Module_5

Maintenance Management

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Industrial repair technologies

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INTRODUCTION

Repair, as the most commonly used element of maintenance, is typically required when a piece of equipment loses its ability to perform its function.In practice, this means that, usually as a result of one of the characteristic defects, changes in shape, geometry, hardness or fabric structure occur which make its intended use impossible. The situation is less serious if the component becomes unserviceable as a result of normal wear and tear, since in this case the degree of deterioration is limited:

- Calculable
- Measurable
- Diagnosable

The situation is more complicated in the case of unexpected failure, usually due to secondary faults. The typical causes are:

- Overloading
- Incorrect adjustment
- External factor

I. THE ASSUMPTIONS OF REPAIRABILITY

The scope of the repair, the technology used and the cost of the intervention sometimes make it more likely to be a renovation, so we will not make a clear distinction between the two types of repair. First of all, it should be clarified when it is worthwhile to continue using the component, i.e. to repair or refurbish it. The basic prerequisite is that the material and heat treatment condition of the component can be determined and that one of the following conditions applies:

- The part is not available
- The spare part is not available, but it is more economical to refurbish it
- Reconditioning or repair will achieve higher quality

The most severe grouping of failed parts is as follows:

Serrated, ribbed, etc. shafts, with the following characteristic defect locations (figure 1.1):

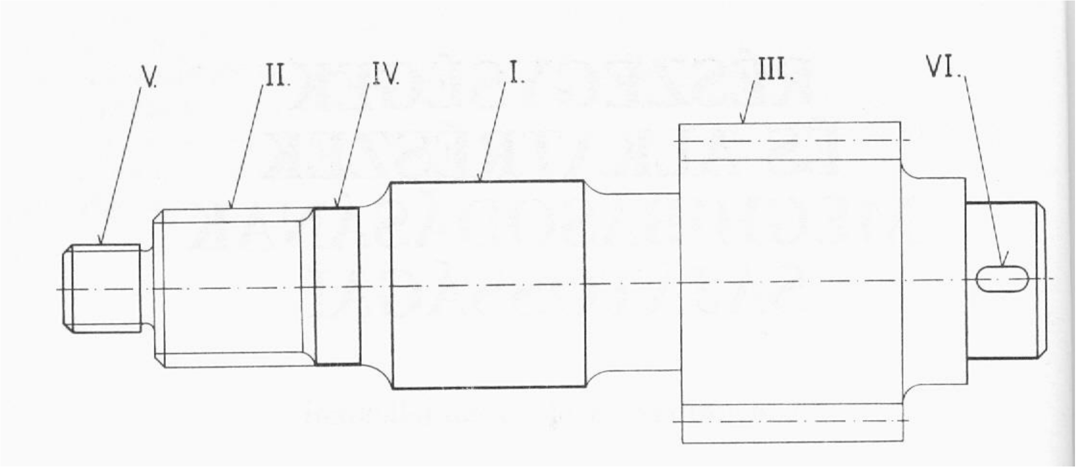


Figure 1.1 Typical failure points of the axle

I. Bearing wear

II. rib wear, chipping

III. chipping

IV. deterioration of surface quality under the sealing ring

V. Thread damage

VI. galling, chipping

Cast iron, aluminium castings Equipment housings, their bores (figure 1.2)

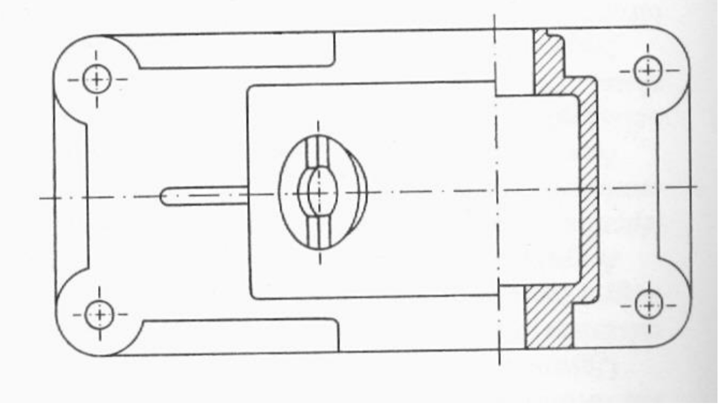


Figure 1.2 Equipment housing failure points

- Cracking, fracture

- Wear of the cylindrical casing of the internal bores

- Thread rupture

- Chemical or thermal corrosion

II. CLASSIC METHODS OF COMPONENT REPAIR AND OVERHAUL

The essential characteristic of these processes is that, with one exception (electroplating), they are suitable for economical individual or small series repairs, which is nowadays the basic requirement for this type of activity. The need for large-scale refurbishment and specialised refurbishment plants was typical of the industry of the former socialist states, mainly because of the scarcity of resources resulting from the planned economy. With the advent of non-renewable raw materials and energy sources and the circular economy, the possibility of a future increase in the life cycle of assets, including the planned cyclical factory refurbishment, cannot be ruled out.

Polishing (seal under the casing surface)

Grinding (valve disc, valve seat)

Turning (I.-II.-III. oversize..)

Plasticizing

Shells

Electroplating

2.1 POLISHING

Only slightly damaged defects affecting the surface quality are repaired. Typical areas of failure are the shroud surfaces under the seals and the shroud of hydraulic power cylinders, where scratches, dirt and possibly rust are removed. An essential feature of the operation is that the associated parts remain interchangeable with their original size.

Grinding is mainly used to form seals on tapered mating surfaces, for example during engine cylinder head overhauls, valve and valve seat rebuilds.

2.2 MACHINING TO REPAIR DIMENSIONS

This is the oldest and simplest method of component reconditioning, but it requires that the component to be reconditioned has sufficient material reserves at the location to be repaired. It involves machining the pin, hole or other fitting surface to a given size. In practice, this is done by trimming the part to a new size step and shaping the counterbore to the new size, or by obtaining a factory replacement part of repair size I or II. The latter method was widely used mainly for cylinder and piston fitting on explosion engines.

