

65
years



İSTANBUL
CHAMBER OF INDUSTRY

TURKISH HEAT TREATMENT INDUSTRY

**İstanbul Chamber
of Industry Sectoral Committees in
Global Competition, Sector Strategies Project**

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INTRODUCTION

As İstanbul Chamber of Industry, we are carrying out the “İstanbul Chamber of Industry Sectoral Committees in Global Competition, Sectoral Strategies Project “ since 2001, in order to improve the competitive power of our manufacturing industry sectors and to achieve a high value added production structure. The sector reports prepared with the contributions of the sector representatives, especially the members of the sectoral committees, aim to support corporate collaborations and to contribute to the efforts of sectoral strategy development, which gains increased importance for our economy and industry.

Heat Treatment Industry sector report, the nineteenth report in the series of sectoral reports published within the scope of the project, has been prepared with the contribution and participation of the 29th Sectoral Committee for Group Metal Processing, Forming, Heat Treatment and Coating Industry.

For the stable development of the industrial sector, vertical and horizontal integration between the sectors must be ensured and the sub-industries must show a balanced development in line with the needs of the sector. As you can see in this document, heat treatment is a branch of the fabrication metal industry sector and it plays a crucial role for the development we underlined due to the close affairs with all other industrial branches.

Heat treatment industry applies heat treatment processes on metal, composite and ceramic products, adds strength, flexibility, long economic life and similar other specifications to these products and provides vital contribution and competitive power to industrial branches particularly including automotive, machinery, aerospace, defence, white appliances, rail systems, etc., that use these inputs.

We observe that the production capacity of the heat treatment industry sector has increased due to the rapid economic growth and the increase in exports which have been experienced especially in 2000s, the significant amount of foreign capital investment has been realized in this area and more importantly, improvement has been achieved in the technology and value added structure of the sector.

Today, there are many innovative companies in our country that use technologies similar to those used by competitors in Europe, have achieved international standards in terms of quality and scale, and have adapted to current requirements on environment and energy efficiency.

Local and foreign companies in our country apply heat treatment in production processes internally especially in parallel with their scale, efficiency and quality requirements. On the other hand, we observe that our commercial heat treatment companies, which are estimated to constitute about 20 percent of the total production capacity of the sector, are going through a significant development process in recent years and that the potential to meet the demands of our industry sector in terms of quality and scale has reached to a great level. This development also means that the most important exporting sectors of our manufacturing industry gain the speed of localization in the production inputs, so that a larger amount of imports are replaced by domestic production and this process contributes to the improvement of foreign trade balance. We believe that in the coming years we will also complete deficiencies in the field of production technology where our heat treatment industry is largely dependent on the foreign countries.

Increased support must be provided to heat treatment sector that has strategic importance in terms of converting Turkey into a strong industrial production centre that leads the region and achieving 2023 targets. This report does not only increase the awareness on the importance of heat treatment industry and meet the requirement on consolidated statistical data on the sectoral scales but it also provides recommendations on strategies and policies in accordance with the opinions and advise of sector representatives. We present our Heat Treatment Industry sector report hoping that it will shed light to the efforts of the sector towards increasing the contribution to our economic growth and we would like to express our appreciation to our consultant Dr. Can Fuat Gürlesel and to Members of the 29th Group Sectoral Committee and employees of our Chamber’s Department of Economic Research who displayed effort and provided contribution during our works.

Erdal BAHÇIVAN

Chairman of the Board of Directors,
İstanbul Chamber of Industry

Heat Treatment Industry

Heat Treatment Industry is found and defined under the division Manufacture of Fabricated Metal Products No.: 25 in the NACE Rev. 2 industry classification. Heat treatment is defined as the set of treatments applied to specifically metallic materials to improve their mechanic properties such as rigidity and durability following certain temperature change methods, thereby increasing the material's value. In technical terms, heat treatment is carried out to improve all properties of the material, including rigidity, toughness, durability, corrosion and wear resistance, etc. Heat treatment is also defined as controlled heating and cooling processes to build necessary properties into solid metals or alloys. Heat treatment is carried out in vacuum, controlled atmosphere furnaces, induction/flame surface-hardening machines, fluidized beds and salt baths.

Considering the industries that need and receive its services, heat treatment is of strategic importance to the economy. The competitiveness of other industries directly depends on an advanced heat treatment industry. Technology-intensive industries develop alongside the development of heat treatment industry. A well-developed heat treatment industry is necessary for the development of machine, automotive, defense, aviation-space, base metal and metal goods industries, all of which vital for economy and industrialization. Heat treatment multiplies the value-added of these industries. Metal pieces that have not undergone heat treatment are not used in the products or manufacturing processes of these industries. Heat treatment industry is the stepping stone for other industries to achieve international standards in their products. A well-developed heat treatment industry also generates considerable foreign exchange revenue.

Heat treatment industry is related to all industries that use metal inputs that have undergone heat treatment. Industries with the highest level of heat treatment processes, hence closest to heat treatment industry, are as follows: Automotive and automotive supply industry, rail systems, defense industry, aviation and space industry, machine industry, medical device industry, base metal industry, metal goods industry, energy industry and construction materials industry. Heat treatment is used in practically every area of the abovementioned industries.

There are two types of heat treatment operations. The first is commercial heat treatment carried out by companies in the heat treatment industry. The second is in-house captive heat treatment carried out in other industries that require heat treatment in their business and utilize heat treatment within their capacity in their manufacturing processes.

A certain number of these companies mainly use heat treatment facilities for their own businesses while also providing heat treatment services to other companies.

Global Heat Treatment Industry

Heat treatment industry plays a vital and critical role in the manufacturing industry. However, heat treatment is an intermediate treatment which does not manufacture final products, nor is a part of the final consumption. Heat treatment is therefore not visible to the end consumer and is mostly underappreciated.

Heat treatment is a capital-intensive industry, requiring large-scale, industrial furnaces and equipment. The industry is also energy-intensive and has high operating costs.

Industrialization is mainly based on the ownership of production and product technologies. Accordingly, heat treatment produces for and drives technological process in a number of medium- and high-technology industries, primarily machine industry and automotive, as well as aviation and space, defense, white goods, energy equipment, healthcare equipment, rail systems, shipbuilding, electrical appliances and electronics. Heat treatment industry applies heat treatment to metal, composite and ceramic material inputs used by all abovementioned industries as well as others. This treatment is a vital contribution to the products of these industries.

In heat treatment industry, several countries take the lead in technology, competitiveness, production capacity and production. These countries are both developed and emerging economies including the U.S., Germany, Japan, South Korea, China, India, Indonesia, Poland, Czech Republic, Slovakia, Hungary, Canada, Mexico, Russia and Brazil.

Two sources inform the global market size calculation of heat treatment. The first one is statistical data published by official and private agencies of countries. The second one are assumptions based on countries' domestic income and the size of their automotive manufacturing. According to these assumptions, the global market size of heat treatment amounted to USD 88.5 billion in 2015.

In 2015, the U.S. had the highest market share of heat treatment, worth USD 19.75 billion dollars. China was the second biggest market in heat treatment, followed by the European Union market. Germany is leading the EU market in the industry.

Approximately 15 to 20% of market share of heat treatment is generated by commercial firms, while the remaining 80 to 85% belongs to companies that carry out heat treatment within their own facilities. Accordingly, commercial firms create a market size worth somewhere between USD 14 and 18 billion.

The market size of equipment used in heat treatment industry is assumed to have amounted to somewhere between USD 4.6 and 5.7 billion in 2015. Approximately 12% of equipment sales come from vacuum equipment while the remaining 88% are atmospheric. U.S., China and Germany are the leaders in equipment manufacturing. Fierce competition takes place in the manufacturing of heat treatment industry equipment and furnaces. Competition is increasingly focusing on technological advancements and furnace design, with energy efficiency and reduction of carbon footprint as determining factors. Among all heat treatment equipment, there is a growing number of furnaces and equipment used with vacuum technology.

Following is the distribution of industries served by the heat treatment industry: Automotive industry 33%, machine industry 15%, building and infrastructure materials industry 13%, connectors and hand tools industry 12%, aviation-space-defense industry 11%, base metal and metal goods industry 11% and other industries 5%.

The global heat treatment market is expected to achieve an average annual growth of 3.0 to 3.5% between 2016 and 2020. Based on these expectations, the market size of heat treatment, which amounted to USD 88.5 billion in 2015, might rise to somewhere between USD 102.6 and 105.7 billion in 2020.

Turkish Heat Treatment Industry



A Heat Treatment Facility

First heat treatment in Turkey was conducted in Mechanical and Chemical Industries Corporation (MKEK). Private sector

initiatives in heat treatment emerged in Istanbul in 1940s and 1950s. The first initiatives were carried out in workshops with master artisans. As of early 1960s, Turkey entered the period of planned development, boosting the demand for heat treatment. During this period, master artisans, as well as workers who have been trained in Germany undertook initiatives in commercial heat treatment in Istanbul and other industrial cities. The work was still small-scale and workshop-based. With the diversification of industrial production in Turkey by the end of 1970s, commercial heat treatment enterprises were founded across the country.

In 1980s, with the goal of economic expansion abroad, the industrial sector experienced an export-based growth while heat treatment initiatives developed into bigger businesses. The signing of Customs Union agreement with the European Union in 1996 ushered in a whole new era for the Turkish industry. The effect was positive in heat treatment industry as well, with the growing number of enterprises in commercial heat treatment and the increase in the production capacity. Technological advancements were also kept abreast of during this period.

As of early 2000s, the normalization and improvement in the economy spurred foreign capital investment in the heat treatment industry. There was a rapid growth in the number of key foreign players engaged in production and trade in heat treatment processes, furnaces and chemicals. From the second half of 2000s onwards, commercial heat treatment companies started engaging in businesses with high added-value and quality while also focusing on obtaining quality certificates and international standards.

The development of the heat treatment industry in Turkey is not limited to commercial heat treatment companies. From early 1980s, major large-scale companies founded heat treatment units on their facilities. These companies were mainly from base metal industry, metal goods industry, automotive industry, white goods industry and defense industry among others.

There is no official data on the total market size of heat treatment in Turkey. The size of heat treatment market is calculated on the basis of the methodology used around the world. It is assumed that the market size of heat treatment amounted to USD 1.1 billion in 2015. Around 15% to 20% of this market size belongs to commercial heat treatment companies, worth somewhere between USD 165 and 220 million.

Advanced manufacturing technologies are used in medium-large scale commercial heat treatment companies, which undertake 80% of all heat treatment in Turkey. Technology progressed especially in 2000s with new investments in capacity and renovation. Furnaces and equipment in use are of new technology, eco-friendly and highly energy-efficient.

Advanced manufacturing technology was also supported by the transition to automation to meet the increasing quality standards and the emergence of foreign-invested companies. Commercial heat treatment companies in Turkey use technologies similar to their European competitors. Turkey is largely dependent on imports in manufacturing technology for the heat treatment industry.

The heat treatment industry in Turkey offers services to many industries with highest export rates, chief of them being the automotive industry, contributing to their achievement of quality and standards in their products as well as transition to value-added manufacturing.

There are two production capacity groups in the heat treatment industry of Turkey. The first one belongs to commercial heat treatment companies. The second one is the production and production capacity of companies utilizing heat treatment within their own facilities. As of 2015, the total production capacity of heat treatment in Turkey is estimated to have reach 1 million 430 thousand tons. Accordingly, commercial heat treatment companies have a capacity of 280 thousand tons while companies engaging in their own heat treatment activities have a production capacity of 1 million 150 thousand tons.

As of 2000s, foreign capital commercial heat treatment companies started investing in Turkey in view of the market's potential and growth, contributing to capacity increase. Major global companies engage in heat treatment activities in Turkey. It is estimated that foreign investment has nearly 10% rate in commercial heat treatment activities.

A great number of industries and major foreign companies carry out heat treatment operations within their own facilities. Major reasons include a motivation to speed up the process, eliminate bottlenecks, achieve quality and standards and enjoy scale and cost advantage.

However, heat treatment industry today has the capacity to meet the heat treatment demands of industries both in terms of quality and scale. Therefore, Turkey's heat treatment industry and heat treatment companies should be developed in line with the general global trend. Just like their developed counterparts across the globe, commercial heat treatment companies in Turkey should turn into larger-scale companies with high value-added; building know-how, expertise and innovation.

Another important role heat treatment industry plays is to provide heat treatment for inputs within exported products. These operations are carried out in Turkey which therefore substitute imports.

Competition and market conditions for heat treatment industry in Turkey have just begun to develop and mature.

Areas that apply heat treatment create high value-added but there is a discrepancy between the created value-added and heat treatment costs. In foreign countries, the heat treatment industry receives returns for the value-added it generates. Heat treatment in these countries amounts to as much as 10 to 15% in total costs while in Turkey the rate is no bigger than around 3 to 5%. However, there is no difference between the value-added and commercial quality of heat treatment in Turkey and abroad. In Turkey, price policies developed within current market and competition circumstances make it impossible for the heat treatment industry to get returns for the value-added and quality service it provides.

