual tasks

The job of chemical products plant and machine operators includes quite a few manual tasks, typically related to preparing and moving substances to the production equipment where the blending processes take place. The job also involves visual inspection of production equipment and products.

The overall trend is for fewer manual tasks as more and more tasks are being taken over by lifting equipment and automated or semi-automated systems at the blending lines. Increasing use of sensor technologies also means that operators have fewer repetitive tasks related to inspection. For example, sensor technology allows for automatic elimination of non-compliant products. This has improved working conditions because operators no longer have to monitor the lines continuously and remove non-compliant products manually. Automation has also increased safety on production lines and reduced errors during the manual handling of production processes, thus improving quality and efficiency.

Overall, the job includes very few tasks related to physical strength as these tasks are now being performed by lifting equipment and automated blending lines. Most of the remaining physical tasks require dexterity related to the inspection, preparation and blending of base products.

Operators are required to check product labels to ensure that all the ingredients needed to produce specific recipes and orders are in place. Before the introduction of ICT production systems with computerised formulas, the different elements were added manually. Nowadays, each batch is marked with a barcode, and each barcode corresponds to the type, order and weight of the elements to be added to the common base. In this way, with the aid of the terminal, the operator just needs to 'read' the batch and add the elements in the order and quantity specified by the software application.

The job still involves visual inspection, but some of these control tasks are being taken over by optical reading terminals and sensor technologies in the production equipment. Increasingly, the production process has become digitalised, automated and managed by computers.

### Intellectual tasks

Because production tends to be digitalised, automated and monitored by computer systems, the job of chemical products plant and machine operators increasingly involves intellectual tasks related to information processing and problem-solving.

With regard to information processing, the operator typically begins the task in hand by reading the weekly production plan specifying the products/recipes to be produced and their amounts. Throughout the production process, the operator is required to submit documentation recording information about all steps of the process. For example, the operator enters information about the exact time of adding specific ingredients to the mix and records that the products added have dissolved.

Problem-solving is increasingly related to the monitoring and quality control of partly or fully automated blending processes. When the ingredients needed for production are in place, the operator adds and mixes the substances according to a given recipe and intervenes in case of problems. Monitoring and control of the mixing and solution processes are managed by the operator digitally via a computer screen.

As production tends to be automated and digitalised, this has increased the span of control (for example, the number of products that the operator can handle and monitor in production). This trend is also driven by the increasing product differentiation due to the increasing focus of companies in high-cost countries on advanced products based on a high level of knowhow and innovation.

For quality control purposes, the operator typically takes test samples throughout the production process for analysis in the company's laboratory. When the operator receives feedback, this information is also entered for documentation.

Chemical products plant and machine operators need to have basic knowledge of the chemical processes involved in their work because, in some cases, they have to perform standardised chemical analyses such as measuring the pH and viscosity of the ingredients or the finished product.

The documentation of all steps in the process is essential to ensure the quality and traceability of the products. If a mistake has been made during production, it is important to be able to identify when and where it was made and which batch has been affected. If it is possible to identify a mistake that has affected the mixing process, it may be possible to correct it by adding substances to rebalance the product.

Honesty and responsibility are key attributes for chemical products plant and machine operators. For example, if the operator has made a mistake in the mixing step or elsewhere in the process, it is important for them to be able to admit and help identify the mistake before a large container is filled or, even worse, shipped to a customer.

### **Social tasks**

Unlike many other industries with assembly lines, chemical products plant and machine operators work on their own performing many tasks in the production process – adding and mixing substances and monitoring equipment. To ensure quality, however, companies may have standards for production processes that require a minimum of two workers to check and confirm the stages of the production process. This is standard practice at the UK case study company, which produces pharmaceutical products: it is relatively common in the pharmaceutical industry for customers to require such procedures to be adopted.

Although chemical products plant and machine operators work individually, the job also includes social tasks involving interaction and cooperation with other employees. In terms of serving and attending tasks, the operator cooperates regularly with technical staff responsible for maintenance. To ensure efficiency, it is important that operators develop self-help experience, such as being able to handle some problems without calling for technical assistance. This requires operators to be good at cooperating with technical staff when machine breakdowns occur and for operators to learn how to handle some of the problems by themselves. In addition, operators participate regularly in meetings on health and safety procedures.

