SHEFFIELD FORGEMASTERS

Technical Capabilities

SHEFFIELD FORGEMASTERS

Casting and Forging solutions for the World's most complex engineering challenges.

Sheffield Forgemasters can trace a history in steel back over 200 years but it is our forward thinking and innovative approach that has kept us as a leader in steel production since then.

Our integrated steel production facility is situated on a single site in Sheffield so we can take care of every step of the process, from preliminary design and R&D through melting, casting, forging, finish machining, testing and delivery.

Contents

Introduction

Sheffield Forgemasters can trace a history in steel back over 200 years on a single site in Sheffield.

ORIGINS

The origins of Sheffield Forgemasters date back to the 1750s as a small blacksmith forge. It was Edward Vickers, a traditional mill owner, who began the foundations for the business as a commercial steelworks in 1805.

Vickers Steel Works in 1830

HISTORY

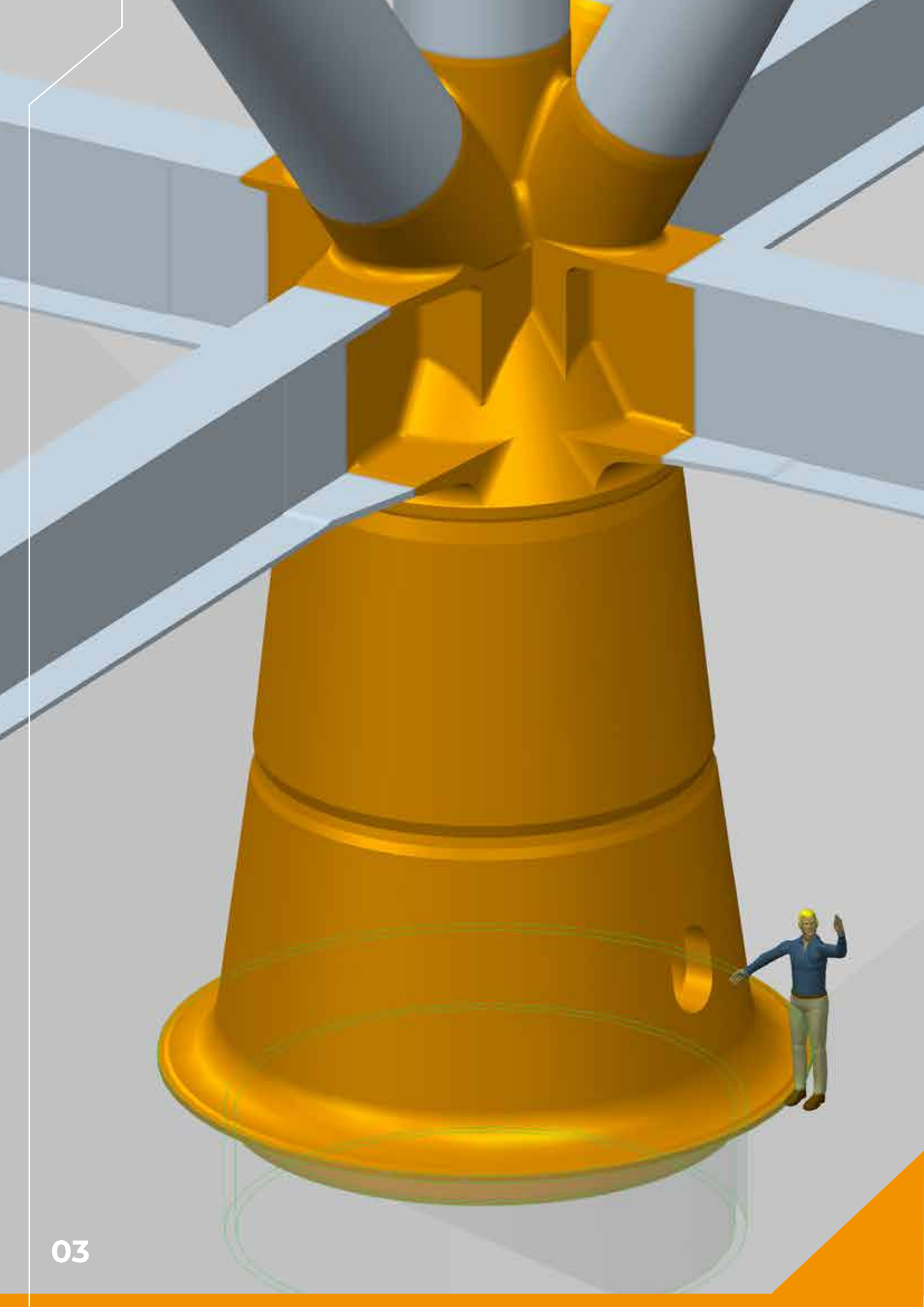
Sheffield Forgemasters has transitioned through many famous names in Steel including English Steel, Firth Brown, British Steel and River Don Castings. Throughout that time the company has always been at the leading edge of steel engineering and design.