Heat treatment in Turkey is applied in the following industries: 60% in automotive industry, 10% in machine industry, 10% in base metal and metal goods industry, 5% in infrastructure and building materials industry, 5% in white goods industry, 2% in rail systems and 1% in defense and aviation industry.

Turkey has set general economic and industrial goals for 2023. Heat treatment in international standards w be instrumental in the achievement of these goals. With the development of a heat treatment industry operating on an international scale and supported accordingly will primarily strengthen domestic production in addition to other industrial goals.

Propositions For The Heat Treatment Industry

Heat treatment industry holds a strategic importance. It should have its own classification in industrial categories, and evaluated independently. Heat treatment industry should be removed from highly hazardous jobs and should be included in hazardous jobs. Obligation to limit maximum daily work to 7.5 hours should be eliminated with amendments. There is a strong need for qualified human resources which should be aided with separate departments in educational institutions. High energy costs should be tackled with investments in energy efficiency. Private Consumption Tax on heat treatment oils should be abolished. Unfair practices in occupational health and safety should be eliminated. Amendments should be made to enable Eximbank loans. Heat treatment industry should be classified a high-technology industry and receive incentives accordingly. Laboratory infrastructure should be built with a national accreditation system. Foreign capital investment should be encouraged. Public tenders with outdated tender processes should be amended. Cooperation models should be developed with large-scale public firms. Technological activities and industry-university cooperation should be strengthened. Heat-treated export products should be well-supervised. Capacity and investment plans should be made in industry. The current capacity should be used more efficiently. The industry should develop common minimum quality and business standards.

Definition, scope, function of the heat treatment industry and its strategic importance for the economy are provided in the first part of the report. For this purpose, first, the place and definition of the heat treatment industry within the NACE industrial classification is given. Then, the functions, activities, production processes, strategic importance of the heat treatment industry and collaborated sectors are described.

1.1. Definition and Scope of the Heat Treatment Industry (with NACE Classification)

First, definition and scope of the heat treatment industry, an industrial branch constituting subject matter of this Report, are provided. The definition and scope provided in this part depend on NACE Revision 2 industry codes. "Metal Processing, Forming, Heat Treatment and Coating Industry" is provided under Title No. 25 Fabricated Metal Items Production in NACE Revision 2 industry codes. Heat Treatment Industry is also addressed and defined under this headline.

25 Fabricated Metal Items Production

Fabricated metal items production usually involves manufacturing of "pure" metal products that are usually static and have a fixed function (parts, containers (barrel, casks, etc.), fittings or assembly pieces that are aimed at converting these products with moving parts that are not fully electrical, electronic or optical into sophisticated units (sometimes with other metals). Fabricated metal items production involves the following manufacturing processes; Heat treatment activities are provided under the headline 25.6.

- 25.1 Metal building materials production
 - 25.11 Metal structure and structural elements production
 - 25.12 Metal door and window production
- 25.2 Metal tank, reservoir and container production
 - 25.21 Central heating radiators and hot water boilers production
 - 25.29 Other metal tank, reservoir and container production
- 25.3 Steam generator production except for central heating hot water boilers
- 25.4 Weapon and ammunition production
- 25.5 Forging, pressing, punching, rolling of the metals; powder metallurgy
- 25.6 Metal processing and coating; machining**
 - 25.61 Metal processing and coating**
 - 25.62 Machine processing and forming of metals**
 - 25.7 Production of cutlery and other cutting tools and hand tools as well as general hardware
 - 25.71 Cutlery set and other cutting tool production
 - 25.72 Lock and hinge production
 - 25.73 Hand tools, cutting tool tips, saw, etc. production
 - 25.9 Production of other fabricated metal items
 - 25.91 Production of steel barrels and similar containers
 - 25.92 Production of light metal packaging materials
 - 25.93 Wire products, chain and spring production

- 25.94 Production of fittings and screw machine products
- 25.99 Production of other fabricated metal products that are not classified elsewhere

Heat Treatment Industry is classified under "25.6 Metal Processing and Coating, Machining" and it is grouped and described as provided below.

25.6 Metal processing and coating; machining

This group consists of general activities such as coating with minerals, priming, drilling, etching, polishing, welding that are carried out for processing metals based on an agreement or against fees.

25.61 Metal processing and coating;

This category consists of:

- Coating, anodizing metals, etc.,
- Heat treatment of metals,
- Deburring, sandblasting, polishing through grinding, cleaning,
- Painting, etching metals,
- Coating metals with non-metal materials; + plastic coating, enamel coating, varnishing, etc.
- Tempering metals, honing with soft things.

- 25.61.11 Metallic coating of metals
- 25.61.12 Non-metallic coating of metals services
- 25.61.21 Heat treatment processes for metals (except for metallic coating)
- 25.61.22 Other surface processing services for metals

25.62 Machine processing and forming of metals

This category consists of:

- Punching, grinding, milling, shaving, polishing, grooving, fixing, sawing, honing, sharpening, welding, connecting of metal parts, etc.,
- Laser cutting or engraving of metals.

- 25.62.01 Punching, grinding, milling, shaving, polishing, grooving, fixing, sawing, honing, sharpening, welding, connecting of metal parts, etc.,
- 25.62.02 Laser cutting or engraving of metals

Heat treatment processes are classified in group 25 in NACE classification. In addition, companies operating in other industrial branches also have heat treatment capacity and operations. Companies in sectors such as base metal industry, defence industry, machinery industry, automotive industry carry out internal heat treatment processes. Heat treatment capacity of these sectors can be greater than the commercial heat treatment capacities of commercial heat treatment companies classified under group 25.

1.2. Heat Treatment Industry and Activities

1.2.1. Definition of Heat Treatment

Heat treatment is defined as the set of treatments applied to specifically metallic materials to improve their mechanic properties such as rigidity (hardness) and durability following certain temperature change methods, thereby increasing the material's value.

In technical terms, heat treatment is carried out to improve all properties of the material, including rigidity (hardness), toughness, durability, corrosion and wear resistance, etc.

Heat treatment is also defined as controlled heating and cooling processes to build necessary properties into solid metals or alloys.

Heat treatment is carried out in vacuum, controlled atmosphere furnaces, induction/flame surface-hardening machines, fluidized beds and salt baths.

1.2.2. Heat Treatment Activities

Heat treatment is a process that is applied to the inputs required and used by almost every sector. However, the heat treatment is carried out for two main purposes in terms of application areas: The first purpose product according to area of use is the application for the purpose of forming. The second purpose is to add proper mechanical properties to the work piece. Heat treatment processes are mostly applied to metals. Metals such as iron, steel, stainless steel, structural steels, aluminium and copper are the most frequently used metals for the heat treatment. Approximately 80 percent of the heat treatment processes are applied on steel products.

1.2.2.1. Heat Treatment Processes for Product Forming

Heat treatment to shape the product involves normalizing (air cooling and tempering) processes which remove the residual stress from the previous processes (e.g. cold forming) and / or metallurgical improvement and soften the material.

Annealing Process: It is the process that involves heating the metals to the temperature below the solidification curve, keeping them at that temperature and cooling back. In other words, the material is always solid.

Annealing processes:

- a. **Soft annealing:** It is mostly applied for reducing the hardness of steel, improving the machining properties or reducing the internal stresses of cast and forged parts.
- b. **Coarse-grain annealing:** It is mostly applied for improving the machining properties of low-chrome metals/ steels.

- c. **Diffusion annealing:** It is applied for the homogeneous diffusion of soluble components in the internal structure.
- d. **Normalization:** It is applied for reducing the grain size, obtaining a homogeneous structure, improving mechanical properties, and scattering the carbide network that is in the grain boundary in metals/ steels above the eutectic point. After the normalization process, the forged, rolled, coarse structures are corrected and the material can be restored to properties that can be gained any time (such as pulling strength, ductility).
- e. **Stress relief annealing:** It is applied to cast, forged, welded parts and cold formed materials. It is aimed at reducing the internal stresses of the material that are created during production.
- f. **Recrystallization:** It is applied for the purpose of restoring the crystal structure of the forged and rolled materials to pre-processing conditions.

1.2.2.2. Heat Treatment Processes Adding Appropriate Properties to Metal Parts

Heat treatment processes aimed at adding appropriate properties to metal parts are carried out to achieve the desired properties with metal parts under working conditions when the heat treatment is completed or nearly completed. The heat treatment processes applied in accordance with the purpose of use vary depending on technical methods.

- a. **Hardening:** This process is applied for the purpose of improving mechanical properties, increasing the hardness and improving the wearing resistance.
- b. **Tempering (Annealing):** This process is applied for eliminating high stresses and brittleness and adding a solid structure to the material.
- c. **Martempering:** This is the intermittent tempering process that is performed slightly above the martensite formation point for the purpose of reducing the cracking and dimension change risks that may arise during hardening (quenching).
- d. **Austempering:** This is the intermittent tempering process that is performed above the martensite formation point for the purpose of obtaining bainitic phase in the micro-structure to increase ductility.
- e. **Surface hardening:** This is the process of hardening a certain zone or layer from the surface to the core that is applied when solid structure is needed against impacts and a solid hard surface against wearing of components. For this purpose, many different processes are applied. These processes are classified in two main groups:
 - e.1. **Thermochemical process:** It is applied to almost all steel groups particularly including low carbon steels. Steels gains a different

chemical composition and micro structure in the surface when nitrogen, carbon and/or boron is sent at a temperature of 500-1000 °C as interstitial atom. Details of these processes are provided below:

- e.1.1. **Carburizing (cementation):** It is based on the principle of introducing carbon as interstitial atom. A hard surface resistant to wearing and a solid core are obtained after the process. The process is performed at 800-1500 °C.
- e.1.2. **Carbonitriding:** It is performed by introducing ni-trogen with carbon as primary interstitial atom. The process is performed at 800-900 °C.
- e.1.3. **Nitriding and nitrocarburizing:** It is performed by introducing carbon (nitrocarburizing) with nitrogen (nitriding) as primary interstitial atom. The process is performed at 400-610 °C .
- e.1.4. **Boronizing:** It is based on the principle of introducing boron as interstitial atom. The process is performed at 850-1000 °C .
- e.2. **Thermal processes:** The hardening is obtained by changing only the micro structure without changing chemical composition of the material during the heat treatment process. It is applied to steel materials with at least 0.35% C.
 - e.2.1. **Surface hardening with induction:** Metallic material is placed in the middle or against an electrical magnetic field and it is heated at 800-900 °C upon which it is cooled gradually.
 - e.2.2. **Surface hardening with flame:** Metallic material is heated to 800-900 °C with flame and subsequently it is cooled suddenly or gradually.
 - e.2.3. **Surface hardening with laser:** Metallic material is heated to 900-1400 °C with laser and subsequently it is cooled suddenly or gradually.

There are limits for the application of heat treatment processes in the heat treatment industry:

- a. In general, heat treatment is the last process applied for eliminating the stress of the carbon or low alloy parts. Therefore, mechanical properties of the treated materials should not be affected adversely.
- b. Stress relief treatments between cutting processes can be applied to pre-treated materials. Stress relief effect is applied in slightly reduced mode in order to prevent loss of mechanical properties.

- c. Many austenite stainless steel materials require rapid cooling after stress relief or solution treatment at high temperature. In these cases, slight bending or permanent stresses are unavoidable. Dimensions of the part that requires stress relief, treatment or normalization depend on the specifications and capacities of heat treatment machines. Providing machine-equipment of suitable size is important for large parts.

Certain requirements may arise during heat treatment applications carried out in the heat treatment industry.

- a. Many stress relief processes are applied under open atmosphere and there are also protective environments. In open atmosphere, alloys change colour and an oxide layer is formed depending on the type of alloy and temperature. Therefore cleaning is required after the process.
- b. In general, normalization is applied to semi-finished steel parts under open atmosphere and oxide layer formation or decarburizing problem does not arise as they are subsequently cleaned through machining. In addition, sometimes, a protective environment may be required. For example, during normalization before partial surface hardening of parts with final dimensions.
- c. Annealing processes can be applied under protective environments such as open atmosphere or salt, controlled gas atmosphere or vacuum. Some annealing processes may require selection of an environment that provides long-lasting protection.
- d. There is always bending/ buckling risk when high temperature processes are applied on delicate, thin-walled vessels and large, heavy parts. Special supports and tools are required during heat treatment in order to prevent this problem.

1.2.3. Strategic Importance of Heat Treatment Industry in the Economy and Sectoral Relations

1.2.3.1. Strategic Importance of Heat Treatment Industry

Heat treatment industry has a strategic importance for the economy because of the sectors it provides heat treatment services.

- 1. Heat treatment processes are carried out on ferrous and non-ferrous metals, composite materials and nano materials that are used by the other industrial sectors, without prior notice. Therefore, competitive power of the other sectors is directly dependent on the presence of an advanced heat treatment industry.
- 2. Activities of the heat treatment industry are usually provided for sectors using medium, high and advanced

technologies. High-tech sectors develop in parallel with the heat treatment industry.