The increasing digitalisation of the production process implies that operators are carrying out more production tasks autonomously. They are therefore increasingly expected to participate in meetings on how to improve production processes, quality and efficiency. Sometimes the meetings may involve maintenance, research and development, and production quality departments.

Social interaction has become increasingly relevant in recent years as production has moved to a just-in-time approach with smaller batches containing a higher number of different products. Before the financial crisis, large quantities of a small number of products tended to be produced. Nowadays, the need to adjust production to smaller batches with higher rotation means that operators also have to interact with colleagues in upstream and downstream departments.

Experienced operators are expected to mentor and coach newly recruited operators. Production in the chemical industry usually takes place in shifts and this work organisation involves several managing and coordinating tasks. The operators in each shift participate in meetings with colleagues on a continuous basis to ensure quality and continuity in production. Each shift is also required to provide shift information on the production for the next shift. It is therefore important that operators in the shift are able to develop good relations with others and work as a team. Each operator is expected to be flexible and able to change working positions and help their colleagues where needed.

To contribute successfully to supervising the proper functioning of the production process, supervisors and managers require a range of social skills such as social interaction with colleagues, teamwork,

interpersonal relationships and verbal communication. These skills are necessary because working shifts and operating through different production departments raises the need to interact with colleagues to be able to achieve positive results.

### **Methods and tools of the work**

The previous sections analysed the content of the work in terms of the occupation's physical, intellectual and social tasks. This section focuses on the methods such as the forms of work organisation used in performing the tasks. The framework developed by Eurofound differentiates between three dimensions:

- autonomy – extent to which a worker is free to carry out the task as they want;
- teamwork – extent to which the task is carried out in direct cooperation with a small group of co-workers;
- routine – extent to which the task is repetitive and standardised.

The case studies indicate that the work of chemical products plant and machine operators tends to be routine work in the sense that the tasks are repetitive and standardised. The production plan decides what orders, products and amounts the operator is going to produce during a given day or week, and the operator must follow a specific recipe. In addition, the operator must carry out detailed documentation procedures at different stages of the process. Operators work together in a team to ensure that the production achieves its particular set objectives, and cooperate with technicians and laboratories on a regular basis. Many of processes, however, are carried out by the operators on their own.

