Forging Industry Technical Conference
Long Beach, CA

Historic Heavy Forging Presses of the World

Jon Tirpak

Mark Timko, Roman Dobrorodny, Dustin Bush, Timothy Howson, Clotide Huett, Brigitte Loewy-Linz

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Outline

- Introduction
  - ASM International Historic Landmark Award Program
  - “Project Vulcan” scope
  - Impetus for monolithic structures
- Heavy press forging timeline
  - 1930s
  - 1940s
  - 1950s
  - 1960s
  - 1970s
  - 1980s
  - 1990s to 2018
- Heavy press forging 2018 and beyond
- Wrap-up
ASM International Historic Landmark Program

- “Since 1969, to identify permanently the many sites and events that have played a prominent part in the discovery, development and growth of metals and metalworking”
- Expanded in 1987 to include materials
Other Landmarks

- Air Force Materials Laboratory, Dayton, OH
- ATI Allvac, Monroe, NC
- Bethforge, Bethlehem, PA
- Caterpillar Tractor, Stockton, CA
- Ladish Forge, Cudahy, WI
- METCUT Research, Cincinnati, OH
- Mission Metalworking Furnaces, San Juan Capistrano, CA
- Weld Mold, Brighton, MI
Project Vulcan Scope

- **International family of presses**
  - Heavy, hydraulic > 35,000 tons
  - Closed die
  - Historic – typically > 50 years
- Cognizant of other presses and recent entries
# International Evolution

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<td>Aubert-Duval + SNECMA</td>
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<td>Alloy families</td>
<td>Mg</td>
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1930s

In between WW I and WW II
Post WW I situation in Germany

- Plentiful supply of magnesium
- Forging hammers for commercial operations
- Hexagonal Close Packed (HCP) crystal structure of Mg provided minimal number of slip planes. Forming required slow strain rates, hence the application of hydraulic pressing
- Designed and commissioned first large presses of the world
  - 7,000 ton*
  - 12,000 ton*
- Pressed aircraft components

* Tons vs. metric tons comment
Bitterfeld, Germany

- “For many years in Germany the I.G. Farbenindustrie plant at Bitterfeld had been the fountainhead of research and development work on magnesium alloys and by far the most important producer. It can be said that these works is the birthplace of the modern magnesium industry. Many of the techniques used in fabricating magnesium alloy and much of the physical, chemical and engineering data on magnesium and its alloys originated in Bitterfeld.”

Reference: Combined Intelligence Objectives Subcommittee teams, June 1945
Aircraft parts

- Messerschmitt Bf 109 forged AZ855 engine bearer
- Focke Wulf 190 engine bearer
- BMW 801D had 20 kg (44 lbs) magnesium forgings
- JU88A-4 had 96 kg (211 lbs) magnesium forgings
- Professor Hertel, Junkers Design Chief
  - Responsible for adaptation of forged Mg engine bearers
  - Preferred Mg over Al except for elevated temperatures
- Prior to 1938 a 7,000 ton press is referenced
- Post 1938 more presses were added including a 15,000 ton press

Reference: Magnesium Technology – Metallurgy, Design Data, Applications
1940s

WW II and Post War activities
Dornier Do335 twin-engined “Destroyer”

Reference: The German Fighter since 1915, Rudiger Kosin
Forged magnesium engine mount

The engine mount on the Messerschmit Me109 is forged in one piece instead of the welded steel tube construction used in this country. At points A and B connections have been made for the vibration dampening engine mount and these two plus two similar connections on the other side are the main supports for the engine. At point C is located a bolt fitting which attaches the mount to the fire wall. Point D is the other connection to the fire wall for the steel tube at A.

Reference:  http://legendsintheirowntime.com/Other/Me109_index.html and Aviation's Sketchbook of Design Detail
Sketch with “Elektron Forging”

Reference: http://legendsintheirowntime.com/Other/Me109_index.html and Aeroplane
Me Bf 109G-10 Engine Bearer
Bitterfeld, Germany

Building – “Older”
- 6,000 ton Eumoco press
- 600 ton forging press
- 300 ton forging press
- Various extrusion presses

Building – “Newer”
- 30,000 ton Schloemann
- 15,000 ton Schloemann
- Forging rolls for propellers
  Eumoco

“The most important magnesium works was the I.G. Farben plant at Bitterfeld — also largely removed (80 percent) to the Soviet Union.”