3. An advanced heat treatment industry is essential for the development of industries such as machinery, automotive main industry, automotive sub-industry, defence, aerospace, base metal industry, metal items industry which are very important for countries and reflect industrialization. This increases the added value of these industries incrementally.
4. The heat treatment industry provides strength, long economic life, safety and quick forming properties to critical and vital metal inputs of many important sectors. Metal parts that were not heat treated are not used in the production and products of these sectors.
5. Sectors conduct a significant part of research and development, innovation and design works on heat-treated metals. Therefore, an advanced and innovative heat treatment industry also supports the technological developments in other sectors.
6. The heat treatment industry provides countries significant advantages in global industrial competition. Many sectors of the industry gain competitive power with the know-how and experience gained in the heat treatment industry.
7. The heat treatment industry is the only function in achieving the international standards sought in the products of other sectors. For this reason, an advanced heat treatment industry also ensures achievement international product standards.
8. The development of innovative materials, composite materials and innovative metals required for sustainability is possible with the advancements in the heat treatment industry.
9. Many industries gain competitive power and participate in global supply chains thanks to the advanced heat treatment industry
10. An advanced heat treatment industry is also an important foreign currency earning industry. Both exports and substitution of imports bring foreign currency revenues.

industry, machinery industry, medical devices industry, base metal industry, metal items industry, energy sector and building materials industry are the sectors for which heat treatment services are provided and thus, the most intensive relationships are established. The following are the most relevant sectors and samples of heat treated critical products.

Heat treatment is used for almost all aspects of life in the above sectors

For example;

- Improving the electrical conductivity of wires,
- Resistance of submarines to high pressures,
- Increasing the strength of rails in railway tracks,
- Strength of implants used in human body in the healthcare sector
- Improving the strength of domestic heating systems
- Resistance of aircraft to atmospheric pressure,
- Stress relief in space shuttles,
- Increasing the number of shots with weapons and strength of the gun barrel
- Increasing the flexibility and durability of roof systems in structures.

Main Sectors	Critical Product Examples
Automotive	Engine components Transmission assemblies Injector nozzles Main chassis All metallic components Rim wheels
Fittings	Bolts and nuts Washers and pims Screws, nails
Rail Systems	Fast train equipment and infrastructure Railway transmission lines, rails Light rail systems Boogie systems Wheel and brake systems
Defence Industry	Rocket and rocket systems Launching ramps Armoured vehicles Unmanned aircraft components and parts War jets and helicopters Gun barrel and mount Armours Light and heavy weapons Submarine components War vessel components

Table 1: Sectors Associated with Heat Treatment Industry

1.2.3.2. Relations of Heat Treatment Industry with Other Sectors

The heat treatment industry is in contact with all sectors using heat treated metal inputs. Automotive main and sub-industry, rail systems, defence industry, aerospace



Main Sectors	Critical Product Examples
Aerospace Industry	Commercial and private aircraft components Landing gears Jet engine components and turbines Space crafts and satellite systems Launching and control facilities
Machinery and Mould Industry	Tunnel boring machines and crushers Moulds used in glass, ceramic, plastic and metal industry Construction machines Mining machines Lifting and handling equipment (forklifts) Cranes Engines Turbines
Shipbuilding Industry	Shaft and propellers Gear systems Crane systems
Medical Equipment	Stent Implant materials Surgical equipment Other medical devices and equipment Imaging system parts and components
Energy Sector	Nuclear power plant turbines and equipment Energy transmission lines Power plant turbines and machines Renewable power plant turbines and equipment Grounding materials Lightning conductors Oil-chemical plants equipment Drilling and extraction pipes
Construction and Infrastructure Materials Industry	Industrial facilities steel structures Steel building columns and beams Industrial grills Water installation materials Roof cladding systems and components Locks
Agriculture and Livestock Sector	Tractor components Agricultural machinery and equipment Irrigation tools Mills Greenhouse constructions
Base Metal Industry	Drilling and cutting tools; bending cutting knives, lathe and planing machine holders, metal saws, products manufactured using powder metallurgy
Non-ferrous Metal Producers	Aluminium production, copper and copper alloys (brass, bronze)
Iron and Steel Industry	Rolled products, cast and forged components, round and flat product manufacturing
Textile and Footwear Subindustry	Sewing needles Accessories Sole steel Toe cap and heel
Electrical Equipment and Electronic Devices Industry	White appliances components Consumer electronic components Home and kitchen appliances and components Small household appliances components Heating equipment

Table 1: Sectors Associated with Heat Treatment Industry (Cont'd)

Source: Prepared by working team and sector representatives.

1.2.4. Companies Conducting Heat Treatment Processes

There are two types of heat treatment operations. The first is commercial heat treatment carried out by companies in the heat treatment industry. The second is in-house captive heat treatment carried out in other industries that require heat treatment in their business and utilize heat treatment within their capacity in their manufacturing processes. A certain number of these companies mainly use heat treatment facilities for their own businesses while also providing heat treatment services to other companies.

1.2.4.1. Commercial Heat Treatment Companies

Commercial heat treatment companies form the basis of the heat treatment industry. The business line of these companies is heat treatment. However, commercial heat treatment processes make up about 15 to 20 percent of the total heat treatment performed.

Commercial heat treatment companies can accumulate know-how in this area, offer a wide range of services and use everevolving technology. Innovation and R&D activities are related only to heat treatment. They create and use specialised, experienced and qualified labour force. Current capacities are constantly full and therefore have higher business efficiency.

1.2.4.2 Industrial Companies Conducting Internal Heat Treatment Processes

In general, companies conducting heat treatment operations internally produce metal inputs for the manufacturing industry or operate in sub-industry sectors by using them. heat treatment processes form a certain phase in the industrial production process. Mostly large-scale capacities are created. It is not the main business line of the company. Therefore, production technology is renewed less frequently, limited number of qualified staff is employed, the existing capacity is used in limited manner, capacity is mostly idle and therefore heat treatment labour force output is low. Despite all of these factors, companies conducting internal heat treatment processes account for about 80-85% of total heat treatment market.

Companies that conduct internal heat treatment processes are mainly located in sectors such as base metal industry, metal items industry, machinery industry, automotive industry, transportation industry, defence and aviation industry.

1.2.5. Heat Treatment Processes, Technologies and Machinery



Heat treatment line manufactured in our country.

Countries such as Germany, Switzerland, Italy, USA, Japan, South Korea and China have technological superiority in machines used in all heat treatment processes and our national heat treatment industry is very advanced and a substantial part has knowledge on these technologies. It is also satisfying that they proved their capabilities by exporting to foreign countries.

Heat treatment process consists of washing and rinsing the metals, heating, quenching and cooling, metal working and testing, respectively.

Basic machinery and equipment used in production processes are as follows;

- a. Metal cleaning (washing-rinsing) machines
- b. Gas fuelled heat treatment furnaces
- c. Heat treatment furnaces with electric heating
- d. Hardening and cooling machines
- e. Metalworking machines
- f. Test and laboratory equipment

In the production process, significant amounts of thermochemicals, special-purpose chemicals and salts are used.

The most important step of the heat treatment production process is the heating process. The heating process takes place in the furnaces. The furnaces are divided into two main groups according to the energy source, either gas or electric. Heat treatment process consumes high energy and the highest level of energy is used during heating of the furnaces. For this reason, preferences for gas and electric furnaces vary.

Gas furnaces are operated by natural gas and electrical furnaces by electricity. Electrical furnaces are used at increasingly higher levels. Energy efficiency is higher and losses are lower. Heat control and regulation are better. It can be used at higher temperatures. There is no risk of explosion thus, it is safer. There is no pollution and CO₂ emission. Installation costs are very low. Installation and operation are relatively easier. Automatic mode can be initiated easily. However, operational costs are higher. Larger furnaces may be required for the same heating process. Renewal and replacement costs are higher.

The second part of the report analyses and evaluates the Global heat treatment market. The importance of heat treatment industry, the requirement for industrialization, important countries, market size, related sectors and global trends and projections are given place.

2.1. Function and Nature of Heat Treatment Industry

Heat treatment industry is a branch of industry that has a vital and critical function in the manufacturing industry. However, heat treatment is an intermediary process, no final product is manufactured. Therefore heat treatment is not considered as a process for end consumers and mostly, its importance is overlooked.

However, in industrialized countries, many metal, composite materials and ceramics containing materials used in industries such as automotive, aerospace, defence, machinery, construction and infrastructure materials, white appliances and consumer electronics are subjected to heat treatment. These industries do not use any input that is not heat treated. Therefore, the existence, development and competitiveness of other industries depend on the presence of the heat treatment industry.

Heat treatment industry is a capital-intensive industry. It uses industrial and large-scale furnaces and equipment. The heat treatment industry is also an energy-intensive industry and the operating costs are high. Given all of these aspects, the heat treatment industry is also decisive in the costs and competitiveness of other industries.

Heat treatment is carried out as an internal process by companies from commercial heat treatment industry and other manufacturing industry branches. The share of commercial heat treatment companies is about 15-20 percent. Nevertheless, in recent years, it has been observed that companies that conduct internal heat treatment processes reduced scale and contracted their works to commercial companies.

2.2. Heat Treatment Industry As a Precondition of Industrialization

Industrialization is mainly based on the ownership of production and product technologies. Accordingly, heat treatment produces for and drives technological process in a number of medium and high-technology industries, primarily machine industry and automotive, as well as aviation and space, defence, white appliances, energy equipment, healthcare equipment, rail systems, shipbuilding, electrical appliances and electronics.

Heat treatment industry applies heat treatment to metal, composite and ceramic material inputs used by all above-

mentioned industries as well as others. This treatment is a vital contribution to the products of these industries.

In other words, if the inputs are not heat treated, the end products of these industries become unusable. The heat treatment industry performs a vital and critical function for the development and industrialization of other industries.

It is not possible to operate a car, fly a plane or use a machine with inputs that are 70 percent metal unless they heat treatment process is applied. Heat treatment adds durability to the components in the space craft that is the only vehicle used for journey to Mars.

The heat treatment industry is the most important area for the development of technology and innovation in this field. Progress in the heat treatment industry results in stronger, long-lasting, smooth-surfaced, easy-to-shape, flexible, durable inputs.

Therefore, heat treatment industries and heat treatment production technologies are available in all industrialized countries. Heat treatment industry is a precondition of industrialization.

2.3. Important Countries in Heat Treatment Industry

There are advanced countries in terms of technology, competitive power, production capacity and production fields in heat treatment industry. Some of these countries are developed countries and some of them are developing countries.

USA

The heat treatment industry in the United States was established in the beginning of the 1930s and the United States continues to lead the way in technology and standards in heat treatment industry. The USA is very innovative in the field of production technologies for the heat treatment industry. The automotive, aerospace and defence industries continue to be the driving sectors in the heat treatment industry. In addition, the USA has created international standards like NADCAP in the aviation, space and defence industries and has been leading the world markets by revising these standards. It also sets global standards in the automotive sector. These standards are implemented in global acquisitions, and accreditation and testing procedures are often carried out by USA companies.

Germany

Germany, together with the United States, is a global decision-maker in the heat treatment industry, technology, standards, inputs and production capacity and leads others especially in

the fields of chemicals and production technology. As a result of the consolidation in 1990s in the European Union, the heat treatment industry has also been consolidated in Germany and Central Europe. Germany maintains its leadership in technology and innovation capacity. The heat treatment industry in Germany is also pioneering in the setting of industrial standards within the EU.

Japan

Japan's heat treatment industry has been established in 1930s, but its main development has been observed starting from the second half of 1960s. Japan has production technology like USA and Germany, and its competitive power comes from the technologically and innovative advancements. Japan is the third largest market together with Germany. In Japan automotive, rail systems, shipbuilding and metallic construction and infrastructure materials support the heat treatment industry. Technology and innovation activities for heat treatment industry equipment in Japan are supported by the state. The heat treatment industry is also dominant in Asia-Pacific countries as many Japanese manufacturing industries moved their production facilities to these countries. In Japan, heat treatment companies work with a business model that involves a smaller number of contracts are accepted for high number of companies. Japan dominates Asia-Pacific region.

South Korea

In parallel with the strategic and planned industrialization process of the South Korean heat treatment industry, it began to develop from the beginning of the 1970s. South Korea has an innovative and competitive heat treatment industry that produces technology. Automotive, shipbuilding, white appliances, machinery and electronics industries support the heat treatment industry. In South Korea, the efficiency of commercial heat treatment companies is higher and small volume of production is carried out for high number of industrial companies. South Korean commercial heat treatment companies that adopt just in time production model use relatively small and medium-sized furnaces. Production technology in the South Korean heat treatment industry is under the influence of Japanese companies. Commercial heat treatment companies also operate together with Japanese furnace producers. In addition, South Korean furnace and commercial heat treatment companies make investments in China and India as well as other developing Asian countries.