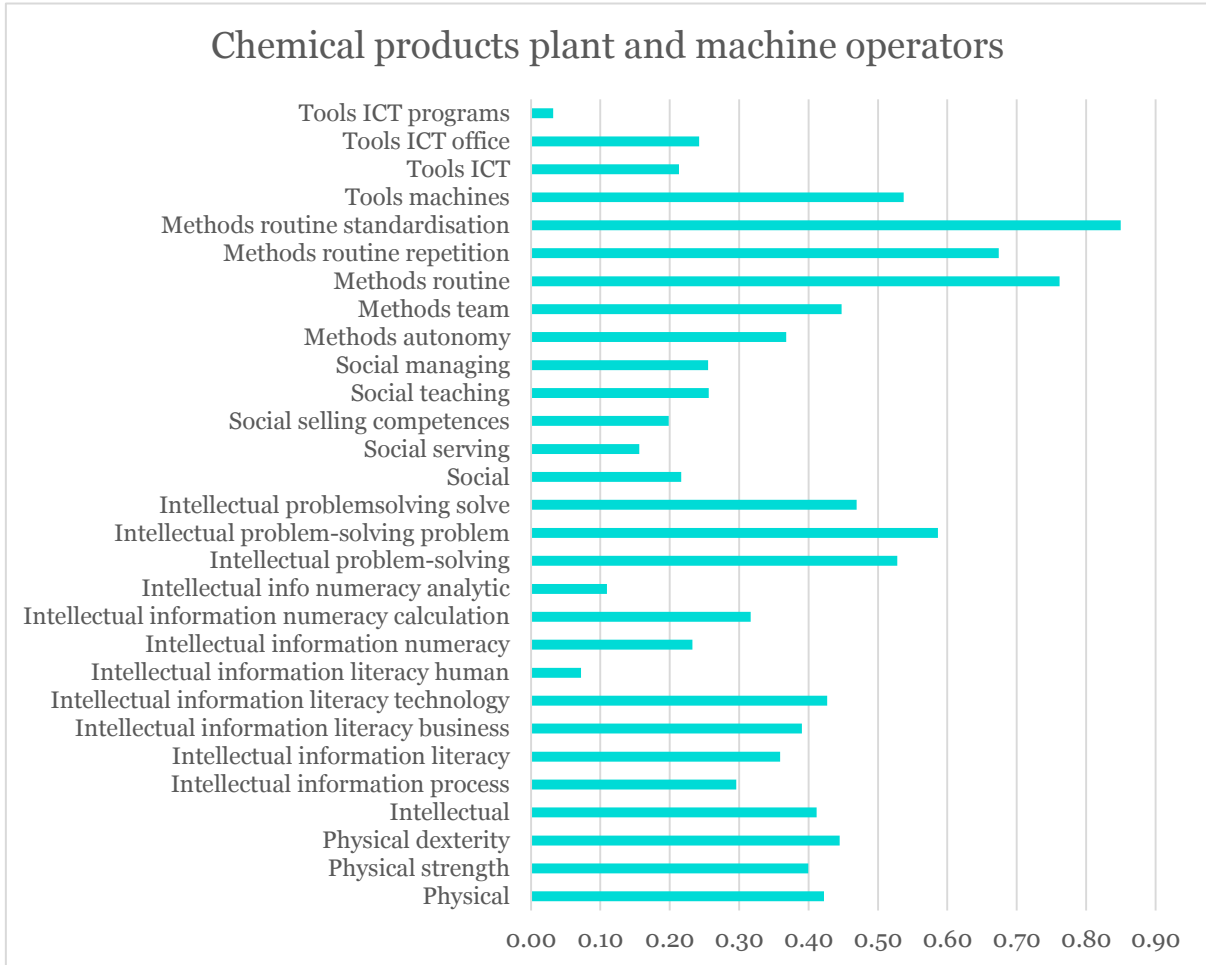
In terms of regards tools, the Eurofound framework differentiates between two main types: machines (excluding ICT) and ICT. The case studies show that chemical products plant and machine operators operate a large amount of production machinery in order to blend, mix, process and package chemical substances. The machines are controlled by electronic equipment, and the operator applies ICT programs when operating and monitoring the machinery. The production machinery and ICT are integrated, and operators typically operate equipment from a control room or from control consoles located near the production units.

### **Comparison with Eurofound's job content scores**

Using data from different international sources, Eurofound researchers constructed a database containing scores of job tasks for many different occupations in Europe (see Eurofound, 2016).

The job content of chemical products plant and machine operators has a high level of standardised, routine tasks (Figure 1). The tasks are performed autonomously, while the level of social tasks is quite low. The level of intellectual tasks is quite high and mainly involves problem-solving, while the level of information literacy is quite low.

Figure 1: Scores of chemical products plant and machine operators for various manual, intellectual and social tasks



## Job quality of the occupation

The concept of job quality refers to the potential impact of the characteristics of jobs on the well-being of workers. Based on information from the case studies, this chapter discusses the job quality of the work of chemical products plant and machine operators. The discussion uses a Eurofound model, which has the following four main dimensions of job quality (Eurofound, 2013):

- intrinsic quality of work (autonomy, skills and social support);
- employment quality (development opportunities and contractual stability);
- workplace risks (health and safety);
- working time and work–life balance (duration, scheduling, flexibility and intensity).

A further dimension, pay/wages, was added for this study to enrich the analysis.

### Intrinsic quality of work

Intrinsic job quality has three main components:

- skills – how varied and stimulating the skills required in the job are;
- autonomy – to what degree the worker work on their own and can decide the pace of the work and how to carry out work tasks;
- social support – how stimulating and enriching the social environment of the job is.

Taken as a whole, intrinsic job quality can be understood as a measure of the richness of work as creative human activity, which is what skills, autonomy and social support are all about.

The case studies show that the intrinsic quality of work of chemical products plant and machine operators is generally regarded as good and improving. The occupation includes a balanced mix of standardised, routine work processes and intellectual tasks related to problem-solving and intervention when technical problems occur. This balanced mix has improved job quality as the job has become more varied and stimulating, whereas previously the work of operators tended to be more monotonous.