Bitterfeld’s 30,000 ton press

Wing Spar Caps: Lesson in Buy to Fly Ratios

**Machined Extrusions**
- 517 pound input weight
- 176 pounds net weight
- Chips = 341 pounds

**Forged**
- 198 pounds input weight
- 176 pounds net weight
- Chips = 22 pounds
- Major reduction in machining time and increased utilization of resources
- Also, 2 cavity design to double production
World War II Reparations

- 80% of Mg industry went to the USSR including
  - 30,000 ton press (largest at that time)
  - 55,000 ton press was designed but not built
- Two 15,000 ton presses landed in Adrian, MI, USA
- Precipitated design and construction of even larger presses in Russia and the United States
1950s

The heavy forging press race started!
Arconic, Cleveland, Ohio 35,000 ton
Arconic, Cleveland, Ohio
50,000 ton
Arconic

Bulkhead Forgings

Gear Rib Forgings

Window Frame Forgings

Main Landing Gear Forgings
PCC Wyman, North Grafton MA
Loewy 50,000 Ton – “Major”

- 9 main hydraulic cylinders
- 6 pullback and balancing cylinders
- 6 eccentric load compensating cylinders
- 6 press columns of rectangular laminated cross-section
- 1 pressure intensifier with 3:2 ratio
- Die bed area: 12 ft x 32.5 ft
- Height above operating floor 48 ft / below operating floor 66 ft
PCC Wyman Gordon, North Grafton MA
Loewy 35,000 Ton – “Minor”

- 8 main hydraulic cylinders
- 4 pullback and balancing cylinders
- 4 eccentric load compensating cylinders
- 4 press columns of rectangular laminated cross-section
- 1 pressure intensifier with 3:2 ratio
- 2 side cylinders of 3,000 tons capacity each
- Die bed area: 12 ft x 30.5 ft
- Height above operating floor 45 ft / below operating floor 62 ft
PCC - Wyman Gordon Forgings
Titanium/Steel/Nickel-Base Superalloys

Fighter Bulkhead
Alloy Ti-6Al-4V ELI

Wide-Body Door Frame
Alloy Ti-6Al-4V

IGT Turbine Disk
Alloy INCO-706

Commercial aircraft
Main Landing Gear
Alloy E35NCD16
Arconic Samara
75,000 metric ton
Over the years it has been retrofitted with upper and lower bolsters and equipped with an upgraded control system.
VSMPO – AVISMA Corporation

- 75,000 metric tons
- Capable of forging parts 6m long x 1m wide
- Travel accuracy of 6,000 metric tons ram is 0.1mm
1974 - forged the docking unit adapter for the US-Soviet Apollo-Soyuz Test Project.

In 2003 – forged the world’s largest forging for A380 Landing Gear Truck Beam weighing almost 3.5 tons.

Ti 10V-2Fe-3Al
1960s
Dominated by production of parts for Cold War and space systems for Russia and the United States
1970s
INTERFORGE of France entered the heavy press forging industry with a 65,000 metric ton press in 1977
Aubert & Duval – INTERFORGE
65,000 metric tons

- Dedicated January 13, 1977
- Shareholders
  - Aubert & Duval 94 %
  - SNECMA 6 %
- Statistics
  - Total height: 38m
    - 26m above ground level
    - 12m below ground level
  - Total weight: 12 500 metric tons, twice the weight of the Eiffel Tower
  - Daylight of 4.5 m and stroke of 1.5 m
  - Forging speed range 0.1 mm/s to 60 mm/s
Aubert & Duval – Closed die forgings