China

The heat treatment industry began to develop in China in the beginning of 1980s and has reached an important size in the last 25 years because of the capacity created in the metal industry and manufacturing industry. Manufacturers of heat treatment equipment and commercial heat treatment

companies have been supported with concealed public incentives. As a result, an excess heat and heat treatment capacity has been created. An important consolidation process has been started with the cut-off of state aid provided to the heat treatment industry. Heat treatment industry companies take measures to reduce energy consumption and carbon emissions while developing production technologies. The Chinese heat treatment industry supports the aerospace industry, automotive industry, machinery industry, renewable energy equipment and rail systems industry. Unlike other countries in China, the share of commercial heat treatment processes is quite high at 25 percent, and this share continues to increase.

India

In India, the heat treatment industry has started to show rapid development starting from early 2000s. The industry that drives the development of heat treatment industry in India is the automotive industry. India has become the production centre of small models of global automotive manufacturers and brands. In India, heat treatment processes are mostly carried out internally by the industrial companies. The share of commercial heat treatment companies is rather limited. However, with the large infrastructure investments and automotive sales for the EU market, commercial heat treatment companies started to grow rapidly and new capacity investments have been made. India is dependent on foreign countries about manufacturing technology. Major heat treatment furnace and equipment producers show presence in the market with sale and distribution channels.

Indonesia

Indonesia has achieved rapid and sustainable economic growth through the development in almost all areas of the manufacturing industry. A large number of industries such as aviation industry, automotive industry, machinery industry, shipbuilding industry are rapidly developing. Accordingly, the heat treatment industry has been developing rapidly since the second half of 1990s. Indonesia is depends on foreign countries about technology and chemical inputs. Japanese, South Korean and Chinese commercial heat treatment companies have investments. The share of commercial heat treatment companies is increasing.

Central European Countries

Poland, the Czech Republic, Slovakia and Hungary are the new European production centres in the heat treatment industry. The heat treatment industry has begun to develop in these countries since the second half of 1990s. These countries are experiencing a new industrialization process. Manufacturers of many countries, especially Germany, move their industrial production operations to these countries. Central European countries, especially Poland, also give incentives to new investments in the new generation industrial zones. Industrial capacity particularly including

automotive industry, is developing. As a result, the heat treatment industry is showing a rapid development. As countries are dependent on countries like Germany and Austria about the production technology, commercial heat treatment operations expand with the participation of foreign actors.

Canada and Mexico

In Canada and Mexico, the heat treatment industry developed starting from early 1990s, in parallel with the increase in investments and joint ventures following the NAFTA agreement with the United States.

Canada and Mexico show presence in the heat treatment industry with the support of investors from the USA as they are countries that quickly adopt the international heat treatment standards of the USA.

Russia

The heat treatment industry began to develop in Russia in early 1930s. Russia has an important technology know-how in this area. However, with the decline and obsolescence of the industrial capacity after 1989, metal industry and heat treatment industry had also weakened and became dependent on the foreign countries for the utilization of the capacity. Commercial heat treatment operations are very limited. Heat treatment is mainly carried out by industrial companies internally.

Brazil

As a result of the development in the automotive, aerospace, petrochemical and white appliances industries, the heat treatment 1990's. Brazil is dependent on foreign countries about the production technology and the chemicals used. Commercial heat treatment companies are small in scale and they are not developed sufficiently. The downsizing experienced in the economy in recent years has adversely affected the heat treatment activities.

2.4. Scale of the Global Heat Treatment Market

The global heat treatment market size is calculated as \$85.0 billion as of 2012. This size does not include heat treatment process aimed at crude iron and steel products. Two sources are used in the calculation of global heat treatment market size. The first source is the statistics published by the official and private institutions of the relevant countries. The second is the projections made in parallel with the national incomes of countries and the volume of automotive production. As a result of the studies carried out for 2012, the global heat treatment market size is calculated as 85.0 billion dollars.

Based on the same projections, in our report, global heat treatment market size is estimated as \$8.5 billion for 2015. The US is the country with the largest market share in the heat treatment industry with \$ 19.75 billion in 2015. In 2015, the United States' national income is \$ 17.95 trillion and automotive production volume is 12.1 million vehicles.

China has become the second largest market in heat treatment industry. The market size is estimated as \$ 15.21 billion in 2015. In 2015, China's national income is \$10.87 trillion and vehicle production volume is 24.56 million vehicles. The share of China's manufacturing industry in the national income is quite high at 30 percent and share of the heat treatment market is relatively higher compared to USA's share that is 12 percent.

The European Union market is the third largest heat treatment market. Germany is the leading country in the EU market. The heat treatment market size in Germany is \$9.95 billion in 2015. Germany's national income in 2015 is \$3.36 trillion and vehicle production volume is 6.0 million vehicles. Another big market in heat treatment industry is Japan.

Japan's heat treatment market grew to \$8.55 billion in 2015. In 2015, Japan's national income is US\$ 4.13 trillion and vehicle production volume is 9.28 million vehicles. South Korea's heat treatment market's size is \$4.0 billion in 2015. India and Brazil are other important big markets.

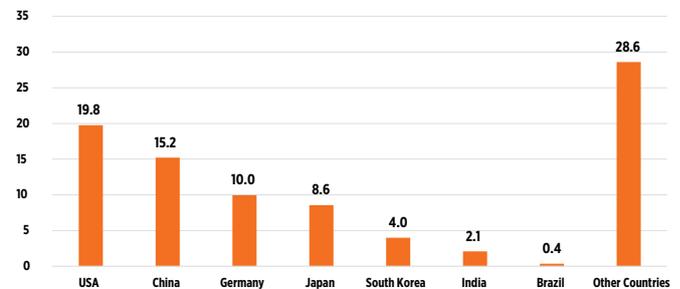


Chart 1: Scale of Heat Treatment Market in Certain Countries (Billion Dollar, 2015)

Source: Prepared by the working team.

The size of the heat treatment market in countries other than these important countries is calculated as \$28.6 billion. EU countries outside Germany have a market size of \$10 billion. Canada, Mexico and Russia are other important markets.

Approximately 15-20% of the market size of the heat treatment industry is created by commercial companies, and 80-85% is created by companies that conduct internal heat treatment processes. Accordingly, the size of the market created by commercial companies is about 14-18 billion dollars.

Country	Vehicle Production (Thousand)	National Income (Billion Dollar)	Heat Treatment Market (Billion Dollar)	Heat Treatment Market/ Vehicle Production	Heat Treatment Market/ National Income
USA	10,335	16,155	18,000	1.74	0.11
China	19,500	8,461	11,500	0.59	0.14
Germany	5,649	2,539	10,000	1.77	0.28
Japan	9,943	4,240	9,000	0.91	0.21
South Korea	4,562	1,223	3,500	0.77	0.29
India	4,174	1,832	1,900	0.46	0.10
Brazil	3,402	2,460	500	0.15	0.02
Other Countries	26,671	35,951	30,600	1.15	0.85
Global	84,236	72,861	85,000	0.86	0.12

Table 2: Scale of the Global Heat Treatment Market (2012)

Source: Janusz Kowalewski, Ten New Trends in Heat Treatment, Global Prospective, 2015.

Country	Vehicle Production (Thousand)	National Income (Billion Dollar)	Heat Treatment Market (Billion Dollar)	Heat Treatment Market/ Vehicle Production	Heat Treatment Market/ National Income
USA	12,100	17,947	19,750	1.74	0.11
China	24,560	10,866	15,210	0.59	0.14
Germany	6,033	3,356	9,950	1.77	0.28
Japan	9,278	4,125	8,550	0.91	0.21
South Korea	4,556	1,378	4,000	0.77	0.29
India	4,126	2,074	2,075	0.50	0.10
Brazil	2,429	1,775	355	0.15	0.02
Turkey	1,358	718	1,100	0.81	0.15
Other Countries	26,010	31,472	27,510	1.04	0.89
Global	90,780	73,711	88,500	0.97	0.12

Table 3: Scale of the Global Heat Treatment Market (2015)

Source: Prepared by the working team.

In the European Union, Poland, the Czech Republic, Hungary and Slovakia stand out as countries with significant development in the heat treatment industry.

New markets are emerging in the heat treatment industry where demand grows faster. The new markets are mainly the base metal industry and especially the fast-developing markets of the automotive industry. In addition to these two criteria, demand for heat treatment is growing faster in countries with high population and high per capita income to support the middle class.

Rapidly growing emerging economies such as India, Thailand, Indonesia, Vietnam, Philippines in Asia stand out as new markets. In Africa, Egypt, Nigeria, Ghana and Tanzania will be prominent countries.

2.5. Development of Furnaces Used in Heat Treatment Industry and Market Scale

The market size of the equipment used in the heat treatment industry is estimated to be between 4.4 and 5.5 billion dollars in 2012. In 2015, the size is estimated at between 4.6 and 5.7 billion dollars. Approximately 12 percent of equipment sales are vacuum equipment, and 88 percent is atmospheric equipment.

There are over 300 manufacturers of heat treatment equipment on a global scale. The equipment manufacturers operate in 34 countries spread over almost every continent. The United States, China and Germany are the most important equipment manufacturers. There is considerable competition in the production of heat treatment industry equipment and furnaces. Competition is increasingly focused on technological developments and furnace designs. Reduction of carbon footprint with energy efficiency is a decisive factor.

The share of furnaces and equipment that use vacuum technology in heat treatment equipment is increasing. Vacuum technology furnaces and equipment are mostly preferred in automotive and aerospace industries, metal items industry and health equipment. Vacuum technology furnaces and equipment The market size is estimated be 610 million dollars in 2012 and it has the growth potential of 6% per annum. Renewal demand of the automotive sector will be particularly effective in this growth.

Conventional atmospheric furnaces will continue to be used predominantly in the shipbuilding industry, construction equipment, rail systems and heavy equipment industries. Due to increased labour costs, the digitalization of furnace and labour shortage, countries such as Japan and South Korea have begun to focus on producing fully-automated equipment and furnaces. High automation makes it possible to use double and multichamber furnaces in large-scale manufacturing industries.

In manufacturing industry, the production technologies and processes are digitalized and continuous processes are adopted. All processes are connected automatically to each other and do not stop at any stage. Thus, the entire production process can be controlled, standards and quality are ensured at every stage, operation costs are reduced and excessive capacity creation is avoided.

Therefore, furnace control systems have changed dramatically over the past 10 years. Heat treatment processes and furnaces and manufacturing process flows are integrated to increase efficiency. In the near future, automatic and continuous integration with fully intelligent furnaces and equipment will be provided; thus, problems and interruptions will be signalled in advance.

Due to global warming trends and high carbon emissions generated by heat treatment furnaces, there is a rapid change in the design and technology of the furnaces as well as investment decisions made for these machines. There is a significant trend towards reducing the environmental impact of furnaces. The purpose is to process at lower temperatures, eliminate heat losses and reduce the duration of heat treatment processes in furnaces.

Heat treatment phases are integrated to reduce the duration and simplify the heat treatment process. Surface treatments create limited destruction at low temperatures. The driving forces behind the developments in heat treatment industry technologies are: Reduction of heat treatment duration, minimizing the total foot print in the environment, minimizing the bending and destruction during heat treatment, reduction of material costs and reduction of operating costs for furnaces.

2.6. Driving Sectors in Heat Treatment Industry

The heat treatment industry applies heat treatment to the inputs of all sectors using metals, ceramics and composites on a global scale. However, there are leading sectors for the heat treatment industry. These are automotive industry, machinery industry, aerospace industry, rail systems, construction and infrastructure materials, casting base metal industry and metal goods industry, hand tools and kitchenware industry and fittings industry.

33 per cent of global heat treatment activities take place in the automotive sector. About 70 percent of the weight of a vehicle is metal, and all these metals go through heat treatment. In this context, the automotive sector is the most important determining factor in the demand for heat treatment.

In the distribution of the sectors served in the heat treatment industry, 33 percent is the automotive industry, 15 percent is the machinery industry, 13 percent is the construction and infrastructure materials industry, 12 percent is the fittings and hand tools industry, 11 percent is the aerospace-defence industry, 11 percent is the base metal and metal industry and 5 percent is other industries.

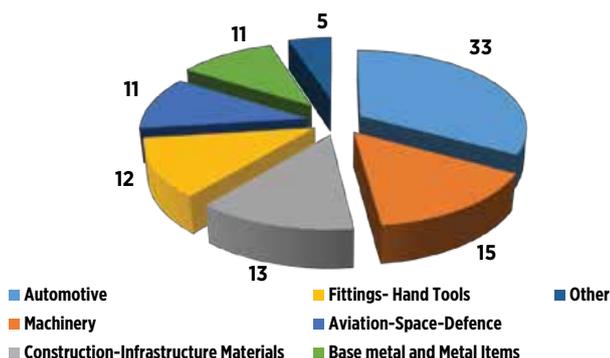


Chart 2: Shares of Sectors Served by the Heat Treatment Industry (Percentage, 2015)

Kaynak: Janusz Kowalewski, Ten New Trends in Heat Treatment, Global Prospective, 2015.