A boiler drum being forged at Brightside Lane

NOW

Sheffield Forgemasters now produces some of the most complex steel forgings and castings in the World. Our components are used in the most extreme environments from Nuclear Reactors to Petrochemical plants.

5-Axis Machining of an Ultra-Large Component



Preliminary Design

Our experienced teams at Sheffield Forgemasters use preliminary design software and hardware tools for steel melting, casting and forging prediction and analysis.

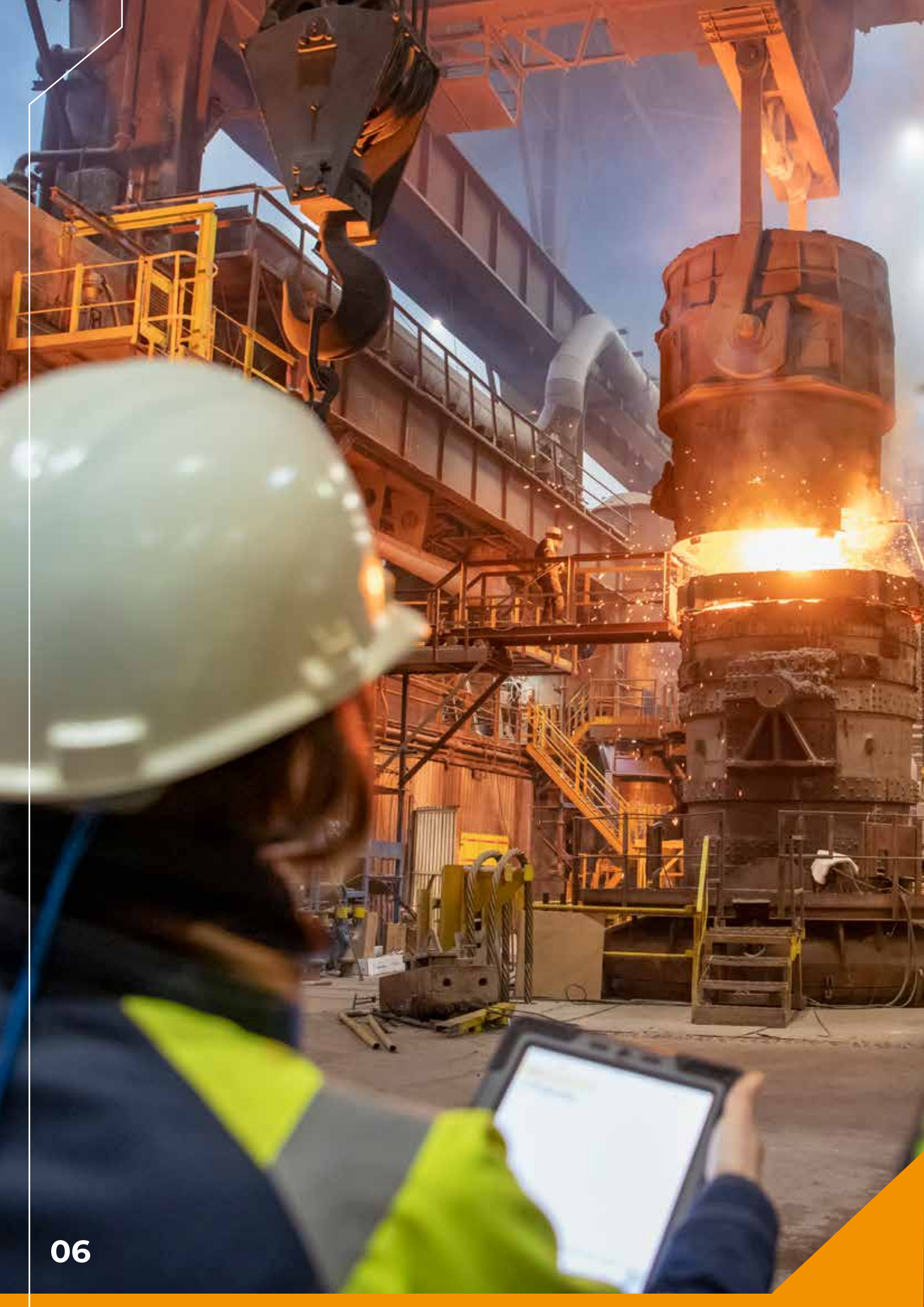
Preliminary design services can reduce the risks and costs involved in various steps of a steel making process, converting heavily stressed and safety critical fabricated components into an optimal cast or forged steel solution.