2.3 PLASTICIZING

A process for structural steels and non-ferrous metals, used in the reconditioning of typical parts where the size to be fitted can be achieved by sealing or stretching the material. Forming can be done by cold or hot pressing. An example of the latter is the radial pressing of a valve plate, the steps of which are (figure 2.1):

- heating the workpiece to 850-900°C

- forming in the deformer

- valve disc grinding and valve stem polishing

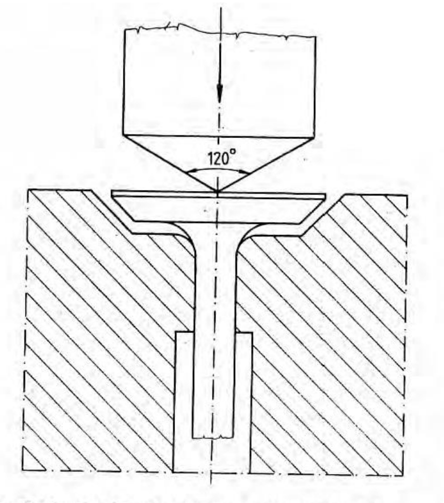
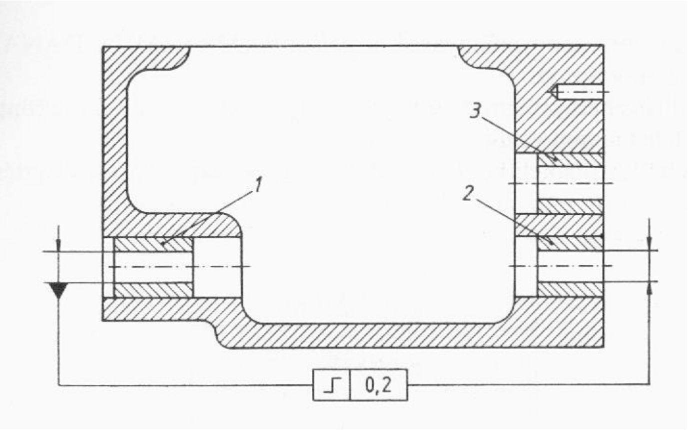


Figure 2.1 Valve plate shaping

2.4 SHELLING

Most often used to increase the size of worn bores, less often to increase the diameter of shafts.[1[Accordingly, in the majority of cases an internal bushing is made, sometimes an external bushing. For internal bushing reconditioning, we use bushing material of the same material as the original, the solid fit is made to H7/n6 and the bore is made to the original size. The bushing 1,2 shown in Figure 2.2 should be made with a seam allowance to allow for the material requirements of the finish work to ensure uniaxiality.



2.2 Ensuring the coaxiality of the bushings

Non-ferrous metal bushings can often be replaced by cheaper and easily machined plastics, but it is essential to maintain a larger bearing size, due to the higher coefficient of thermal expansion of plastics and their high tendency to absorb water, which can lead to a significant increase in size after installation. Traditionally, the bushing can be fixed in the bore by a solid joint or, in the case of a thin-walled bushing, by gluing.

2.5 ELECTROPLATING

Hard chromium plating is the most common type of electroplating. It is mainly used to coat lightly worn but finely fitted parts to a thickness of 0.2-0.3 mm, provided that the surface was originally chromium plated [1]. The quality of the finished coating is influenced by the following technological parameters:

- composition of the chrome bath

- bath temperature

- current density used

Characteristic properties of the applied chrome layer:

- high hardness, 45-50 HRC

- wear resistance

- resistance to corrosive effects

- Heat resistant up to 500°C

As mentioned above, the method is only economical for large series, so its importance in today's repair practice is not significant.

III. METHODS THAT MEET TODAY'S REQUIREMENTS

In order to meet the new requirements for repair and renovation, i.e. to achieve cost-effective individual and small series production, and to achieve quality and durability that exceeds the original, the following methods have been widely used:

- Flame spraying of metallic powder
- Flux cored metal spraying welding
- Casting repair welding
- Hard metal surfacing
- Application of plastics

3.1 FLAME METAL SPRAYING,

More accurately termed cold metal powder spraying, it satisfies all the above needs. Acetylene and oxygen cylinders can be found in the simplest locksmith's shop, the spraying equipment is not a major investment, (figure 3.7) while at the same time a very wide range of different alloys can be commercially available in powder form. The spherical alloy powder, which is introduced into the acetylene and oxygen flame, becomes plasticised by heat and is deposited on the surface to be treated at the velocity of the flowing gas mixture. (figure 3.8) The high temperature and impact energy cause adhesion and mechanical bonding between the coating and the surface to be repaired.

The sequence of operations to follow:

- Preparation and cleaning of the component
- Pre-machining of the surface to be filled
- Application of primer coat
- Application of filler powder
- Finishing
- Quality control

Preparation means the cleaning of the surface to be treated from physical and chemical (grease, oil) contamination and testing of its suitability for spraying (exclusion: cracking, fracture).

Pre-machining and roughening are used to bring the shape and surface of the part into line with the mechanical

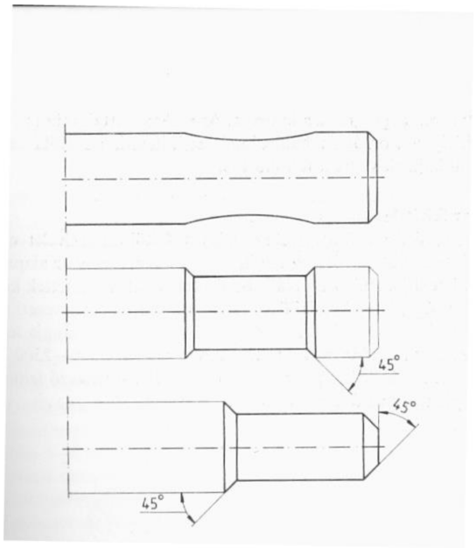


Figure 3.1 Pre-machining

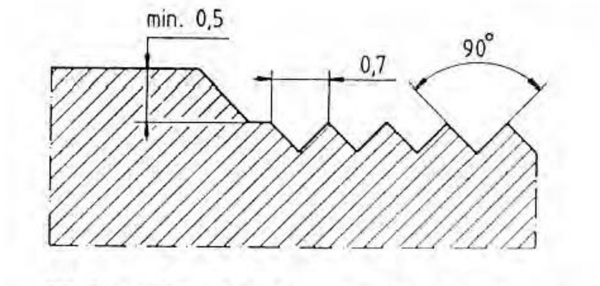


Figure 3.2 Surface roughening

to a condition suitable for bonding (figure 3.1;.3.2)

The primer powder is used to ensure a stable adhesion to the surface of the part and to the overlay.