2.7. International Standards in Heat Treatment Industry

Quality standards and procedures in the heat treatment industry are increasingly common and internationally used. The developments in information and communication technologies and the development of the international supply chain lead to the increasing, and common use of standards in the heat treatment industry. AMS2750E is the most widely used standard in heat treatment industry in the global scale. Common standards for heat treatment increase the quality of heat treatment on a global scale.

NADCAP standards used in the aerospace industry and NADCA # 207-2016 and AMS2759 international standards used in other industries are examples of common and international standards. The use of these standards ensures that the supply chain works efficiently and quickly in the automotive and aerospace industry.

Heat treatment industries of Asia and other developing countries are also added to the global supply chain by using these standards. In the coming years, the heat treatment processes will evolve into single hybrid processes from dual and multiple processes. For this reason, the number of international standards will also decrease. In this process the CQI-9 NADCA and AMS 2759 / 1-6 standards will become more widely used for all types of heat treatment.

2.8. Global Trends in Heat Treatment Industry

1. Three important elements lead global growth in the heat treatment industry. The first of these is rapidly expanding in Asian markets. More new capacity investments are being made in this market. The second one is replacing old furnaces in the US-Mexican market with energy-efficient and less polluting machinery. And the third is to replace old furnaces with energy efficient and less polluting machines in developed markets.
2. With regard to the equipment used in the heat treatment industry, the share of vacuum technology and lower temperature processes is increasing. Vacuum furnaces with higher process capacities and functions stand out.
3. Heat treatment is increasingly becoming digital. Mass heat treatment processes are reduced and heat treatment processes are integrated with other manufacturing processes. Digitalization automation provides visualization (3 dimensions), real-time process controls and connectivity. The machines become intelligent and production processes do not stop.

4. Heat treatment standards, processes of application procedures and furnace-equipment designs are becoming increasingly global. Zero accident furnace-design philosophy is gaining importance.
5. Furnaces that consume high energy and cause carbon emissions are replaced by furnaces that apply heat treatment at lower temperatures and shorten the heat treatment processes.
6. The importance of nanotechnology and thermal / chemical surface treatments, precision technologies and MIM processes in thermal processes is increasing. It is aimed to shorten the duration of heat treatment operations.
7. 3D Design-Production-Manufacturing technology influences the heat treatment industry as well as every industry of the manufacturing industry. With the use of this technology, the use of composite and new materials will become widespread. For this reason, the demand for metal heat treatment will be limited.
8. Energy sources used in heat treatment furnaces are being renewed. For increased energy savings and less energy consumption, resources such as microwave, laser and infrared rays is considered.
9. The capacity of indoor cooling furnaces is steadily increasing.
10. The base metal industry and the automotive industry are developing and producing more, and also countries with the populations of which middle-class is developing are offering new market potentials.

2.9. Global Projections for 2020 in Heat Treatment Industry

The global predictions in the heat treatment industry is evaluated under three titles. These are production technology, market size and user sectors.

2.9.1. Projections on Production Technologies in Heat Treatment Industry

The heat treatment industry is an energy-intensive industry with an impact on the environment due to carbon emissions. For this reason, production technologies in the heat treatment industry tend to focus on improvements in these fields. Thus, reducing the costs of other industries and increasing their competitiveness are also targeted. Many areas of the heat treatment industry are expected to develop technologically.

The International Federation of Heat Treatment and Surface Finishers (IFHTSE) has identified the areas that need to be technologically advanced in the upcoming period. These areas are classified under three titles.

1. Heat Treatment Production Equipment and Materials
 - Achieving zero carbon emissions, reducing processing time by 50%
 - Reducing production costs by 75 percent
 - Increasing furnace life 10 times
 - Reducing furnace prices by 50 percent
2. Energy and environment
 - Reducing energy consumption by 80 percent
 - Reducing heat losses by 50 percent
3. Processes and metals processed with heat treatment
 - Shortening treatment processing by 50%
 - Reducing production costs by 75%
 - The least distortion and the highest compatibility (similarity) in heat treated products

Technology and innovation studies will be carried out in order to reach these targets in the heat treatment industry.

2.9.2. Projections on the Market Scale in Heat Treatment Industry

Until 2020, the determinants of market size will be effective. First, a relatively slower growth trend is predicted in the world economy. It is estimated that the growth rate of the world economy will be between 2.5-3.0 per cent between 2016-2020.

Economic growth has also slowed in developing countries, which have been leading growth in the heat treatment market. Developing countries are expected to grow by an average of 4.5 percent between the years 2016-2020. China's economy is regressing at a growth rate of 6-7 percent.

In China, the consolidation process, which started in many manufacturing industries, especially in the metal industry, will limit the growth in demand for heat treatment, especially due to the economic transformation. Global population growth is also slowing.

The middle class expansion and purchasing power will also be slower with the relatively stronger dollar anticipation. However construction and infrastructure activities will grow relatively quickly. Depending on these expectations and projections, the world heat treatment market is expected to grow at an average annual rate of 3.0-3.5 percent between 2016-2020.

Depending on these expectations, the size of the heat treatment market, which was \$ 88.5 billion in 2015, will reach a market size of \$ 102.6-105.7 billion in 2020.

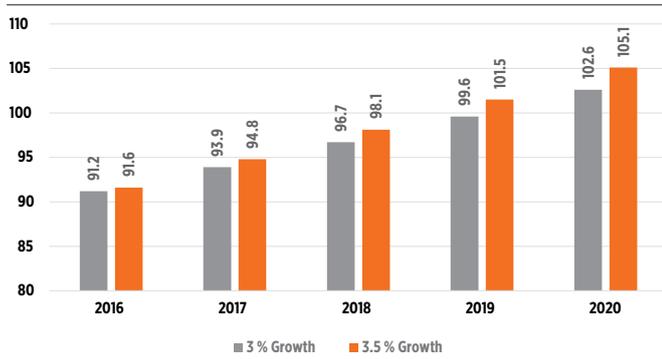


Chart 3: Growth Projections for the Global Heat Treatment Market (Billion Dollar, 2016-2020)

Source: Prepared by the working team.

2.9.3. Development Projection on Sectors Served by Heat Treatment Industry

Projections for the sectors served by the heat treatment industry are as follows until the year 2020:

Automotive Sector



Some engine components requiring heat treatment

The automotive sector will be the sector that will provide the highest level of support to the heat treatment industry until 2020. Automotive production has exceeded the global crisis level and demand and sales are increasing. It is expected that the demand will become more dynamic upon transition into energy and carbon efficient, lighter and smaller vehicles. The new capacity and model investments will also take place.

Developments in technology and innovation are increasing the importance and necessity of heat treatment in the automotive industry. Within the framework of all these developments, the automotive industry will be the industry that will provide the highest level of support to the heat treatment industry until 2020.

Aerospace Industry



Hurkus requires heat treatment for some important parts such as engine, transmission assemblies.



Heat treatment is used in satellite systems.

The new and renewed fleet investments will continue due to the increase in passenger demand in the aviation sector. Relatively rapid growth is expected, especially in the Asia-Pacific region. Accordingly, the construction of commercial and private aircraft will continue. The aviation industry is the industry that uses the highest quantity of metals in addition to special metal and composite materials. For this reason, commercial heat treatment companies will continue to develop new products and solutions for the aviation industry. Commercial space vehicles, especially space studies of space agencies and satellites, will grow.

Defence Industry



Our unmanned aerial vehicle: ANKA



National Tank Project: Altay Tank



Atak helicopter

Global uncertainties and risks are leading to an ongoing increase in production in the defence industry. Particularly, the desire of the developing countries to have their own defence industry technology comes to the forefront.

Machinery Industry



Machinery production industry

The new investments will have a weak trend due to slowing in the global economy and the global supply surplus in the manufacturing industry. On the other hand, the use of machines with particularly high energy efficiency and low carbon emissions will expand. Depending on these, the demand for heat treatment of the machinery industry will show a limited increase until 2020.

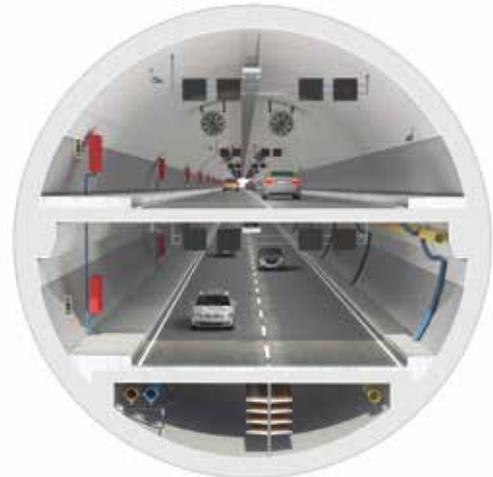
Rail Systems



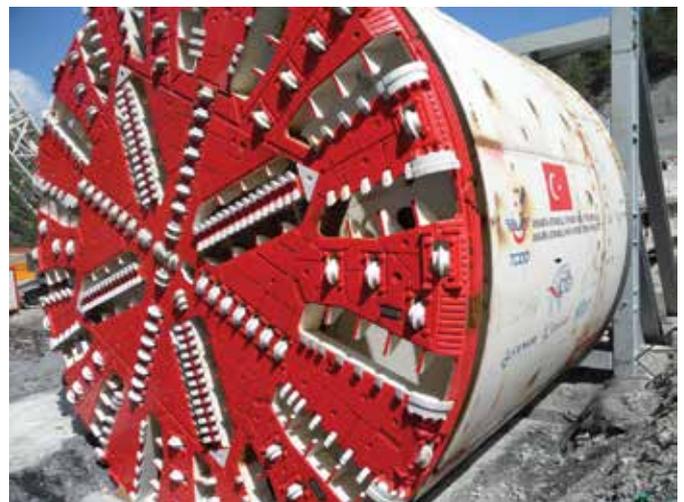
Heat treatment is used for many rail systems particularly including the fast train.

Developing countries will increase the use of railway systems in transportation and intra-city transportation, and accordingly investments will continue. In developed countries, investments for modernization of existing infrastructures and expansion of high-speed train network will continue. Rail systems' heat treatment requirements will have a relatively rapid expansion.

Infrastructure and Construction Materials Industry



Tunnel boring machines and many infrastructure equipment use heat-treated components.



Tunnel boring machine

Construction and infrastructure expenditures have become stagnant due to slow growth in developing countries and decrease in the income of countries exporting energy and commodity. For this reason, demand for construction materials from developing countries will show a limited increase. In developed countries, construction works will be more important for renewing the infrastructure. Depending on these, growth and demand for heat treatment in construction and infrastructure materials will remain limited.

Energy Sector

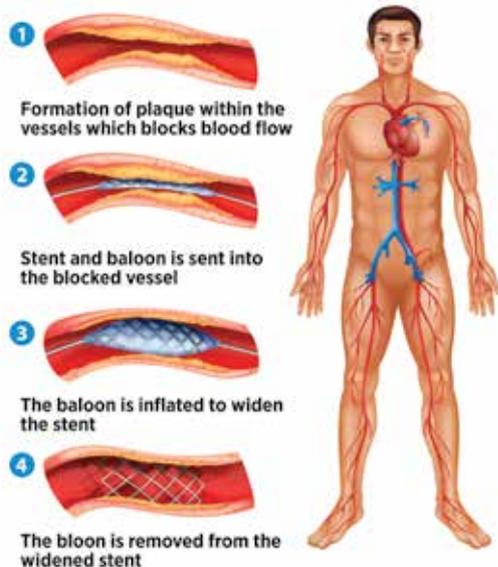


Gear mechanism in a wind turbine

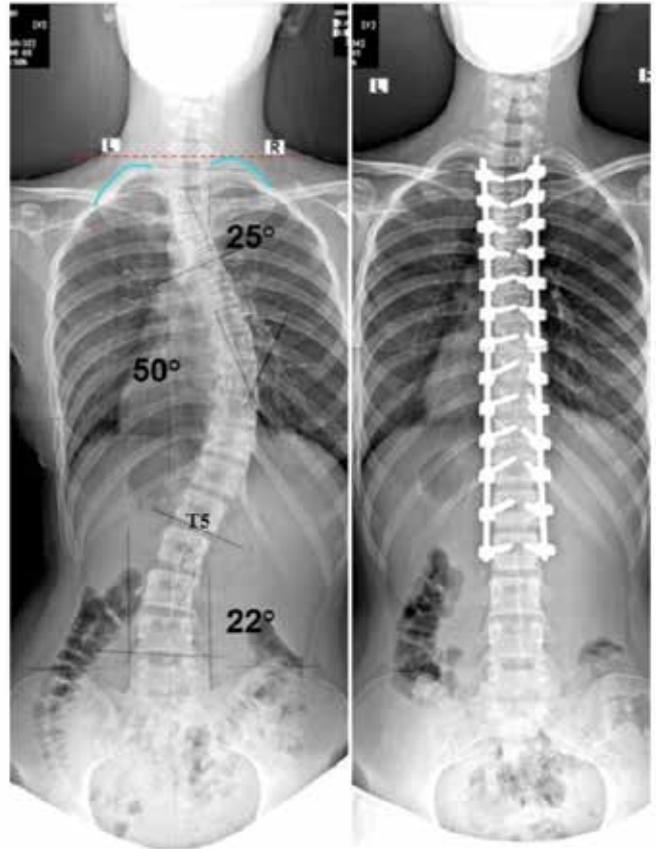
Growth in energy demand and thus, energy investments continues. In addition, investments for renewable energy sources are increased rapidly. New capacity investments in developing countries as well as renewable energy investments in developed countries will continue. As a result, the demand for energy equipment for the heat treatment industry will grow rapidly.