Preliminary Design Capabilities

- Design for manufacture
- Residual stress prediction
- Forging & shaping simulation
- Liquid metal flow simulation
- Segregation prediction modelling
- Fabrication & welding simulation
- Structural stress modelling
- Heat treatment & cooling simulation
- Mechanical properties prediction
- 3D CAD modelling
- 3D Printing
- Ingot mould design

Design Facts

- **Dedicated R&D department**
- **Advanced prediction simulation and design software and skills**
- **Design optimisation**
- **Combination of existing designs**
- **Reduced cost, risk and through life support requirements**



Melt Shop

At the heart of our steel melt shop is a 105 tonne furnace, which produces liquid steel in a wide range of grades.

Liquid steel is supplied directly to our foundry for steel castings or poured into ingot moulds. Ingots are then forged in one of our open die presses or supplied to our customers as a material for further processing. Ingots can be air cast from 1.5 up to 84 tonne and vacuum cast up to 300 tonne.

Melt Shop Capabilities

- Thousands of cast and forged steel grades available including complex grades such as NQ1, HY80 and HY100
- 105 tonne capacity Electric Arc Furnace (EAF)
- 105 tonne Vacuum Arc Degasser (VAD)
- Ladle Furnace (LF)
- 80 tonne Vacuum Oxygen Decarburisation unit (VOD)
- 300 tonne Vacuum Stream Degas Pits
- Lifting capacity 400 tonnes

Melt Facts

- **The most agile steel melt facilities in the world with single melts from 35 - 105 tonnes**
- **Integrated melt facilities onsite**
- **Ultra-clean steel**
- **Over 600 tonne liquid steel capacity at a single time**
- **Numerous ingot sizes and shapes available up to 285 tonnes**

Forge

Sheffield Forgemasters can trace its first forges back to the late 1800's when Tom Vickers introduced the first heavy forging press.

The company has advanced significantly from this point and now includes two open die forging presses, 4,500 tonne and 10,000 tonne which are capable of handling ingots up to 300 tonnes.