The increasing digitalisation of production means that operators tend to handle and document more production tasks autonomously because they can monitor the processes on a computer interface. The increasing autonomy also enhances job quality as the operator has a more comprehensive overview of the production processes, and is stimulated by having to carry out occasional problem-solving and interventions when problems occur.

The skill requirements of the job are becoming broader as the operator now has to:

- oversee more comprehensive production processes;
- handle problem-solving related to digitalised production;
- document all stages of the process.

Operators need to have:

- a comprehensive insight into all stages of the production process;
- ICT skills at user level;
- the learning skills to keep themselves continuously updated on new ICT programs and manuals.

The case studies indicate that these broader skill requirements tend to enrich the operators' work, making the job more varied and stimulating.

Although chemical production increasingly takes the form of digitalised automated mass production, this has not led to the de-skilling of chemical products plant and machine operators. On the contrary, digitalisation means that operators have wider areas of responsibility and are required to work autonomously to handle, monitor and document all stages of the production process. Operators are also responsible for monitoring the quality of the processes by taking test samples and making corrections if needed.

The social support component of intrinsic job quality appears to be becoming more important. Even though the operator handles many processes individually, the work also involves social support as the operator works closely with a team of other operators to ensure that production objectives are achieved. Furthermore, ‘good manufacturing principles’ in some sectors such as the pharmaceutical industry set the standard that a minimum of two operators are required to cooperate and verify all steps of the production process. Operators also cooperate regularly with technical staff responsible for maintenance and laboratories, and give feedback on test samples and quality issues.

### **Employment quality**

In the four case study countries, no formal qualifications are required to enter the occupation. As operators become more experienced, good development opportunities are available. These mean that operators can gradually gain more responsibility and move upwards into management positions related to quality control, maintenance or shift management. Shift management typically involves schedule planning to determine staffing levels and calculate overtime payments. With further study, an operator can become a process technician or a chemical engineering technician.

The case studies indicate that the employment quality and contractual stability of chemical products plant and machine operators are generally good, as industrial relations are based on cooperation and consensus at both industry and company level. At company level, employee representatives and management have a common interest in bringing the company safely through market challenges and crises to ensure long-term job stability. At the same time, good working conditions are important to ensure a stable, experienced workforce and a low staff turnover. For example, the employee representatives at the Swedish case study company stated that the common strategy was not to keep as many jobs as possible ‘but to keep the good jobs’. The turnover among operators is very low in this company and many operators have worked for it for more than 10 years.

### **Workplace risks**

In terms of health and safety, the job of chemical products plant and machine operators has improved significantly in recent decades. The case studies indicate that the occupation tends to involve fewer manual and physical tasks due to the introduction of lifting equipment and automation technologies. This means that the job has become much less physically demanding. In addition, safety has improved because of the automation of production machinery. Automation means that operators have much less contact with dangerous substances or machinery. This is because:

- chemical substances are now typically injected through tubes;
- mixing processes take place in closed vessels;
- the whole process is controlled from remote computer screens and dashboards.

But although the physical risks have decreased, the mental working conditions of the job may have become more stressful. For example, working in teams at night may be physically as well mentally demanding, and at the same time, the work speed of the job has increased as the operator is expected to handle and monitor the production of many different products.

### **Working time and work–life balance**

The case studies show that:

- the work–life balance of chemical products plant and machine operators is generally good;
- working time and working conditions are regulated in collective agreements at industry and company level.

The case studies also show that:

- the scheduling and duration of working hours and overtime payments are negotiated in work councils at company level;

- the negotiation of working conditions involves issues such as health and safety, work clothes, parking facilities at the plant, the duration and number of breaks, and the number and scheduling of shifts.

The agreements on working time and overtime payment may also involve flexibility and different options for the employees.

In the Italian case study company, for example, overtime can be paid as a combination of wage supplements and paid rest days at the worker's choice.

In the German case study company, the shift system was changed a couple of years ago from a four-shift system with three weeks' work and one week off, to a five-shift system with many more days off in between shifts. In addition, weekly working hours were reduced by 1.6 hours to 35.9 hours. This reduction was crucial for the acceptance of the new working system by the works council.