When selecting the composition of the filler powder, the component material and the expected stresses are taken into account.

Rules for applying the topcoat:

- Spray temperature: 50-250 °C
- Allow cooling time in case of multiple layers, up to the maximum layer thickness (1-2 mm)
- A machining allowance of 0,2-0,6 mm is required

Finishing to achieve the required dimensions for the installation of the part and its intended use. The method used is turning for soft coatings and grinding for hard coatings.

The advantages of cold metal spraying:

- The amount and proportion of alloying elements can be freely varied (Cr, Ni,W, Cu, Mo, Al,)

- The resulting surface is corrosion-resistant and has good lubrication properties.

- The hardness of the surface can be controlled, so it can replace other surface treatments.

Disadvantage is that it cannot be used:

- If dynamic loads are present

- In case of point or linear contact

- In areas subject to high thermal stress

- The applied layer is porous

Areas of application

- Shaft bearing locations (figure 3.3;3.4)

- Bearing bushes

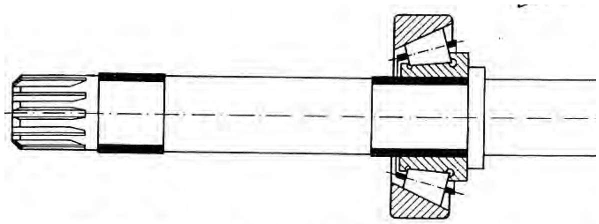


Figure 3.3 Repair of bearing locations

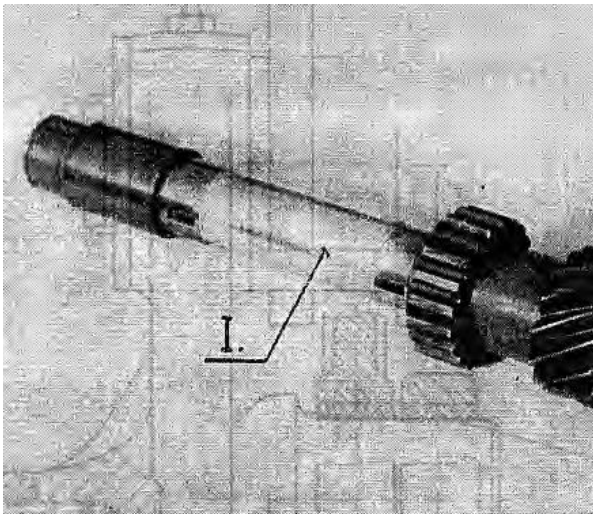


Figure 3.4 Application of an Al-Bronze layer to replace bronze bushes

3.2 HOT METAL POWDER COATING

The technological process itself is similar in many respects to cold powder spraying, but the technical parameters of the resulting surface show significant differences [1]. The most important difference is that the coating is heated to 950-1000 °C after application. As a result, the porosity of the coating is eliminated, forming a continuous solid layer. A further important difference is that the heated material diffuses into the surface of the component, but does not mix with it, as the melting point of the filler powder is 300-400 °C below the melting point of the base body. The process therefore creates a diffusion bond.

The steps of hot metal spraying

- Preparation, cleaning, preferably on a metal cleaner, determination of the defect type depending on the degree of deformation or wear.

- Pre-machining (necessary and sufficient), roughing not necessary

- After preheating the surface to 400-600 °C, sprinkling of the alloy powder. Apply the desired layer evenly (max. 0,2 mm in one step)

- Flame fusing of the top coat to a homogeneous, compact mass at 950-1000°C When determining the coating thickness, the chipping allowance before fusing is increased by 30% to allow for expected shrinkage.

- Cooling in air

After finishing min. 0,25-0,3 mm of cover layer is desirable.

Characteristics of the applied layer:

- 18-65 HRC, without heat treatment

- Good resistance to dynamic abrasive wear

- Corrosion resistant

- Unsafe for use on shafts thicker than 35-40 mm due to intense heat ablation

- Melting may sometimes result in a change in the fabric structure of the base material, with a concomitant loss of strength.

Applications:

