

2012 Energy Efficient Hydraulics and Pneumatics Conference

Return on Investment of Energy Efficient Designs

Steve Zumbusch, Eaton Hydraulics Dan Helgerson, Cascade Rolling Mills, Inc.



© 2012 Eaton Corporation. All rights reserved

Discussion:

- Challenges for Equipment Manufacturers
- Minimize the Losses
- Thinking Outside the Box
- Communicating Savings to Decision Makers
- System Issues to Consider



Significant Role of Hydraulics

- Hydraulics in Ag/Construction
 - 1940's: Addressing First Set of Challenges
 - Ease of Operation
 - Power Steering
 - Three Point Hitch System
 - Distributing Power
 - Live Hydraulics





New Times: New Challenges

- Rising Operating Costs
 - Energy Efficiency
- Higher Productivity Demands
 - Paid for Delivering Useful Work
- Less Skilled Operators Available
 - Operator Ease/Simplicity
- Increasing Emission/Regulation Demands
 - EPA Tier 4 / EU Stage IV
 - Noise
 - Safety, ...





Impact to Designers - Tier 4/EU Stage IV

- Similar Engine Displacement:
 - Added Components Consume Real Estate (vs. Desire to Reduce Engine Compartments)
 - Higher Heat Loads
 - May Have Less Power Available

(Larger Engine Required for Same Power)

• Significantly Increased Cost (\$6-12K)



Impact to Designers - Tier 4/EU Stage IV

• Structure of Regulations:

• Favors Lower Power Class Engines

kWm*	(HP)	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
37 - 55	(49 - 74)			0.01					(7.5)		= 0/0/	0		(4.7)/5.0/0.30					(4.7) /	5.0 / 0.0	03	1000	
56 - 74	(75 - 99)			9.27-	/-/-					(7.5)73	/ 5.0 / 0.40				(4.7) / 5.0 / 0.40			24/0	10/50	100	0.40/		10/50
75 - 129	(100 - 173)		9.2/-	1-1-		(6.6) / 5				5.0/0.3	/ 0.30 (4.0) /			5.0 / 0.30				3.470	197 5.0	10.0	0.407	.1975.0	.070.02
130 - 224	(174 - 301)	9.2 / 1.3 / 11.4 / 0.54						(6.6) / 3.5 / 0.20				(4.0) / 3.5 / 0.20											
225 - 449	(302 - 602)	9.2 / 1.3 / 11.4 / 0.54					(6.4) / 3.5 / 0.20				(4.0) / 3.5 / 0.20						2.0 / 0.19 / 3.5 / 0.02			0.40 /	0.19 / 3.5	3.5 / 0.	0.02
450 - 560	(603 - 751)	9.2 / 1.3 / 11.4 / 0.54						(6.4) / 3.5 / 0.20			(4.0) / 3.5 / 0.20												
>560	(>751) ^a	9.2/1.3/11.4						1/0.54				(6.4) / 3.5 / 0.20					3.5 / 0 0.67 /	.40/3	.5 / 0.1 3.5 / 0.	0 10 ^b	3.5/0.1 0.67/0.	9/3.5/ .19/3.5	0.40 / <i>0.03^b</i>
* mechanical equivalent		Tier 1						Tier 2				Tier 3			٦	Tier 4 Interim				Tier 4	Final		

(NOx+HC) / CO / PM (g/kW-hr) [Conversion: (g/kW-hr) x 0.7457 = g/bhp-hr] NOx / HC / CO / PM (g/kW-hr) [Conversion: (g/kW-hr) x 0.7457 = g/bhp-hr] a. Applies to portable power generation >1200hp b. Applies to portable power generation >751hp

Today



Tier Hangover

- Tier 4i Hangover Here... Tier 4f Party Getting Started
 - Now need to live with Tier IV Realities
 - How to get more power to the point of work???
 - Reduce Engine Size???





Impact to Designers – Other Drivers

- Rising Energy Costs
 - Driving Need For Lower Energy Consumption
- Higher Productivity Demands
 - Getting More From Work Circuits
- Less Skilled Operators
 - Need To Manage Available Power Automatically







Needs: Manage the Power Available

- Managing Power Effectively Addresses:
 - Less Power Available from New Engines
 - Potential to Drop to Smaller Engine
 - Save Cost on Engines
 - Move Into Less Severe Emissions Band
 - Reduce Fuel Consumption
- Managing Power Smarter Addresses:
 - Getting More Work from the System
 - Removes Work Load (Skill) from Operator
 - Less Dependency on Operator Skill
 - Less Wear/Tear on Machinery...



Changing Value Landscape

- Previously
 - Emphasis on Installed Costs
 - Simple, Fixed Displacements
 - Conventional Manifold Designs
 - Technology Solutions
 - Hard to Justify for Operating Cost Savings...