In the Swedish case study company, an agreement offers each employee the right to be rotated to other work functions or to stay in the same function if that is what they want.

Agreements at company level, such as in the Italian case study company, also focus on the special needs of senior employees who may need further training or replacement.

In companies with no collective agreements, however, there can be dissatisfaction with working time arrangements. In the UK, industrial relations have become less 'unionised' over the past four decades and trade union density has dropped significantly from 56.3% in 1980 to its present level at around 24% (OECD, undated; The BEIS, 2016). This may explain that why some of the UK employee interview included ones with dissatisfied chemical products plant and machine operators who complained about long and stressful working hours in noisy surroundings and a detached management. Working time and work-life balance may therefore vary at company level depending on whether a collective agreement is in place.

## **Pay/wages**

The wage statistics across the four case study countries indicate that the wages of chemical products plant and machine operators vary depending on the experience required and the job's content and responsibilities. In Germany, for example, the average wage per month for a new operator (Chemikant) is €2,962 and €4,288 for an experienced operator. In the UK, annual pay varies between €16,650 and €21,090 for a new worker, and between €22,200 and €27,750 for an experienced worker.

Pay also depends on whether the operator has a permanent or temporary employment contract. In the UK, job advertisements for 'chemical plant process workers' on Indeed.com include examples of the wages being offered to temporary employees as being about €9.2–11.1 per hour or about €20,000 per year. Further searches found advertisements with almost identical job descriptions and responsibilities offering about €29,000 per year; the reason for the difference in pay was that the more well-paid job requires experience with batch production and with ISO9000 quality systems.

In general, wage levels reflect the level of experience. Current labour market prospects are good as demand exceeds the supply of experienced workers. Looking to the future, the long-term provision of skilled workers will be of critical importance to the growth of the chemical industry and the wage levels of operators may therefore increase.



## Conclusions

Chemical products plant and machine operators have become skilled workers who manage digitalised, automated production processes. The job increasingly involves intellectual tasks including problem-solving and information processing. Operators are increasingly required to have specific competences in the field of electronics and mechatronics. When blending chemical products, operators use software applications to manage the recipes and documentation of the blending process. The software-based management of the blending process also requires the operator to carry out standard analyses and procedures to identify various parameters.

The intrinsic job quality of chemical products plant and machine operators can be characterised as good since the job involves a varied mix of routine tasks as well as autonomous work related to the intellectual tasks of problem-solving and processing of information. The skills required by operators have broadened, with ICT and problem-solving making the job more intellectually stimulating. Social support for the work has grown as the job now involves more teamwork and cooperation with quality and maintenance functions. In addition, the health and safety conditions of the job have improved considerably as physical tasks have been taken over by lifting equipment and chemical substances are sealed in closed vessels and tubes. In general, operators work in stable employment relationships that benefit the employer as well as the employee who develops experience and becomes more productive. These developments have been driven by a combination of market changes, new technologies and other contextual factors.

International competition from low-wage countries is forcing European companies to specialise in advanced products. This competition suggests that the key to future competitiveness and value creation in high-cost countries is to focus on innovation and the development of complex products that require knowhow in production and application. In contrast, the production of simple commodities now tends to be outsourced to low-cost countries. The focus on advanced, knowledge-based products is also driven by the increased focus on sustainability, which is an important driver for innovation and the development of new markets for knowhow and consultancy services.

The digitalisation and automatisisation of production to increase efficiency means that the European chemical industry has become less labour-intensive. In addition, operator productivity has tended to increase as each operator can handle and monitor more production processes and functions. The work organisation in the case study companies has become leaner, with more responsibilities for the machine operators employed in the production process.

Industrial relations in the chemical industry are characterised by as cooperation and consensus at both industry and company level. These characteristics are driven by the increasing need for skilled workers and the development of stable employment relationships. The experience developed by chemical products plant and machine operators over time, coupled with the increase in the knowledge content of the work, makes the operators valuable to the company and difficult to replace.

At company level, negotiations on wages and working conditions reflect the common interest of employers and employees in developing the company's competitiveness and growth. At the same time, good working conditions are important to ensure a stable, experienced workforce and a low staff turnover. A Swedish employee representative explained it this way: 'Our goal in negotiations with company management is fewer, but better jobs – in stable employment relationships'.

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