- Needle roller bearing seats

- Water pump shaft

- Valve discs, valve seats

- Turbocompressor shaft

- Switch forks side faces

- Camshaft cams

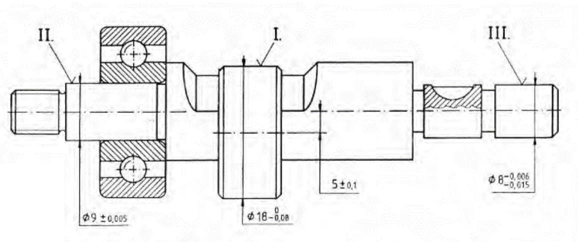


Figure 3.5 Excenter structure of a feed pump

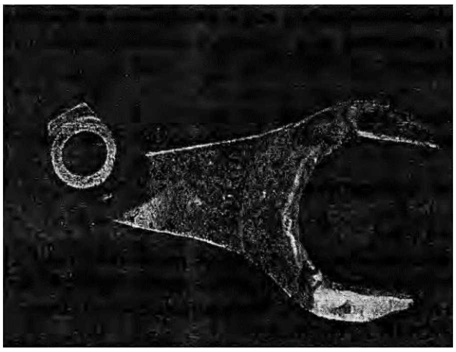
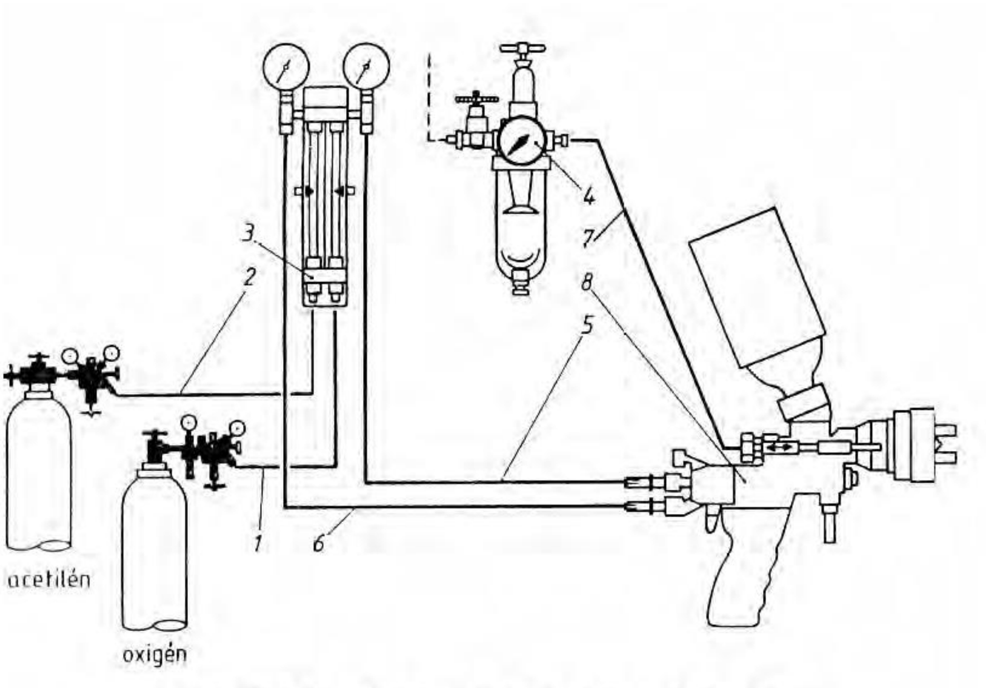


Figure 3.6 Switching fork



3.7 Spray head wiring diagram

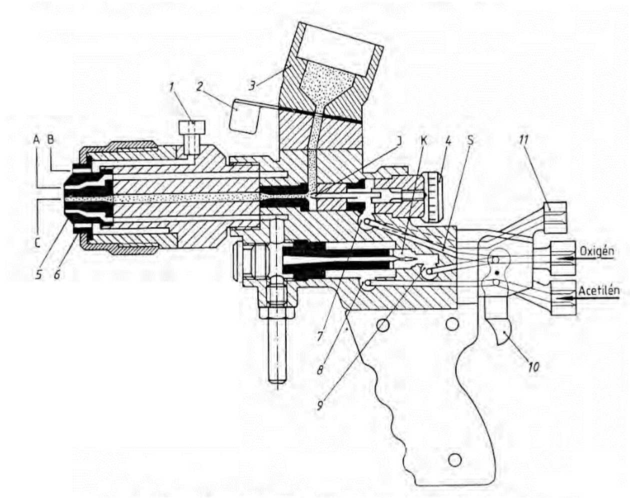


Figure 3.8 Scattering device to reduce scattering loss and increase impact energy

3.3 REPAIR WELDING OF IRON CASTINGS.

As with cast iron components, their size and weight vary widely. While a damaged or broken bearing housing can be easily replaced commercially, the same cannot be said for large, specially designed cast housings. In such cases, the organisation and execution of a professional repair should be considered.

Welding methods for cast iron

The following methods are used to repair cracks and fractures in cast iron [2]:

- Cold welding (does not require preheating)

- Semi-hot welding (preheating temperature 300-400°C)

- Hot welding, (preheating temperature 500-600°C)

During semi-hot and hot welding, care must be taken to ensure that the preheating temperature is maintained at all times during the welding process. This sometimes requires a large furnace and special custom-built equipment to ensure a constant temperature of the equipment. For these reasons, cold welding is preferred for custom repair welding of iron castings.

Operations:

- Preparation of the part: cleaning, inspection of the defect type, extent of the defect and its repairability. Also at this time, the extent of disassembly, the method of fixing, the need for any orientation elements, should be determined.

- Sewing preparation
- Rounding of edges, corners (thermal sensitivity...)
- After marking the crack trace, groove design (Figure 3.9 ;3.10)
- Grooving electrode
- Engraving
- Grinding (in this case, the stone residue must be removed as it may cause inclusions)

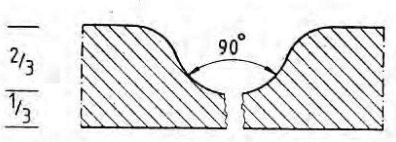


Figure 3.9 Groove 60% of the wall thickness at 90°

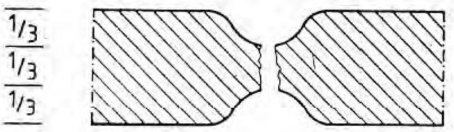


Figure 3.10 Wall thickness above 15mm, double groove or 110° groove

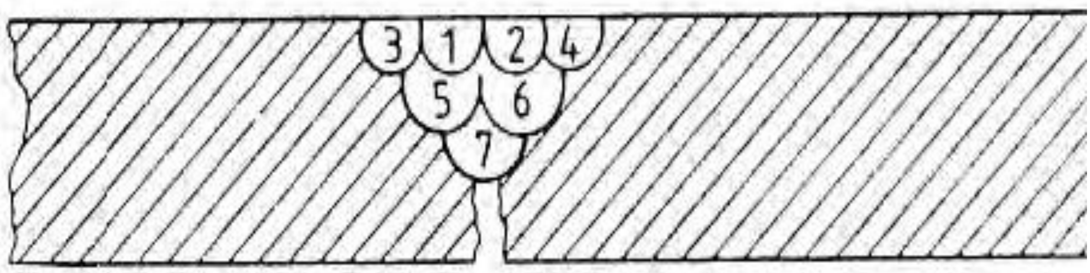


Figure 3.11 Grooving sequence for thick wall castings

Performing a repair weld

To minimise heat input, a thin 2-2.5 mm diameter nickel-based electrode is used to provide sufficient flexibility. The current is chosen between 40 and 60 A [2]. Also to avoid concentrated heat input, the correct application sequence of each weld section is chosen (Figure 3.11), and crack propagation is prevented by two auxiliary welds perpendicular to the weld section (Figure 3.12).