Forge Capabilities

10,000 tonne Open Die Hydraulic Forging Press

- Capable of complex forgings up to 300 tonnes.
- Max Dias - Discs – Ø5080mm
  Tubes – 3050mmOD x 1900mmID
  Rings 5560mmOD x 4900mmID
  Shafts Ø2100mm | Collars Ø3048mm
- Min Dia - Ø355mm
- Max Length - 19800mm

4,500 tonne Open Die Hydraulic Forging Press

- Typical weights from 6 up to 40 tonnes.
- Max Dias - Rolls – Ø915mm | Bars – Ø660mm
- Min Dia - Ø270mm
- Max Length - 12000mm

Forge Facts

- The most diverse forging capabilities in the UK ranging from weights of 1 tonne up to 200 tonnes
- The largest open die press in the UK
- Forgings from 1 tonne up to 300 tonnes
- Complex step forgings
- Quench facilties in close proximity to forge

Foundry

Sheffield Forgemasters produces the largest and most technically demanding castings in the World.

Our foundry is one of the most agile in the world and can produce finish machined steel components from 1 tonne up to 350 tonnes. The foundry is capable of handling liquid steel volumes of over 600 tonnes at a single time.

Foundry Capabilities

- Finish machined castings available up to 350 tonnes
- Maximum casting weight of 650 tonnes
- A wide range of steel grades including low alloy, stainless and precipitation hardened steel.
- Complex grades such as HY80, HY100 and NQ1 all available.
- Heat treatment furnaces with ancillary water quench facility
- Annual capacity of 10,000 tonne delivered product
- Pattern and mould making

Foundry Facts

- **One of the most diverse foundries in the the world offering castings from 1 tonne up to 350 tonnes finished weight**
- **Over 600 tonne pour capacity**
- **Advanced prediction, simulation and flow software capabilities**

Heat Treatment

Sheffield Forgemasters offer a comprehensive range of heat treatment, cryogenic treatment and quenching facilities.

Our wide range of traditional and vertical heat treatment facilities are designed to produce optimal metallurgical properties of castings and forgings.

Heat Treatment Capabilities

- 16 Bogie Hearth Gas Fired Furnaces
  - Capacity of 7,600 x 5,000 x 17,500mm (w x h x l)
- 4 Top Hat Gas Fired Furnaces
  - Capacity of 3,500 x 2,500 x 20,00mm (w x h x l)
- 2 Vertical Electric Induction Furnaces
  - Capacity Ø3,700 x 20,000mm (d x l)
- Selas furnace for differential hardening of Backup Roll products
- Computerised dual frequency induction stands for work rolls
- Cryogenic Treatment
  - Two cryogenic tanks available for cooling to -130°C

Heat Facts

- A wide variety of heat treatment facilities are available onsite including some of the largest in the World
- Centrally computer controlled for accurate treatment
- Full water and oil quench options in close proximity to heat treatment facilities

Machining

Our state of the art machining facilities offer rough and finish machining as well as specialist services such as cladding and liner fitting.

Our facilities include a vast array of milling, turning, boring and finishing machinery including the UK's largest Vertical Turning Lathe and Horizontal Floor Borer.

Machining Capabilities

- Milling up to 17,000mm, 5,500mm x 5,500mm (l x w x h)
- Boring up to Ø2,200mm x 21,000mm (d x l)
- Turning up to Ø8,500mm x 23,000mm (d x l)
- Linishing and grinding
- Pressure testing up to 80,000 Psi
- Assembly and production fitting
- Dynamic balancing
- Epoxy coating and fibreglass wrapping
- Cladding and liner fitting

Machining Facts

- **Integrated machining facilities**
- **Most advanced 5-axis machining facilities in Europe**
- **Capable of machining small to ultra-large components**
- **Complex profiles, lengths, sizes and weights can all be accommodated**

Non-Destructive Testing (NDT)

Proud to offer the most capable Non-Destructive Testing facilities and personnel in the World.

Our Level III and Level II industry certified NDT engineering team is trained in conventional and advanced techniques including radiography, ultrasonic, dye penetrant & magnetic particle to evaluate the material properties of a component without damage.