Medical Equipment

Stent used in cardiology practices



Stent used in cardiology practices



Implant materials used for the treatment of scoliosis

The progress in health technologies and the relatively rapid growth in health investments will continue in the coming period. Accordingly, the medical devices will grow at a relatively higher rate than the heat treatment requirement of the manufacturing industry.

Shipbuilding Industry

Demand for new ships building will continue to be weak, as the growth of the world commodity trade slows down and the idle transport capacity that emerged after the global crisis continues. For this reason, the demand for heat treatment in this industry will be weak.

Base Metal and Metal Items Industry

Stagnation in the base metal industry will continue for another period because of some reasons such as global consolidation in the metal industry, excess supply and weakening of metal prices. Metal goods industry and fasteners industry will grow more limitedly in industrial areas and more rapidly in retail areas. Demand for the heat treatment industry will remain limited.

The third part of the report analyses and evaluates the heat treatment industry in Turkey. First of all, the history of the heat treatment industry is given place. Then, numerical indicators show the size of heat treatment industry. Particular aspects of the heat treatment industry are analysed and evaluated. Finally, its importance for the industry, its relevance to other sectors, and its critical importance for the 2023 targets are given.

3.1. Development of Heat Treatment Industry in Turkey

The first heat treatment processes in Turkey were performed at the Mechanical and Chemical Industries Corporation (MKEK). Machinery Chemical Industries was moved to the Republican era as a continuation of the institutions that produce defence equipments since the 15th century under various titles and statues.

In 1921 Atatürk brought some of the looms, equipment, materials and masters from the military factory located in Istanbul to Ankara and collected them under the newly established Military Fabrics General Directorate, thus the MKEK was laid in Ankara. MKEK has become a school for the heat treatment industry. Like MKEK, State Railways has become the second school of the heat treatment industry with the heat treatment activities it includes. The first private industry ventures in heat treatment industry emerged in Istanbul in 1940's and 1950's. The first initiatives took place in the workshops and were performed by skilled craftsmen.

Starting from the beginning of the 1960s, Turkey has undergone a planned development period and investments in the public and private sectors, especially the base metal industry, have gained momentum. Accordingly, the demand for heat treatment started to expand. In this period in the field of commercial heat treatment in Istanbul and in other provinces where other industries established, there were also attempts by masters and those returning from Germany. However, the scales are still small and workshop size.

From the beginning of 1970's onwards, the capacities of the industries such as automotive, white appliances, machinery, shipbuilding and building materials in Turkey have been forced to move from workshop size to factory size and institutionalization. Accordingly, at the end of 1970's, commercial heat treatment initiatives started to be established throughout Turkey. MKEK continued to provide human resources in this period.

1980's became the period of export-oriented growth in industry, with the aim of economically opening to the world. The 1980s was the period when the industry started to grow with export aimed at expanding trade. This transformation also affected the heat treatment industry. The 1980s initiatives are now becoming bigger businesses.

Until the end of the 1980s, heat treatment processes in the salt baths of the workshops were started with new technologies and furnaces. In the 1990s, the atmosphere and automatically controlled furnaces, which are high-tech products and capable of mass production, have been used.

The customs union process that was executed with the European Union in 1996 marked the onset of a new period in Turkish industry. As a result, product quality and standards have been improved, foreign capital investments have accelerated, and new production capacities have started to be established. During this period, the first vacuum hardening furnace investments were made in commercial heat treatment companies. This transition also positively affected heat treatment industry, and the number of heat treatment enterprises and their production capacity started to grow. The recent technology was also accessed in this period.

Starting in early 2000's, with the normalization and amelioration in economy, there were foreign capital investments in the heat treatment industry. The number of important foreign players who came to perform manufacturing and trade in heat treatment processes, furnaces and chemicals rapidly increased.

With the developments in the automotive, white appliances and defence industries, there has been an increase in quality and capacity for heat treatment suppliers. Therefore, commercial heat treatment companies also ventured in high value-added and qualified works starting in the second half of 2000's, and focused on obtaining quality certificates and compliance certificates for international standards.

The development of the heat treatment industry in Turkey is not only limited to the commercial heat treatment companies. Starting in early 1980's, heat treatment units were created at important, large-scale companies that operated in other industries in Turkey, particularly in base metal industry, metallic goods industry, automotive industry, household goods industry and defence industry.

Today commercial heat treatment companies and other industrial companies that perform heat treatment in their fields continue to carry out qualified heat treatment operations by using advanced technology.

3.2. Key Parameters in Turkish Heat Treatment Industry

Key parameters in Turkish heat treatment industry are evaluated under two main titles. First, the heat treatment market size is calculated. Second, the production capacity of the industry, the number of companies and employment indicators are shown.

3.2.1. Scale of the Heat Treatment Market

The scale of the heat treatment market is calculated and presented as the sum of the works performed by the companies that carry our heat treatment activities. There is not any official data available on the total market volume of the heat treatment industry in Turkey. Sector representatives only have market size data of commercial heat treatment companies. In this respect, the market size of heat treatment in Turkey is calculated and presented with the help of the methodology used in the world. Two main criteria in this methodology, national income and automotive production data, are also used in Turkey. 1.36 million vehicles were produced in Turkey in 2015 and the national income was 718 billion dollars. The correlation between the heat transaction market and national income and vehicle production is also established for Turkey. For this, 5 scenarios shown in the tables below are used.

Potential heat treatment market sizes are calculated based on the current vehicle production and national income when we have correlations in Brazil, South Korea, India and China or global average. For example, if we assume that we have the world average for correlation, Turkey's heat treatment market size is estimated between \$ 860 million and \$ 1.32 billion. Based on these assumptions and scenarios, the market size of the Turkish heat treatment industry is estimated at 1.1 billion USD in 2015. 15-20% of this market volume is held by commercial heat treatment companies, and the market size of the commercial heat treatment business is calculated at 165-220 million USD. 80-85 percent of the market is made up of the companies that are involved in the heat treatment and it is calculated that they have a business volume of 880-940 million dollars.

Turkey's National Income (718 Billion Dollars)	Scenario 1 Global Average		Scenario 2 Brazil		Scenario 3 South Korea	
	Heat Treatment Market/ Vehicle Production	Heat Treatment Market/ National Income	Heat Treatment Market/ Vehicle Production	Heat Treatment Market/ National Income	Heat Treatment Market/ Vehicle Production	Heat Treatment Market/ National Income
Vehicle Production (1.358 Thousand)	0.97	0.12	0.15	0.02	0.77	0.29
Assumptions for Turkish Heat Treatment Market (Million Dollar)	1,317	860	205	145	1,045	2,082

Turkey's National Income (718 Billion Dollar)	Scenario 4 India		Scenario 5 China		Scenario 6 Turkey	
	Heat Treatment Market/ Vehicle Production	Heat Treatment Market/ National Income	Heat Treatment Market/ Vehicle Production	Heat Treatment Market/ National Income	Heat Treatment Market/ Vehicle Production	Heat Treatment Market/ National Income
Vehicle Production 1.358 Thousand)	0.50	0.10	0.59	0.14	0.81	0.15
Assumptions for Turkish Heat Treatment Market (Million Dollar)	679	718	800	1,005	1,100	1,100

Table 4: Estimation of Heat Treatment Business Volume for Turkey, Comparison by National Income and Automotive Production (2015):
Source: Prepared by the working team.

An important set of information for the commercial heat treatment industry market size in Turkey is given in the Industry and Service Statistics of the Turkish Statistical Institute. According to this, statistics are produced for the sub-sectors up to 4 breakdowns at TURKSTAT NACE codes.

The commercial heat treatment industry is in the sub-sector of 25.61, processing and coating of metals. This sub-sector involves coating and anodising of metals, heat treatment of metals, deburring, sandblasting, rolling, cleaning, painting, engraving, nonmetal coating of metals; plastic coating, enamelling, varnishing, hardening of metals and honing with soft things.

TURKSTAT statistics on sub-sector for the processing and coating of the metals are presented below. Accordingly, the 2015 turnover or market size of processing and coating of metals industry is 2.93 billion TL or 1.1 billion dollars.

The market size for the commercial heat treatment industry is projected to be between \$ 165-220 million in 2015 and the processing and coating of the metals is coherent with the total size of the sub-sector or market size.

Years	Number of Companies	Number of Employees	Turnover (Million TL)	Production Value (Million TL)
2009	3,640	16,201	1,121	1,070
2010	3,188	17,613	1,668	1,652
2011	4,191	18,341	2,135	2,100
2012	3,396	20,396	1,825	1,760
2013	3,262	18,902	2,384	2,355
2014	2,776	17,463	2,644	2,667
2015	2,770	17,266	2,930	2,911

Table 5: Scale of Metal Processing and Coating (Nace 25.61) Industry
Source: TURKSTAT, Annual Industry and Service Statistics.

Considering the automotive production and other sector sizes in Turkey, the size of the commercial heat treatment industry is well below the potential. An important reason for this is that companies in the industrial sector, where business volume is great, prefer to heat treatment at their own business.

In Germany, for example, 35 percent of the \$ 9.95 billion market in 2015 was heat treatment processes in the automotive industry, which produced 6 million vehicles in the same year, and there was a size of \$ 3.5 billion. Commercial heat treatment companies account for about 25 percent of this size and have a business volume of \$ 875 million.

In Turkey, while 1.36 million vehicles were produced in 2015, the business volume of the commercial heat treatment industry for the automotive industry was about 120 million dollars. If the share of the commercial heat treatment industry in Germany were reached, in Turkey this figure should have to be 200 million dollars.

3.2.2. Production in Heat Treatment Industry

Three topics are analysed under the title of production in the heat treatment industry in Turkey. These are production technology, production capacity, number of companies and employment indicators.

3.2.2.1. Production Technologies in Turkish Heat Treatment Industry

Heat treatment industry production technology in Turkey has developed over the years and today the most advanced technology has become available. Production started with traditional methods and salt baths was applied with the use of technical equipments in 1960's years.

With industrialization and factory scale production, furnaces have started to be used. In the first stage, second hand furnaces and equipments were used more widely in the industry.

Today, medium and small scale commercial heat treatment companies which account for 80% of total production currently use advanced manufacturing technologies. The technology has been significantly advanced, particularly with the new capacity and renovation investments in 2000's.

New technology of furnaces and equipment that are environment-friendly and energy efficient are used. Use of advanced manufacturing technology is also supported by transition to automation and participation of foreign capital companies to respond to the increasing demand for quality standards.

The heat treatment companies in Turkey currently use similar technologies as their European competitors. Turkey is largely foreign-dependent in manufacturing technologies in heat treatment industry.

3.2.2.2. Production Capacity of the Heat Treatment Industry

The production capacity in the heat treatment industry in Turkey consists of two groups. First one is the companies that are mainly engaged in commercial heat treatment. The second one is the production capacity and production of companies that perform heat treatment at their own.

As of 2015, the production capacity of heat treatment industry in Turkey is estimated to be 1 million 430 thousand tons.

The capacity of commercial heat treatment companies is 280 thousand tons, while the production capacity of companies that perform heat treatment at their own is determined as 1 million 150 thousand tons. Commercial heat

treatment companies owns 20 percent of the heat treatment production capacity.

Production Capacity	Ton
Commercial Heat Treatment Companies	280,000
Industrial Companies Conducting Internal Heat Treatment Processes	1,150,000
Total	1,430,000

Table 6: Production Capacity of Turkish Heat Treatment Industry (2015)

Source: Prepared by working team and sector representatives.

The commercial heat treatment industry production capacity increased significantly between 2002-2005 and especially with new investments from 2006-2008. Since the beginning of the 2000s, the heat treatment capacity has expanded to meet the additional heat treatment demand created by manufacturing and export of manufacturing industries.

There have been healthy capacity increases, especially based on planned and long-term projections with customers. New capacities have been created in areas close to customers. After 2000s, foreign commercial heat treatment companies have invested in Turkey and contributed to capacity increase due to their market potential and growth.