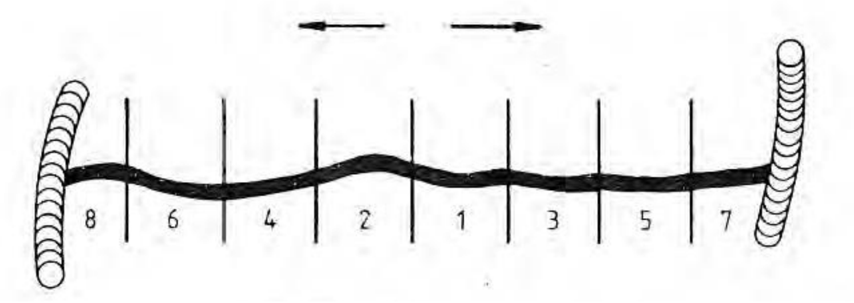


Figure 3.12 The correct welding sequence

The first weld line is formed by sections of maximum lmax=20-25 mm

By following these instructions, it is possible to ensure that the weld area remains "hand-warm" throughout.

During welding, an undesirable brittle cementitious fabric structure is formed in the weld and dangerous stresses are generated in the weld zone. The effect of both phenomena can be reduced to a certain extent by compressing and stretching the weld line with a hammer. This will cause the cementitious layer to crumble and reduce its brittleness, similarly to the stresses generated in the thermal zone (Figure 3.13; 3.14).

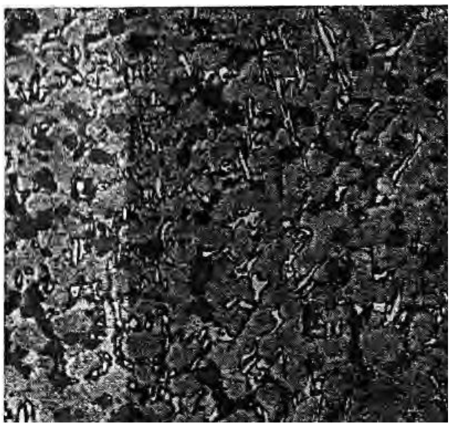
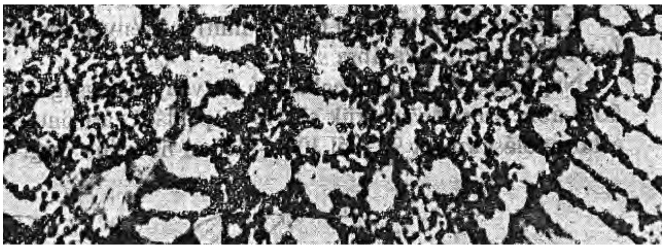


Figure 3.13 Structure without compaction



. Figure 3.14 Layer 2 also compacted, layer 1 automatically normalised

Slag residues must be removed continuously to avoid the formation of deposits.

- Quality control

The method of inspection is determined by the function of the repaired part. For reasons of simplicity, a paint penetration test is always justified, but for high-value or high-risk equipment, ultrasonic or even radioisotope testing may be used. In the event of failure, the component can be re-welded after removal of the suture material.

3.3 RECONDITIONING OF ALUMINIUM CASTINGS

Due to their widespread use, the repair welding and reconditioning of aluminium and various aluminium alloys is also quite common.

Possible methods are:

Coated electrode arc welding

- The coating of the electrode used for this purpose has a highly hygroscopic property and should therefore be dried at 200°C for at least two hours before use. The coating contains, in addition to the alloys (Mg, Cu) present in the component material, silicon in excess of the alloying elements present in the component material, and a fluxing agent to aid weld formation.

- In addition to the usual cleaning, the preparation of the defect site also consists of grooving, but this can also be done by drilling holes of appropriate diameter and distance (Figure 3.15).

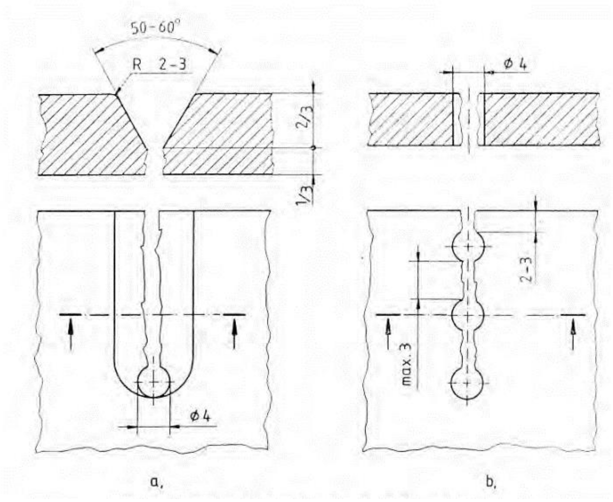


Figure 3.15 Simplified grooving.

- Preheating of the area around the fault location is required (150-200°C)

- A 2.5 mm diameter electrode and 50 A current with reverse polarity is used, which causes the oxide layer covering the component to break down, making the base metal accessible.

- Using this method, it is usually necessary to apply a single weld up to a wall thickness of 10 mm, above this thickness a multilayer weld is required.

AWI (argon shielded tungsten) welding (Figure 3.16)

- Preheating to the same extent as for electrode arc welding cannot be avoided.

- Up to 15 mm wall thickness, a 4 mm diameter electrode, 220 A welding current, 10 mm arc length and left-hand welding are used.