An array of aerospace parts and semi-finished products for aircraft and helicopter engines (shafts, fan disks, spinners, etc.), structural parts (airframes fittings, hinges, engine pylons, transmission components) and landing gear components (main fittings, sliding tubes, braking systems, etc.). Parts from 50 kgs / 110 lbs to 20 t - Up to 8 m / 314 in.
Aubert & Duval’s “Little” Sibling

40,000 metric ton press (2007)
1980s

Weber Metals enters the heavy press forging industry
First and largest privately financed large press (no government incentives) at the time of construction

Press designed by Pahnke in Germany

Last, large piece of equipment built by Mesta Machine Co. in Pittsburgh, PA

Press became operational in 1983

Demonstrated capability of 42,600 tons
Weber Metals
Weber Metals

- 61808 Al window frame support
- 10323 Al fin support
- 12396 Al side frame to floor
- 40138 Ti pickle fork
- 11709 Al landing gear
1990s to 2018
Exploration of new presses around the world ultimately with major investments
Kobe Steel Ltd. and Messier-Bugatti-Dowty (Safran Group) signed a contract for Kobe Steel to supply the French company with titanium forgings for the main landing gears of the next-generation, wide-body Airbus A350 XWB planes. The main landing-gear parts will be manufactured by Kobe Steel and its group company, Japan Aeroforge Ltd. of Kurashiki, Japan. Equipped with a 50,000 [metric]ton hydraulic forging press, Japan Aeroforge manufactures large titanium forgings for the global aerospace industry. The A350 XWB is Airbus' all-new, medium-size, long-range product line comprising three versions that seat from 270 to 370 passengers. Japan Aeroforge is a joint venture established in January 2011 by Kobe Steel and Hitachi Metals Ltd. as the two major shareholders.

Source: http://www.kobelco.co.jp/english/releases/2014/1189413_13891.html
China

- Installed 2 presses
  - 40,000 metric tons, city of Xian
  - 80,000 metric tons, city of Deyang (making it the world’s largest press)
- Operational
SMS Meer to build Weber Metals’ new press in Paramount, CA.

Press purchase is privately financed similar to current Mesta press.

Press will be a multi-cylinder, hydraulic, pull-down style, Operational beginning 2017.

Loading/unloading performed by robotic manipulators.

Press will hot forge aluminum, titanium, nickel-base alloys plus cold compression stress relieve aluminum alloys.
Large presses resulted from the combination of factors. Plentiful supply of magnesium, limited slip planes, and transition from forging hammers to hydraulic presses.

Large presses create large, monolithic structures enabling efficient and effective components primarily for the aerospace industry.

Large presses will continue to contribute to the aerospace industry with the unique ability to economically shape difficult to form alloys resulting in weight saving structures.
# Historic Forges

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<td>Owner</td>
<td>80,000 metric ton press owned by state run</td>
<td>Japan Aeroforge (JV = Kobe Steel + Hitachi Metals + Others)</td>
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<td>Otto Fuchs Aerospace Group</td>
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<tr>
<td>Comment</td>
<td>Functioning and producing parts</td>
<td>Large, aerospace titanium</td>
<td>Still ferreting out details</td>
<td>Announced 4/16/2014</td>
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<td>Source</td>
<td>Correspondence with Dr. Howson</td>
<td>FORGING Magazine, March/April 2014, Page 8</td>
<td>Talk on the street</td>
<td>Weber Metals, HLM Award Presentation, April 2014</td>
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<td>WSJ Article dated Dec 3, 2014, pp B1 &amp; B5</td>
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Acknowledgements

- Bob Halverstadt
- ASM International
  - Staff, Awards Committee, Chapters
- Forging Industry Association
- Project Vulcan Team Members
  - PCC Wyman-Gordon, North Grafton
  - Alcoa (Now Arconic)
  - VSMPO-AVISMA
  - Weber Metals
  - Aubert & Duval
  - Ms. Brigitte Loewy Linz
- Sponsors of the plaques
  - Anonymous patron who understands the power of forging
  - SFTC
  - SCRA Applied R&D (now Advanced Technology International)
  - Forging Industry Association
- Defense Logistics Agency
HLM Ceremony at Weber Metals