Major foreign companies on a global scale are engaged in heat treatment operations in Turkey. It is estimated that the share of foreign investment in commercial heat processors is about 10%

New capacity investments were realized in the 2010-2011 period. However, with these investments, idle capacity has been created in the heat treatment industry. Idle capacity also negatively affects price and quality competition.

In addition, it is anticipated that the idle capacity will be used in the midterm. In this context, there is a need for good planning of investments and production capacity in the heat treatment industry.

3.2.2.3. Production of the Heat Treatment Industry

Heat treatment industry production or activities in the world and in Turkey are gathered in two groups. The first one is commercial heat treatment companies. The second one is companies that operate heat treatment at their own. There is a similar distribution in Turkey as well.

Commercial heat treatment companies have shown a significant improvement over the last fifteen years. Commercial companies in the heat treatment industry are in maturation period. Companies are usually small and medium sized and have met especially international standards with technology and quality. Commercial heat treatment companies are working more efficiently with higher capacity utilization rates.

Continuous improvement and efficiency enhancement studies are being carried out in order to meet high investment and operating costs. Another advantage of commercial heat treatment companies is continuous renewal by following new production technologies. However, commercial heat treatment companies are faced with problems such as scale, term and capital. In Turkey, many domestic and foreign companies are involved in heat treatment at their own. There are many reasons for companies to do heat treatment processes in their production processes.

The most important of these are accelerating the process, overcoming bottlenecks, achieving quality and standards, and achieving cost advantage with scale. Firms apply heat treatment to critical parts, important parts due to safety and durability issues and precision works at their own. In addition, in areas such as the defence industry, heat treatment processes are also applied at their own in order to protect know-how. Besides, the heat treatment is applied at their own to meet the special demands of the customers. All production processes of the companies and the traditional attitude of have the furnaces at their own are also effective.

However, in heat treatment processes, production and product technologies are being rapidly renewed, standards are being developed and expertise is increasing. Companies carrying out internal heat treatment processes make investments one time and the technology they have gets outdated quickly as they are not renewed. Capacity is left idle for a considerable period of time and productivity drops. These companies also encounter various difficulties as they are not experts in heat treatment. Very frequent application and management mistakes can be made in the heat treatment process. These investments within the company lead to resource losses and additional costs that can not be calculated.

One of the reasons for Turkish companies to carry out internal heat treatment processes was that the commercial heat treatment industry did not have sufficient quality and scale during the initial period. However, today commercial heat treatment has the potential to meet the demands of the industry for heat treatment in terms of industry quality and the scale. For this reason, in accordance with the general trend in the world, the development of commercial heat treatment industry and companies in Turkey should be provided. The commercial heat treatment companies in Turkey must also become large scale, highly value-added, know-how accumulating, specialized and innovative companies and they must be supported for this purpose.

In addition, there are still some heat treatment processes that cannot be carried out in Turkey because standards and quality can not be met. These works are done largely abroad and the requirements are met through imports. In order to

substitute imports, commercial heat treatment companies should be supported towards achieving high quality and standards.

3.2.2.4. Key Indicators in Commercial Heat Treatment Industry

There are about 200 companies operating in the commercial heat treatment industry in Turkey. Approximately 70 percent of these companies are medium-sized companies operating with advanced technology. The production capacity of commercial heat treatment industry companies is 280 thousand tons. Approximately 4,000 people are employed in the commercial heat treatment industry. The turnover of the commercial heat treatment industry is 220 million dollars as of 2015.

Sizes of the companies operating in the commercial heat treatment industry at the end of 2015 according to the data prepared by the The Union of Chambers and Commodity Exchanges of Turkey by covering companies that receive capacity reports are given below.

City	Registered Manufacturer	Personnel Information							Production Capacity
		M	T	U	İ	İD	Total	Kilogram	
Adana	4	6	2	7	103	12	130	5,998,000	
Ankara	10	18	21	40	128	24	231	41,314,695	
Bursa	9	23	6	17	177	26	249	17,152,090	
Çorum	1	1	0	1	5	0	7	*	
Hatay	1	2	6	16	149	22	195	*	
Mersin	1	22	10	8	168	7	215	*	
İstanbul	36	63	39	45	659	119	925	81,891,380	
İzmir	10	22	20	41	272	41	396	40,670,620	
Kayseri	1	0	0	2	2	2	6	*	
Kocaeli	8	32	1	10	121	56	220	20,846,450	
Konya	8	6	4	21	190	49	277	12,508,000	
Manisa	3	12	8	6	124	24	174	*	
Total	92	207	117	214	2,098	382	3,025	237,399,595	

C: Engineer T: Technician; U: Foreman; İ: Worker; İD: Administrative;
 * Production capacity details are not provided if the number of registered producers is 3 or higher.

Table 7: Information on Heat Treatment Service Companies for Metals (Except for Metallic Plating) 2015

Source: The Union of Chambers and Commodity Exchanges of Turkey

3.2.3. Characteristics of Commercial Heat Treatment Industry

In Turkey, the commercial heat treatment industry is primarily composed of small and medium-sized companies, and it increasingly focus on high value added heat treatment processes.

Employment and Human Resources

While employing an increasing number of qualified engineers and technical staff, the commercial heat treatment industry continues to be a labour-intensive industry. When evaluated in this framework, there are not enough qualified

engineers, technical staff and unqualified staff. Commercial heat companies in Turkey often train their own human resources. The only vocational high school that provides training in the heat treatment industry and opened by the private sector initiative is located in Istanbul. In this school, heat treatment laboratory was established by private sector, teachers were trained and internship opportunities were provided to the students.

The professional definition of the heat treatment industry has been prepared and put into practice with the joint work of Metal Heat Treaters' Society (MISAD), which is a representative association of the industry, vocational qualification authority and Turkish Employers' Association of Metal Industries (MESS).

Assessment criteria have been prepared along with the definition and employees who are not graduated from vocational high school are getting professional qualification certificate if they pass the post-course examination they attend.

Energy Use

While commercial heat treatment industry is capital and labour intensive, it is also an energy intensive industry. The basic input of the heat treatment industry is energy. Within production costs, energy takes a high share. Natural gas and electricity prices in Turkey and their costs to industry are high. For this reason, the competitive power of the commercial heat treatment industry is adversely affected.

In the European Union, if companies make investments that increase energy efficiency, they will be supported both investments and if they do not meet the criteria, they pay 20-30 percent cheaper energy cost in the business process.

Environment

The commercial heat treatment industry operates as an industry branch with high environmental impact and consequently environmental sensitivity. The industry interacts with the environment in terms of water and energy consumption, the use of chemicals and the wastes generated.

Export and Import

The heat treatment industry carries out its activities in the domestic market largely due to its characteristics. The industrial inputs to be heat treated are brought by the customers and after the heat treatment the inputs are sent to the production areas. Due to this structure of services, activities are carried out domestically.

The direct activities of the heat treatment industry, which are considered as exports, have significant indirect contributions to export. Industrial inputs brought from abroad by the temporary import method are heat treated and exported to abroad with the exact export record. However, this direct export service is very limited. The main function of the commercial heat treatment industry arises with the heat treatment processes applied to the inputs used in the exported products and the fact that import is substituted because these processes are carried out in Turkey.

The heat treatment industry in Turkey offers services to many industries with highest export rates, chief of them being the automotive industry, contributing to their achievement of quality and standards in their products as well as transition to value added manufacturing.

Costs/ Prices and Profitability

Depending on the services offered by the commercial heat treatment, energy costs, charges, prices of chemicals used as input (and exchange rates), transportation costs (closeness), scales, capacity utilization rates, and environmental costs are determinants of costs.

Costs in the commercial heat treatment industry tend to increase. Costs of preparation and certification for international standards in the industry also appear as additional costs. In the prices of heat treatment services, there is a stagnation and a downward trend due to the idle capacity that emerged in recent years. These trends in costs and prices lead to reduced profitability.

The comparison of service prices applied in the heat treatment industry as of 2016 with other countries (dollar / kilogram) is presented below.

Country	Tempering [\$/Kg]	Carburizing [\$/Kg]	Tempering Vacuum Furnace [\$/Kg]	Nitriding [\$/Kg]
Turkey	0.15-0.75	0.75-1.50	0.75-1.80	0.75-1.10
Mexico	0.70-1.10	1.20-1.40	1.80-2.30	1.00-1.50
India	0.27-0.45	0.47-0.67	1.87-2.39	0.75-1.00
China	0.40-0.50	0.45-0.70	0.90-1.10	0.75-1.25
Sweden	0.75-0.96	1.35-1.60	2.05	1.08-1.80
Germany	1.20-1.50	1.40-2.50	2.80 +	1.00-4.00
USA	0.80-0.95	1.10-1.50	2,60 With	1.00-1.65
2 Temper	2.30-2.50	3.40-3.60	5.45 +	3.40-3.70
Brazil	2.30-2.50	3.40-3.60	5.45 +	3.40-3.70
Russia	1.00-2.00	1.00-3.50	4.00-5.50	2.50-4.50
Poland	0.50-0.80	0.80-1.50	2.00-2.50	0.70-1.50
United Kingdom	1.30-1.96	1.04-1.96	3.91-6.52	XXX
Australia	1.20-4.50	2.40-3.50	4.50-4.90	2.10

Table 8: Heat Treatment Service Prices (2016)
Source: Janusz Kowalewski, September 29th, 2016

3.2.4. Competition and Market Conditions in Commercial Heat Treatment Industry

Competition and market conditions for heat treatment industry in Turkey have just begun to develop and mature. The added value created with heat treatment processes is high. However, there is a discrepancy between the created value-added and heat treatment costs. In foreign countries, the heat treatment industry receives returns for the value-added it generates. Heat treatment in these countries amounts to as much as 10 to 15% in total costs while in Turkey the rate is no bigger than around 3 to 5%. However, there is no difference between the value-added and commercial quality of heat treatment in Turkey and abroad.

In Turkey, price policies developed within current market and competition circumstances make it impossible for the heat treatment industry to get returns for the value-added and quality service it provides. Time and price pressures are experienced in the works made by commercial heat treatment companies in Turkey. Heat treatment processes are often not included as a step in the production processes of companies that get the work done, and it is not a costs and budget item either. Heat treatment is not given enough importance and orders are given for very short terms. Depending on these, there is a significant price pressure on the market. A significant part of the heat treated products in Turkey are exported or used for exported products. Companies exporting these products are also faced with price pressures before buyers. When these companies lower their prices they try to reduce their costs in the production process and they pressure the heat treatment prices downwards.

The price policy applied within the current market and competitive conditions often also reduces prices. This practice creates unfair competition as well as creating a reference for the price level of the industry and other companies are also adversely affecting. These pricing practices make a false impression on buyers. Prices are pressured downward due to the recent capacities created in the industry, investments with a short turnaround time and sector inputs without measuring the business potential. With the current price policy, the profitability of the companies falls, and no renewal investment can be made because the capital accumulation can not be created. This process leads to further suppression of prices. Thus, the heat treatment industry can not get in enough return for the investments and the added value it provides. For this reason, there is a need to improve market and competition conditions. Otherwise, new investment in commercial heat treatment will not be rational with current price and profitability level. The commercial heat treatment industry in Turkey is in the process of maturation in terms of market and competition conditions and aims to get out this process by increasing its competitiveness.

3.3. Relations of Commercial Heat Treatment Industry with Other Sectors

The distribution of the heat treatment processes carried out Turkey in sectors and the distribution of the sectors to which heat treatment services are offered are similar to each other.

According to this, 60 percent of the heat treatment in Turkey is in the automotive industry, 10 percent is in the machine industry, 10 percent is in the metal goods industry, 5 percent is in the infrastructure and construction materials industry, 5 percent is in the white appliances industry, 2 percent is in rail systems industry, and 1 percent is in defence and aerospace industries.

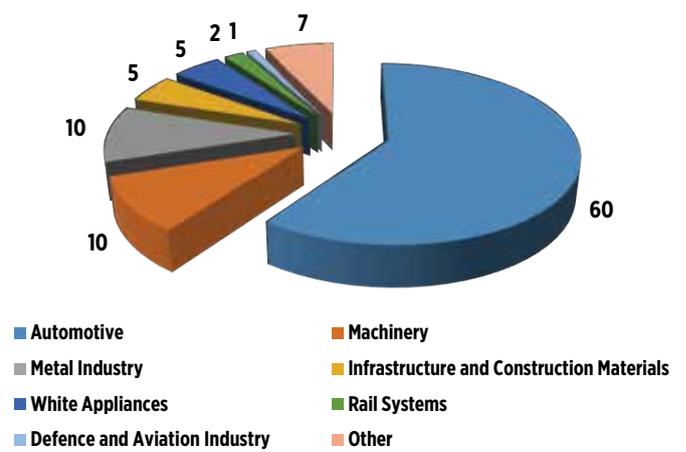


Chart 4: Shares of Heat Treatment Sectors in Turkey (Percentage, 2015)
 Source: Prepared by working team and sector representatives.