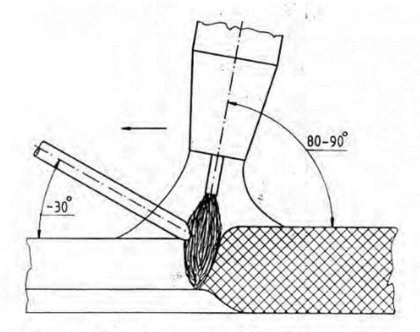


Figure 3.16 AWI welding

Melt penetration should be monitored continuously and if insufficient, repairs should be carried out immediately on the hot workpiece (Figure 3.17).

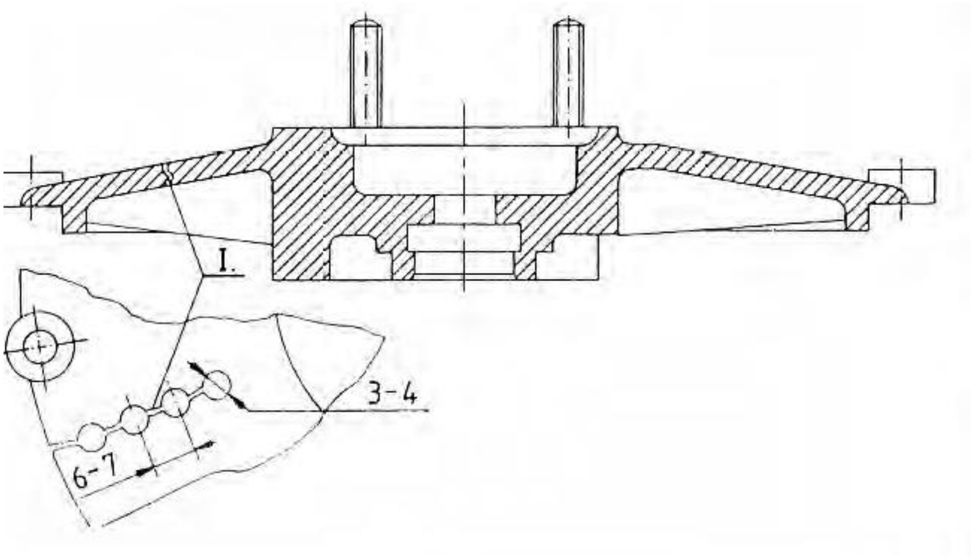


Figure 3.17 Al impeller repair welding

3.5 SURFACE REINFORCEMENT BY OPEN ARC WELDING

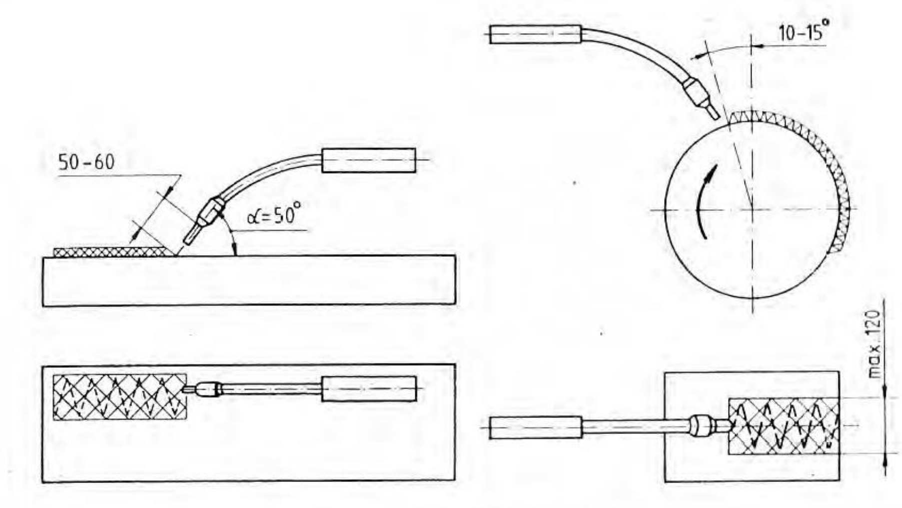
- A 2-6 mm thick, hard, abrasion-resistant layer can be applied to "armour" the base surface (Figure 3.19)

The tool used is a tubular wire with a charge that performs the following functions:

- Arc stabilizer
- Deoxidizer
- Fluidising
- Carbide forming
- In addition, it may also contain additives to provide the desired surface properties.
- The most commonly used diameter range is 2-4 mm, including 2.8 mm.

Applications:

- Low carbon
- Non-alloyed
- Mn
- Mn, Cr alloy structural steels
- Butt and fill-up welding of medium carbon alloy steels
- Forming of stainless steel surfaces (Cr, Mn,Ni)



3.18 Repair of special parts using special welding techniques

3.6 REPAIR OF SPECIAL PARTS USING SPECIAL WELDING PROCEDURES

Machine frames, frame structures, leaf springs

The typical failure modes of parts in this category are cracking, fracture, and high carbon or alloy steel. Due to their composition, there is a risk of indentation, embrittlement or even annealing during welding, and therefore a hardness test in the weld area is recommended before reuse [1].

Welding technology: direct current, positive polarity

Electrode material: the use of electrodes with high Cr, Ni and Mn content is recommended to achieve adequate elasticity and tensile strength (~24%) of the weld.

Tensile strength of the weld: expected to be between 800-850 Mpa.

Minor chipping, fracture of the pinion, sprocket, rib shaft

These are components that operate very frequently, and sometimes under unpredictable conditions, so failure and repair is a frequent occurrence. These components are manufactured with cemented or crimped surfaces to increase wear resistance, and require preheating to 500-600 °C before welding. The use of a fluxing agent is justified to ensure proper filling of the flaw space.

Welding technology: electrode arc welding

Characteristics of the welding rod to be chosen:

- Cr, Ni, Si alloys,

- Low melting point (60-700 °C), to accurately pick up the shape of the defect without melting the part.

- High hardness (~580 HRC), similar to the original surface

Highly stressed cutting edges for machine tools (agriculture and forestry, mining, construction)

Carbide filling, sharpening

Welding processes suitable for coating application

Methods:

- Manual flame welding

- Electrode arc welding

- Flame spraying

Bonding method:

- Fusion (mixing)

- Diffusion (boundary case of solder and weld...)