NDT Capabilities

- All NDT personnel are PCN and SNT-TC-1A qualified and certified in Non-Destructive Testing to level 2 or 3.
- Our Level 3 engineers develop specialised techniques, methods and procedures for the inspection of all forgings, castings and weldments.
- Volumetric and surface inspections:
  - Visual inspections – Direct and Indirect
  - Magnetic particle
  - Dye penetrant – Visible and Fluorescent
  - Ultra-sonic testing
  - Radiography

NDT Facts

- **The most capable NDT facilities and personnel in the World**
- **All forms of volumetric and surface inspections can be offered in line with customer requirements**
- **Quality is guaranteed with the addition of advanced prediction and real-time monitoring services**

Test House

Our independent test house provides mechanical and metallurgical testing services to the steel industry.

Equipped with a range of preparation techniques for metallurgical examination of metals and alloys for steel foundries, forges, rolling mills and steel stockholders. These techniques are supported by comprehensive photographic and digital imaging capabilities.

Test House Capabilities

- Independently UKAS accredited to the requirements of ISO/IEC 17025
- Metallurgical Testing Available
  - Macro & micro
  - Anodised surface depth
  - Decarburised depth
  - Grain size determination
- Charpy Impact testing
  - Measuring projector measuring ‘V’ and ‘U’ notch Charpys
- Hardness testing including micro and macro Vickers tests
- Tensile testing
- Microscope imaging

Test House Facts

- **Our Test House offers a full range of metallurgical, machine and laboratory test services**
- **The Test House is independently UKAS accredited to maintain quality and assurance**
- **All services are available for third party hire**

Research & Development

Our dedicated R&D team carry out full new concept design and design optimisation for our customers using expert capabilities.

The team's intimate knowledge of the manufacturing process, combined with experience and design skills, allows Sheffield Forgemasters to solve the engineering challenges posed to us by our customers. R&D services are also available for customer projects as an integrated service.

Research & Development Capabilities

- Design and innovation
  - 2D drafting
  - 3D solid modelling
  - Full finite element analysis
  - Solidification (casting) simulation
  - Forging simulation
  - Detailed hand calculations, loading analysis and fatigue assessments
  - Portable large volume & high precision metrology
  - Digital image correlation
  - Infrared thermography
  - Augmented reality
- Consultancy
  - Collaborative research projects
  - ASME consulting
  - Technology transfer
  - Safety case support
  - Design for manufacture
  - Plant and process development
  - Technical trials

R&D Facts

- **Dedicated Research and Development department offering support to Sheffield Forgemasters projects and to external contracts**
- **Highly experienced**
- **Advanced prediction and simulation techniques means a 'right first time' solution for our customers**
- **A combination of experience and capabilities allows Sheffield Forgemasters to solve the most complex engineering challenges**

Project & Quality Management

Quality is at the heart of every project we undertake and as such we have dedicated Projects and Quality team who manage the process from initial order through to final delivery.

Our internal quality assurance in each area of our organisation monitors day to day activities while a central quality function carries out a comprehensive internal audit programme.

Over the years, Sheffield Forgemasters has developed Quality Management Systems and gained accreditation to national and international standards, showing commitment to providing the best possible products and service to our customers and a promise of continual development and improvement. Just some of the accreditations we have gained are listed below:

Accreditations & Approvals

- American Bureau of Shipping
- ASME Material Organisation – QSC-557
- BSEN OH SAS 18001
- Bureau Veritas
- Def Stan 02-736 Part 2 and 3 approval to manufacture thick section Q1N Castings and Forgings
- DNV-GL
- ISO 9001:2015
- ISO 14001:2015
- JOSCAR
- Lloyds Register – Castings, Forgings & steelmaking
- Made In Sheffield
- Ministry of Defence
- NAVSEA T9074-BD-GIB-010/0300 Approval to manufacture thick section HY80 Castings and Forgings
- Roll Royce Nuclear Submarines sector - Castings, forgings, heat treatment & finish machining
- ISO/IEC 17025 Test Laboratory UKAS 4355