A comparison of the sectoral distribution of heat treatment processes in Turkey and in the world is presented below. Accordingly, the automotive industry has a majority of the jobs in Turkey. In the world there is a more balanced distribution. In the world, machinery industry, defence-aviation industry, infrastructure and building materials industry and base metal and metal goods industry have important share. The distribution in the world is an important indicator in terms of the development dynamics of the industry in Turkey.

Sectors	Turkey Share (%)	World Share (%)
Automotive Industry	60	33
Machinery Industry	10	15
Base metal and Metal Items Industry	10	23
Infrastructure and Construction Materials	5	13
White Appliances Industry	5	2
Rail Systems	2	2
Defence and Aviation Industry	1	11
Other	7	1

Table 9: Comparative Sectoral Distribution of Heat Treatment Services in Turkey and the World
 Source: Prepared by working team and sector representatives.

3.4. Turkey's 2023 Targets and Role of the Heat Treatment Industry

Turkey has 2023 targets for general economy, industry and sectors. The heat treatment industry has an important role in achieving these goals. In parallel with achieving these objectives, the heat treatment industry will show growth and development. The general economy has targets of 2 trillion dollars national income, 25 thousand dollars income per person, being the 10th largest economy in the world and taking 1.5 percent share of world exports with 500 billion dollars exporting.

Being the industrial production centre of the region in the final development plan of the industry and in the industrial strategy document, concentrating on the medium, high and high technology industries, creating 10 global brand and making high value-added production are among its targets. The heat treatment industry will play an important role in achieving the above mentioned general economic and industrial objectives with its presence and development. This role will be carried into effect with the services that it provides to the sectors. In this framework, the targets of the sectors in Turkey and the position of the heat treatment industry are evaluated below.

Main Automotive Industry and Sub-Industry

The automotive industry aims to reach 4 million vehicle production capacity in 2023 and to \$ 75 billion export. In addition, domestic cars are planned to be produced. Hybrid, environmentally friendly, lighter vehicle technology also stands out in automotive production. There are rapid innovations in the field of technology and innovation. Parallel to the development of the automotive basic industry in Turkey, the sub-industry will continue to develop. The sub-industry has the export potential at least like main industry.

Machinery Industry

In order to reach the industrialized country status, Turkey aims to have its own production technology and an important development in the machine industry for this purpose. Machinery industry also has a target of \$ 100 billion export for the year 2023. The Industrial Revolution 4.0 is carried into effect with the progression of the machine industry.

Defence Industry

Turkey is aiming to increase the nationalization rate in the defence industry and carries out a number of defence vehicle projects for this purpose. National ships, national tanks, national combat aircraft, national helicopters, national unmanned defence vehicles are the most important ones. The nationality of these projects will only be possible with

the use of domestic inputs. The defence industry also has an export target of \$ 15 billion for the year 2023. Armed forces' equipment and gear will be gradually replaced by national projects.

White Appliances Industry

With white appliances industry brands and its products, Turkey aims to lead both regional market and innovation and technology and plans to meet the demand of the growing domestic market. The white appliances industry aims to produce 40 million items and export \$ 10 billion in 2023.

Rail Systems

Turkey aims to expand the high-speed train network, renew existing train lines, joining regional train lines, while it aims to use light rail systems and subway systems in urban transportation. For this reason, important infrastructure investments and equipment production will be realized in the field of rail systems in short, medium and long terms.

Infrastructure and Construction Materials Industry

The construction sector in Turkey will continue its pioneering role in the economy. Large public projects and infrastructure investments will continue to increase in the next period. Construction works will continue within the scope of urban transformation and urban renewal. Population growth and urbanization will also expand demand for housing and non-residential buildings. In addition, standards are increasing in the area of sustainability, resulting in innovative and innovative products.

Aerospace Industry

Turkey targets domestic commercial aircraft production. Production of unmanned aerial vehicles is expanding. Targets for the space agency that is planned to be established and for space vehicles and equipment will also be revealed.

Medical Devices and Equipment Industry

With the restructuring of the health and social security system in Turkey, healthcare services are expanding and diversifying. In this context, it is aimed to meet the health care equipments with domestic production.

Energy Equipment Industry

Turkey's energy demand is rising above the global average. In the next 10 years, a \$ 160 billion energy investment is planned. These investments include energy generation, energy distribution and transmission, improvement of existing transmission lines and increasing energy efficiency. In this framework, it is focused on nuclear energy, renewable

energy, and thermal energy based on domestic coal. It is aimed to increase the domestic share and domestic production of machinery, turbines, equipment and electrical equipment to be used in these extensive investments.

Outlook for Sectoral Targets

Heat treatment for almost all of the metal, composite and ceramic materials used in production at international standards will play an important role to achieve the goals set forth for the sectors of Turkey's manufacturing industry.

With the development of a commercial heat treatment industry operating on international standards and supported by this framework will enable the achievement of the goals of the industry, especially the nationalization.

However, in recent years private sector investments have been slowing down and even declining and it is being moved away from sector targets for the year of 2023. This development will also limit the growth rate of the heat treatment industry.

Problems of Turkish heat treatment industry, recommendations for solution of these problems and development of the heat treatment industry are given place in the fourth part of the report.

1. Definition and Independent Evaluation of the Heat Treatment Industry

Problem;

The heat treatment industry is not included independently in the current regulations (law, communiqué, incentive etc.), its visibility is reduced within the metal goods industry and an incomplete definition is made implying quenching.

Solution Proposal/ Requirement:

Heat treatment industry must be addressed independently and with its official name in the regulations. New and up-to-date definition must be provided in the current legislation.

Public regulations about the heat treatment industry (business life, environment, etc.) must be made independently.

2. Heat Treatment Industry Is Classified within Highly Dangerous Works Group

Problem;

Heat treatment industry is classified within “highly dangerous works” group. In global practice, heat treatment industry is not classified within “highly dangerous works” group thanks to technological advancements and new process methodologies.

Solution Proposal/ Requirement:

Heat treatment must be classified as dangerous work. Thus, occupational health and safety regulations of heat treatment industry must be amended.

3. Limitation of Maximum Daily Working Hours In the Industry with 7.5 Hours

Problem;

Maximum daily working hours in the heat treatment industry are limited with 7.5 hours. However, furnaces and production processes in the heat treatment industry do not stop for 24 hours due to the nature of this process.

Solution Proposal/ Requirement:

Current heat treatment technology eliminated the labour intensive aspect of the sector. Working environment has high

standards with respect to occupational health and safety. Therefore, daily working hours limitation must be cancelled.

4. Requirement to and Placement of Qualified Human Resources

Problem;

The heat treatment industry uses medium-high and high technology industries, and in this respect it is an industrial branch that performs high-tech and value-added activities. The industry is in need of qualified engineers, technical staff and workers and R&D specialists.

Solution Proposal/ Requirement:

In the Metallurgical and Materials Engineering departments of universities, heat treatment classes must be made compulsory and it should be taught in 4-year faculties and 2-year vocational high school programs.

Professional qualification certificate trainings for workers must be supported with internal training expenditures.

The number of heat treatment departments should be increased in the vocational high schools and scholarship paid internship opportunities should be offered to students in order to encourage them to study this program.

After graduation, on-the-job training/ induction training programs must be organized in collaboration with Turkish Labor Agency (İŞKUR) and part time working must be supported by İŞKUR.

Audits aimed at preventing off-the-record employment must be increased and unfair competition must be prevented in the industry.

5. Energy Costs and Supports

Problem;

Energy costs are high and competitive power of the industries served is affected adversely.

Solution Proposal/ Requirement:

Energy use of furnaces and equipment with high energy efficiency and advanced technology should be supported, energy usage in the heat treatment sector should be considered as the main input and energy prices should be reduced by 20-30% or a part of energy costs should be subsidized in parallel with the amount of investment.

6. Uncertainty in Environmental Regulations and Support Requirements

Problem;

There is uncertainty in the definition and classification of environmental regulations in the heat treatment industry. Therefore, diverse and wrong applications and investments are observed. Licence cancellations are also observed.

Solution Proposal/ Requirement:

A special environmental regulation must be enacted for the heat treatment industry and classification, job description, inputs used, wastes generated, disposal of wastes must be clarified and environmental practices must be unified. In addition, environmental investments of companies must be supported.

7. SCT Applied for Oil Purchases

Problem;

Cooling oils directly used in the heat treatment processes, solvent and benzole type products added to fuel oil and mineral oils are subject to SCT.

Solution Proposal/ Requirement:

SCT must be lifted for oils used in the heat treatment industry.

8. Unfair Practices About Occupational Health and Safety

Problem;

As the heat treatment industry is not known well, unfair practices are encountered about occupational health and safety regulations and thus, additional costs are incurred. Closing and licence cancellations are experienced.

Solution Proposal/ Requirement:

Occupational health and safety regulations for the industry must be revised and improved jointly by representatives of the industry and the Ministry of Labour and Social Security.

9. Benefiting from Eximbank Loans

Problem;

Eximbank can not use the loans directly because the heat treatment industry does not export directly. However, a significant portion of the heat-treated inputs are used in the final products exported. Exporters are not allowed to access the Eximbank loans through the exporters.

Solution Proposal/ Requirement:

Companies conducting heat treatment processes on inputs of companies exporting end products should have access to Eximbank loans. For this purpose, Eximbank should launch a new program and provide Eximbank loan to heat treatment companies in parallel with their turnover and based on TURSTAT data.

10. Classification of Heat Treatment Industry As High-Tech Industry and Providing Support Accordingly

Problem;

The heat treatment industry carries out high-tech operations and serves to medium-high and high-tech industries. However, it is classified within the metal items industry category and it is considered as medium -low technology industry and cannot benefit from the incentives.

Solution Proposal/ Requirement:

Heat treatment industry must be classified and supported as a high-tech industry. Particularly investment incentives must be provided.

11. Development of an International Accreditation System and Laboratory Infrastructure

Problem;

International standards are applied for the compliance of heat treated products to the standards, compliance certificate is obtained from foreign accreditation agencies and infrastructure of foreign companies are used for laboratory services.

Solution Proposal/ Requirement:

In the medium-term, an advanced professional laboratory must be established for heat treatment industry in Turkey, contribution must be provided to the standards and internationally accepted accreditation companies must be founded.

12. Encouragement of Foreign Capital Investments

Problem;

Foreign investors are discouraged because of the regulations, inspections and sanctions about heat treatment industry in Turkey.

Solution Proposal/ Requirement:

Definition of the heat treatment industry and adoption of international standards and elimination of uncertainties for the foreign investments.

13. Improvement in Public Tenders

Problem;

Specifications of public tenders on heat treatment must be up-to-date and clear; therefore, heat treatment companies cannot participate and the contracts are awarded to companies that conduct internal heat treatment processes.

Solution Proposal/ Requirement:

Definitions must be up-to-date and clear in tender specifications, improvements must be made in connection with scale, guarantee, reference and payment terms to ensure participation of heat treatment companies.

14. Collaboration with Large-Scale Public Companies

Problem;

Large-scale public companies in Turkey that conduct internal; heat treatment processes (TAI, MKEK, State Railways, etc.) maintain these operations as they are and they do not contribute to the development of commercial heat treatment companies.

Solution Proposal/ Requirement:

These public companies must implement special development programs and support private commercial heat treatment companies based on clustering model.

15. Technology-Related Activities and Industry-University Collaboration

Problem;

Technology-related activities and industry-university collaboration are not at the desired level. The number of researchers is limited.

Solution Proposal/ Requirement:

Special heat treatment education must be given at universities, the number of academicians and researchers must be increased, 3 focused projects must be implemented annually through industry-university collaboration using R&D incentives.

16. Inadequacy of Monitoring in Imports

Problem;

Even though many products imported and used as input must be heat treated, these products are imported without applying heat treatment. These products are, then, cause

quality and standard related problems and create unfair competition against quality domestic production.

Solution Proposal/ Requirement:

Strict inspections must be applied about the import of heat treated products. Sample tests must be performed before customs clearance. Thus, unfair competition created by imports must be prevented.

17. Capacity and Investment Planning for the Industry

Problem;

Competition and market conditions decline as there is no capacity and investment planning in the industry and new investments are made without proper feasibility surveys.

Solution Proposal/ Requirement:

Heat Treatment Industry Strategy Report must be prepared in collaboration with the Ministry of Science, Industry and Technology, capacity requirement must be determine and new investments must be steered accordingly.

18. Better Utilization of the Existing Capacity

Problem;

The capacity in the heat treatment industry cannot be used efficiently. There is excess capacity in commercial heat treatment industry and companies install new internal heat treatment lines.

Solution Proposal/ Requirement:

New business models must be adopted between commercial heat treatment companies and potential customers, capacity leasing, long-term utilization agreements must be made to increase the utilization rate and efficiency of the capacity.

19. Uniform Quality and Business Standards in the Industry

Problem;

Current market and competition conditions of the industry must be improved.

Solution Proposal/ Requirement:

Minimum quality and business standards must be created in the industry and an auto-control mechanism must be established.

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