The excellent abrasion resistance of materials used to reinforce cutting edges is essentially due to their specific structure. The basically soft austenitic bedding fabric contains various metal carbides, nitrides, borides, which are highly resistant to abrasion and have a hardness comparable to diamond [2]. (Figure 3.20) The most common carbide-forming alloys in the deposited layer are Cr, Mn, Mo, Nb, Ti, V, W, B

The concept of self-sharpening needs to be clarified in the field of carbide charging, as the term is misleading. If there is a five to six-fold difference between the hardness of the base material of the tool and the hardness of the coating applied to the edge, and the thickness of the coatings is well chosen, the softer base material and the more abrasive edge will wear at the same rate and therefore be effective for longer (Figure 3.21)

Coated-electrode manual arc welding is performed with direct current and bonded with positive polarity.

Preparation:

- Removing the remains of previous armouring to obtain a homogeneous edge structure

- Preheating

- If necessary, a tough, flexible pad layer (Cr>18%, Ni >8%) can be applied between the base body and the edge to prevent premature delamination of the carbide layer.

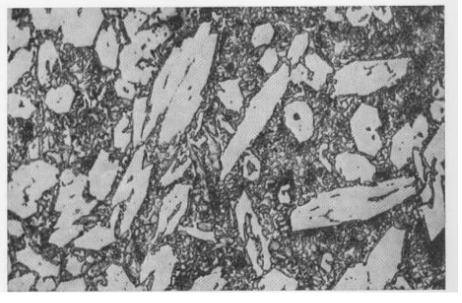


Figure 3.19 Hard metal layer structure

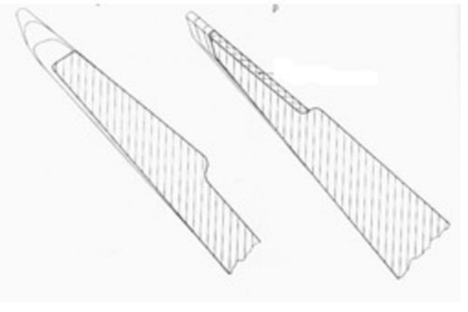


Figure 3.20 Self-edging mechanism

In many cases there is no noticeable difference between the wear of the tool surfaces, in which case the entire surface is covered with a thin coating (food mixer blades). The welding method used in this case is flame spraying.

3.7 REPAIR AND OVERHAUL USING PLASTICS

The continuous development of the chemical industry is rapidly increasing the range of plastics that can be used as repair materials. Their most common applications are:

- Coating
- Bonding
- Filling
- Sealing
- Sheltering

The following physical parameters should be examined before deciding on their application and suitability:

- Coefficient of thermal expansion, which exceeds that of metals by an order of magnitude, is proportional to the melting temperature during coating formation and also causes residual internal stresses.

- Heat resistance. From a thermomechanical point of view, a plastic is considered to be heat resistant if it retains 80 % of its mechanical properties when heated to 150 °C. Durability above this.

temperature, thermal decomposition occurs after melting or carbonisation, depending on whether it is of the thermoplastic or thermosetting type.

- Their thermal conductivity is 2 to 3 orders of magnitude lower than that of metals, which can sometimes cause local heating. Graphite powder, embedded metal powder used to further reduce friction can improve this property of plastics.

Mechanical properties:

- Their abrasion resistance is more favourable than metals, but embedded metal wear can damage the mating steel component.

- Hardness,

Chemical behaviour:

- Adhesion.

- Chemical resistance good, low sensitivity to lubricants.

- They have a tendency to moisture absorption of more than 14 %, so it is advisable to reach the operating moisture content before machining.

Types of plastic

Poly-Vinyl Chloride

Application:

- Films

- Sheets

- Pastes (adhesive, sealant)

- Parts subject to low stress

Poly(tetra-fluoro) ethylene [Teflon]

Features:

- Low friction (plain bearing)

- Low compressive and tensile strength

- High heat resistance (pan)

- Good sealing performance

- Chemical resistant, even difficult to bond..

Polypropylene

- Low density (injection mouldable, extrudable)

- Medium mechanical properties

- Good chemical resistance (pipe lining)

- Weldable, deep-drawable, also suitable for vacuum forming

Material for plates, foils, tubes, fibres, low stress structural elements, components.

Acrylic resins

Instant, emulsion and solvent adhesives.

Polyamides

Can be used as a coating for sintering, spraying.

Suitable for the manufacture of bearings, gears, pulleys, belt pulleys and other simple machine parts.

Good strength adhesive

Polycarbonate

- Translucent, crystalline, thermoplastic, moderately chemical resistant material.

- Suitable for gears, structural components, electrical fittings.

- Forms an adhesive coating by flame spraying.

IV. REPAIR WELDING OF CORROSION-RESISTANT MATERIALS

The use of corrosion-resistant steels is recommended in many areas of the food and pharmaceutical industries, and in many other technologies, such as chemical processing, but sometimes this type of steel is chosen purely for aesthetic reasons.

A material is said to be corrosion-resistant if the rate of corrosion on the surface does not exceed 0,1 mm per year.

Characteristics: The surface is coverted by a uniformly sealed solid CrO layer and the internal fabric structure is homogeneous austenitic or ferritic [3].

Types:

I. Ferritic (max. 0,1 % C, 12-18 % Cr)

II. Martenzitic

1. Refined (0,16-0,25%C, 12-18% Cr

2. air-entrained (C> 0.25%, Cr 12-18%)

III. Austenitic (C 0.03-0.07%, 18-30% Cr, 8-30% Ni)

Welding technology varies by material type

Ferritic (KO1-KO6)

- Preparation (grinding out the defect)

- Preheating to 200-350°C is required to avoid grain hardening, cracking

- Root welds are applied by Argon Arc Welding (AWI), filler welds are made by electrode coated welding.