Steel Grades

Sheffield Forgemasters Casting Production Grades

Carbon Steel

Werkstoff No.	UNS No.	US – ASTM/SAE/AISI	European - EN	Other
1.0420	J03000	A27 Grade 60-30	GE200	SC 360 (JIS)
1.0449	J03001	A27 Grade 65-35	GS240	SC450 (JIS)
1.0446	J03001	A27 Grade 65-35	GE240	SC450 (JIS)
1.0455	J03001	A27 Grade 65-35	GS240	SC450 (JIS)
1.0454	J02501	A27 Grade 70-40	GE270	SC480 (JIS)
1.0558	-	A148 Grade 80-40	GE300	SCC5A (JIS)
1.0591	-	A148 Grade 80-50	GE320	SCW550 (JIS)
1.0597	-	-	GE360	SCMn1B (JIS)
1.1131	J03003	A352 Grade LCB	G17Mn5	SCPL 1 (JIS)
1.6220	J02505	A352 Grade LCC	G20Mn5	-
1.1118	-	-	G24Mn6	-
1.1165	-	-	G28Mn6	-
1.5419	J12524	A217 Grade WC1	G20Mo5	SCPH 11 (JIS)
1.0619	J03001	A27 Grade 65-35	GP240GH	SC450 (JIS)
1.0625	J02501	A27 Grade 70-40	GP280GH	SC480 (JIS)
1.5422	K12821	A352 Grade LC1	G18Mo5	SCPL 11 (JIS)
1.0552	J03501	A27 Grade 70-36	GS-52	SB450M (JIS)
-	J31575	A148 Grade 105-85	-	SCMn 5B (JIS)
1.0619	J02502	A216 Grade WCA	GP240GH	SCPH 1 (JIS)
1.0625	J03002	A216 Grade WCB	GP280GH	SCPH 2 (JIS)
1.0625	J02503	A216 Grade WCC	GP280GH	SCPH 2 (JIS)
1.1131	J02504	A352 Grade LCA	G17Mn5	SCPL 1 (JIS)
1.1131	J03002	A757 Grade A1Q	G17Mn5	SCPL 1 (JIS)
1.6220	J02505	A757 Grade A2Q	G20Mn5	-

Low Alloy Steel

Werkstoff No.	UNS No.	US – ASTM/SAE/AISI	European - EN	Other
1.7357	J12072	A217 Grade WC6	G17CrMo5-5	SCPH 21 (JIS)
1.7379	J22091	A487 Grade 8	G17CrMo9-10	SCPH 32 (JIS)
1.7221	-	-	G26CrMo4	-
1.5638	J31550	A352 Grade LC3	G9Ni14	SCPL 31 (JIS)
1.5681	J41501	A757 Grade B4Q	GX9Ni5	-
1.6750	-	-	G20NiMoCr4	-
1.6781	J42215	A352 Grade LC2-1	G17NiCrMo13-6	-
1.6771	-	-	G30NiCrMo14	-
1.5636	J22500	A352 Grade LC2	G9Ni10	SCPL 21 (JIS)
1.7365	J42045	A217 Grade C5	GX15CrMo5	SCPH 61 (JIS)
1.7218	-	-	GS25CrMo4	SCCrM 1 (JIS)
1.6740	-	A958 Grade SC 4330	GS33 CrNiMo 7 4 4	SCNCrM 2 (JIS)
1.7379	J21890	A217 grade WC9	G17CrMo9-10	SCPH 32 (JIS)
1.7379	J22091	A487 Grade 8	G17CrMo9-10	SCPH 32 (JIS)
1.7365	J42045	A217 Grade C5	GX15CrMo5	SCPH 61 (JIS)
1.4710	J82090	A217 Grade C12	GX30CrSi7	-
1.6781	J42215	A757 Grade E2N / E2Q	G17NiCrMo13-6	-