- Air cooling

- Post-treatment, heating to 720-760°C (200-250°C/h) after 1 hour of heat treatment to 600, then rapidly to 350°C, followed by normal further cooling

Ferritic chrome steels will permanently brittle between 45-500 °C (475 °C brittleness) and should therefore be avoided or minimised when used in this temperature range. It is also essential to observe the correct welding sequence as shown in Figure 4.1.

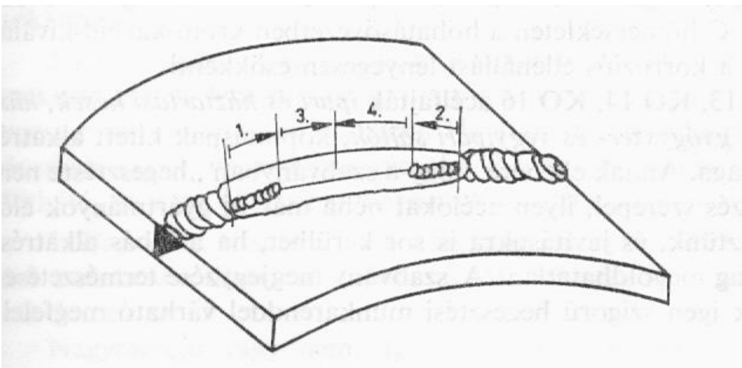


Figure 4.1 Correct welding sequence, seam sealing

Martenzitic (KO11-KO16)

Applications: shafts, pins, knives, cutting tools, instruments, turbine blades)

Two main types of martensite are known in terms of carbon content:

1. C% 0,16-0,25

Preheating to 300-350 °C, followed by immediate tempering at 700-760 °C without cooling the weld below 350 °C.

2. C% > 0,25

Preheat to 350-400°C and anneal immediately at 750-800°C

References:

1 Vilmos Hartmann, József Felker, Vilmos Kalmár, Gábor Horváth: Reconditioning of agricultural machinery parts, Mezőgazdasági kiadó, Budapest, 1986

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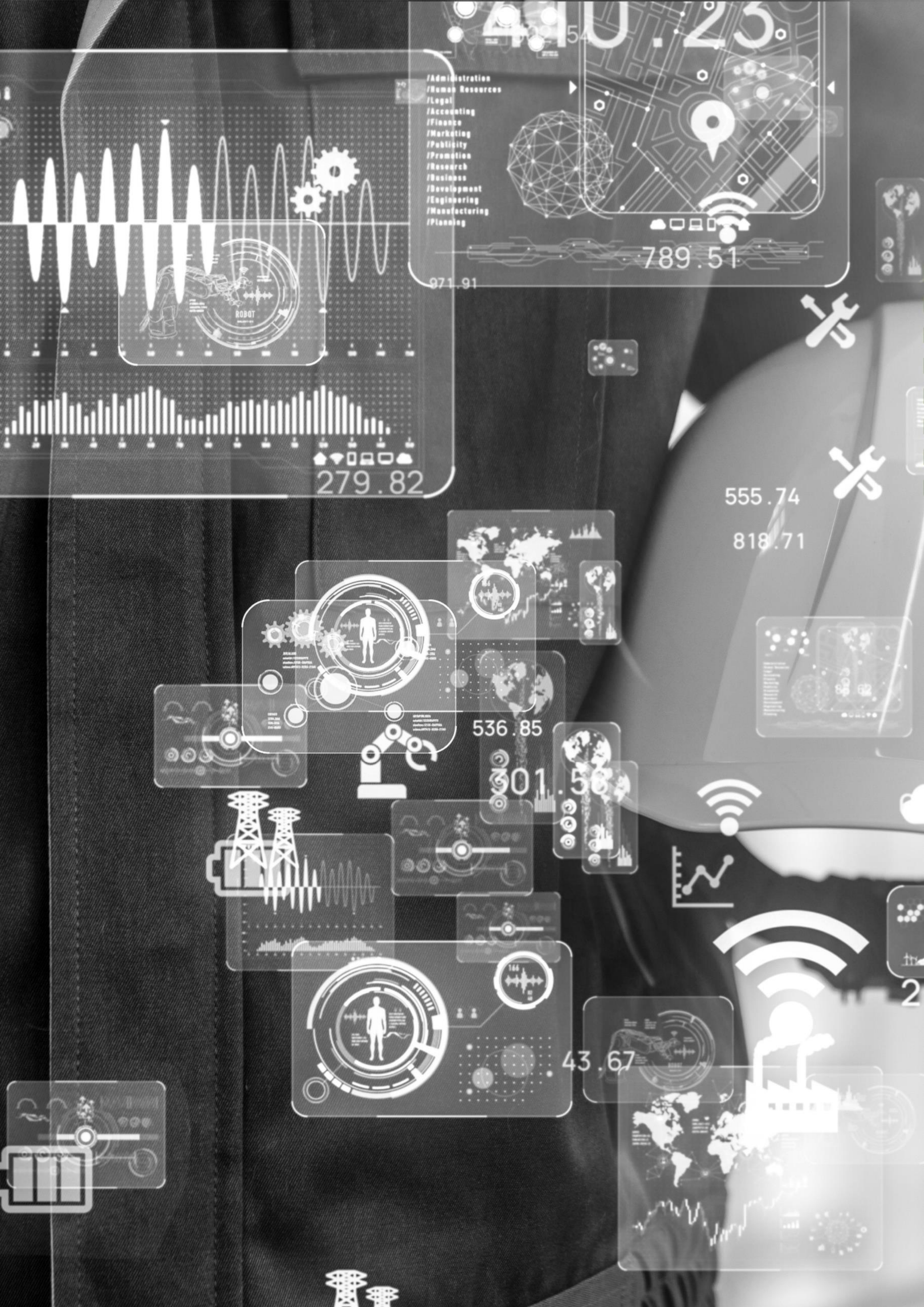
3 Dr. Béla Zorkóczy: Metallography and Materials Testing, National Textbook Publishing House, Budapest, 1968

Module_5

Maintenance Management

Géza CS. NAGY

Industrial repair technologies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789.51
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279.82
555.74
818.71
536.85
43.67