Stainless Steel – Ferritic & Martensitic

Werkstoff No.	UNS No.	US – ASTM/SAE/AISI	European - EN	Other
1.6982	J91540	A487 Grade CA6NM	GX3CrNi13-4	SCS 6 (JIS)
1.4317	J91540	A487 Grade CA6NM	GX4CrNi13-4	SCS 6 (JIS)
1.4421	-	-	GX4CrNi16-4	-
1.4405	-	-	GX4CrNiMo16-5-1	-
1.4107	J91171	A487 Grade CA15	GX8CrNi12	SCS 1 (JIS)
1.4011	J91150	A743 Grade CA15	GX12Cr12	SCS 1 (JIS)
1.4008	J91151	A743 Grade CA15M	GX7CrNiMo12-1	SCS 3 (JIS)
-	J91153	A743 Grade CA40	-	SCS 2 (JIS)

Note – Minimum Carbon levels less than 0.06% may not be achievable for some grades – please ask for more information

Stainless Steel – Austenitic & Duplex

Werkstoff No.	UNS No.	US – ASTM/SAE/AISI	European - EN	Other
1.4309	J92700	A351 Grade CF3 / CF3A	GX2CrNi19-11	SCS 19 (JIS)
1.4308	J92600	A351 Grade CF8 / CF8A	GX5CrNi19-10	SCS 13 (JIS)
1.4552	J92710	A351 Grade CF8C	GX5CrNiNb19-11	SCS 21 (JIS)
1.4409	J92800	A744 Grade CF3M / CF3MA	GX2CrNiMo19-11-2	SCS 16 (JIS)
1.4408	J92900	A351 Grade CF8M	GX5CrNiMo 19-11-2	SCS 14 (JIS)
1.4581	-	-	GX5CrNiMoNb19-11-2	SCS 22 (JIS)
1.4458	N08007	A351 Grade CN7M	GX2NiCrMo28-20-2	-
1.4859	-	-	GX10NiCrSiNb32-20	-
1.4470	-	-	GX2CrNiMoN22-5-3	-
1.4517	J93370	A351 Grade CD-4MCu	GX2CrNiMoCuN25-6-3-3	-
1.4417	-	-	GX2CrNiMoN25-7-3	-
1.4469	-	-	GX2CrNiMoN26-7-4	-
-	J92602	A743 Grade CF20	-	SCS 12 (JIS)
1.4446	-	A743 Grade CF3MN	GX2CrNiMoN19-11-2	-
-	J92999	A743 Grade CG3M	GX2CrNiMoN19-11-3	-
1.4412	J93000	A743 Grade CG8M	GX5CrNiMoN19-11-3	-
-	J93402	A743 Grade CH20	-	SCS 17 (JIS)
1.4527	N08007	A744 Grade CN7M	GX4NiCrCuMo30-20-4	SCS 23 (JIS)
1.4416	J94652	A743 Grade CN3M	GX2NiCrMoN25-20-5	-
1.4588	J94651	A744 Grade CN3MN	GX2NiCrMoN25-20-6	-
1.4593	J93254	A744 Grade CK3MCuN	GX2NiCrMoN20-18-6	-

Note – Minimum Carbon levels less than 0.06% may not be achievable for some grades – please ask for more information

Steel Grades

Sheffield Forgemasters Forge Production Grades

Carbon & Carbon Manganese Steel Grades

Werkstoff No.	UNS No.	US – ASTM/SAE/AISI	European - EN	Other
1.0038	-	SA105	S235JRG2	-
1.0570	-	SA266	S355J2G3	E36-3 (AFNOR)
-	-	SA105	C20	070M20 (UK)
1.0402	G10200	1020	C22	-
1.0406	G10250	1025	C25	-
1.0528	G10300	1030	C30	-
1.0501	G10350	1035	C35	-
-	G10380	1038	-	-
1.0511	G10400	1040	C40	080M40 (UK)
1.0503	G10450	1045	C45	-
1.0540	G10500	1050	C50	-
1.0535	G10550	1055	C55	070M55 (UK)
1.0601	G10600	1060	C60	-
1.1170	G13300	1330	28Mn6	30Mn2 (UK)
1.1133	G15180 / G15220	1518 / 1522	28Mn5	-
-	-	-	-	20SiMn (UK)

Low Alloy Steel

Werkstoff No.	UNS No.	US – ASTM/SAE/AISI	European - EN	Other
1.7218	G41300	4130	25CrMo4	25CD4 (UK)
1.7225	G41400	4140	42CrMo4	708M40 (UK) 42CD4 (AFNOR)
-	G41420	4142	-	-
-	G41450	4145	-	-
-	G41500	4150	-	-
1.6511	G98400	9840	36CrNiMo4	816M40 (UK)
1.6580	G43400	4340	30CrNiMo8	823M30 (UK) 30CND8 (AFNOR)
-	G43200	4320	-	-
-	-	4330V	-	-
1.6582	-	SA540/4340	34CrNiMo6	817M40 (UK) 35NCD16 (AFNOR)
-	G86300	8630	-	-
-	-	A336 F11	-	-
-	J21890	A336 F22	-	-
-	J22091	A336 F22V	-	-
-	J42045	A707	-	-
-	J82090	HY80	-	Q1N (UK)
-	J42215	HY100	-	-
-	-	-	30NiCrMo16-6	835M30 (UK)
-	-	-	23CrMoNiWV88	-
-	-	A668	-	-
-	-	SA350 LF2	-	-
-	-	SA350 LF3	-	-
1.5622	-	SA350 LF5	14Ni6	-

Low Alloy Steel cont.

Werkstoff No.	UNS No.	US – ASTM/SAE/AISI	European - EN	Other
-	-	SA508 Gr 3	-	16MnD5/20MnD5 (AFNOR)
-	-	SA508 Gr 4N	-	-
1.6931	-	-	26NiCrMoVV8-5	-
1.6948	-	-	27NiCrMoV11-6	-
1.6957	-	-	27NiCrMoV15-6	-
1.6962	-	-	25NiCrMoV12-7	-
1.6963	-	-	27NiCrMoV16-7	-
-	-	SA 723	-	-

Tool Steel

Werkstoff No.	UNS No.	US – ASTM/SAE/AISI	European - EN	Other
1.2343	T30106	A681 H11	X37CrMoV5-1	Z38CDV5 (AFNOR)
1.2344	T30106	A681 H13	X40CrMoV5-1	Z40CDV5 (AFNOR)
1.2714	T61206	L6	55NiCrMoV7	-
1.2362	-	-	X63CrMoV5-1	-

Stainless Steel

Werkstoff No.	UNS No.	US – ASTM/SAE/AISI	European - EN	Other
1.4301	S30400	SA965 F304	X5CrNi18-10	304S15 (UK)
1.4306	S30403	SA965 F304L	X2CrNi19-11	304S11 (UK
1.4311	S30453	SA965 F304LN	X2CrNiN18-10	304S62 (UK
1.4401	S31603	SA965 F316	X5CrNiMo17-12-2	316S16 (UK
1.4404	S31603	SA965 F316L	X2CrNiMo17-12-2	316S12 (UK
1.4406	S31653	SA965 F316LN	X2CrNiMoN17-11-2	316S61 (UK
1.4541	S32100	SA965 F321	X10CrNiMoTi1810	321S12 (UK
1.4450	S34700	SA965 F347	X6CrNiNb18-10	347S17 (UK

Martensitic Stainless Steel

Werkstoff No.	UNS No.	US – ASTM/SAE/AISI	European - EN	Other
1.4902	-	-	X14CrMoVNbN10	COST F (UK)
1.4096	-	-	X12CrMoWVNbN10-1-1	COST E (UK)
-	1.4903	A336 F 91	-	-
-	-	A336 F92	-	-
1.4313	-	A336 F6NM	-	-
-	1.4594	-	-	FV 520B (UK)

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