Changing Value Landscape

- Today:
 - Installed Costs Still Important
 - Focus Now on <u>Total</u> System Cost
 - If Improvements Can Be Delivered...
 - Justification for Adding Technology
 - Power on Demand Systems
 - Electro Hydraulic Solutions
 - Integrated System Designs ...



How to Gain Improvements?

- Complete System Review
 - Look at All Existing Sub-Systems
 - Individual Areas Consuming Power
 - Look For Overall System Needs
 - Alternate Ways to Achieve Mission
- Sources Of Power Loss:
 - Parasitic Losses
 - Efficiencies
 - Standby Losses
- So Let's Look at a Few...



General: Pressure Drops

- Pressure Drops Can Occur in 2 Areas
 - Fluid Conduits (Hose, Fittings, Tubing, ...)
 - Hydraulic Components (Valves, Pumps, Motors, ...)
- Product Selection Critical
 - Products Designed For Different Criteria
 - Higher Starting Torques
 - Lower Pulsations
 - Quiet Operation
 - Etc.
 - Example: No Load Pressure Drop in Hydraulic Motor...





Example: Proper Product Selection

- Product Selection Critical
 - No Load Pressure Drop in Hydraulic Motor
 - New Technologies Used in Component Designs
 - New Motor Designs Target Specific Goals
 - Starting Torque
 - Pulsations
 - No Load
 Pressure Drop
 - Etc...





No Load Pressure Drop

- **Example Hydraulic Motors**
 - No Load Pressure Drop = Parasitic Loss (Power Loss)
 - Worse at Cold Temperatures



System Pressure Selection

- Systems Moving to Higher Pressures
 - 210 Bar \rightarrow 280 Bar \rightarrow 420 Bar

Powering Business Worldwide

- Why?: Power = Flow x Pressure
 - Parasitic Losses Increase as Flow²



System Parasitic Losses vs Flow

Fan Drives

- Traditional Mechanical Drive Systems
 - Sized For Cooling At Idle
 - Excess Power At High Speeds (Lost Power) (Power to Fan → RPM³)
- Hydraulic Fan Drive Advantages
 - Easier To Mount Fan In Best Real Estate
 - Tighter Mounting To Shrouds (Better Efficiency)
 - Significant Power Savings -At High Speeds...





Propel Solutions: Hydrostatics

• "Automotive Drive"

- Simplified Operator Control
- Electronic Versions More Capabilities
 - Match Engine Power Curves
 - Consistent Performance Hot/Cold



Propel / Circuit Solutions

- "Anti-Stall"
 - Prevents Demands Beyond Power Available
 - Improved Fuel Efficiency
 - Better Productivity
 - Reduces Wear/Tear on Starters
 - Electronic Versions
 - Optimize for All Throttle Settings





Work Circuits

- Historic Method: Fixed Displacement
 - Puts Out Full Flow All The Time
 - Bleed Off What Is Needed
 - Common Across Many Areas
 - Steering, Work Circuits, Transmission Lube, ...
 - Power Loss Can Be Significant
 - Especially At Low Flow/High Pressure

Example: If Need is 8 LPM @ 200 Bar... ... but system puts out 80 LPM ... 24 kW (32 HP) Loss





Eaton Gear Pumps

Work Circuits: Power on Demand

- Better System: Variable Displacement
 - Varies Flow Based on Demand
 - Maintains Pressure in Circuit
- Best System
 - Intelligent Pump and Valve Work Together
 - EH System Provides Only Flow Required
 - Smart Valve Directs Flow Where Needed





Eaton x20 Series Piston Pump Family

Load Leveling Systems

- Complex Systems Power Management
 - Opportunities for Specialized Circuits
 - Store Energy to Level Out Peak Demands
- Intelligent, Pressure Compensated Valve
 - Capability to Proportionally Divide/Share Flow
 - Operate from Pressure Rail/Accumulator
- Already Used in Industrial Applications





Eaton Ultronics EH Valve



Adding Brains – Electro Hydraulics

- Critical Technology for Significant Savings
- Ties Intelligence To Key Areas
 - Engine Power Management
 - Hydraulic "Smart Components"
 - Operator Interface (Controls/Displays)





• Questions?









Helping Build the Business Case



Communicating With Stakeholders

- Engineers' Challenge:
 - Convincing Stakeholders/Decision Makers
- What Engineer Says:
 - Reduce energy consumption by 22%, up the drop rate by 5%, and simplify maintenance with a little more up front costs in the components
- What Purchasing Hears:
 - blah..blah.. It's more expensive... blah... blah



Showing the Value Added

- Customers Want to Believe...
 - But Need to Articulate to Others
 - Is it Worth Added Cost?
- Some Customers Already Set Measures
 - \$100/kW?
 - Operating Costs
 - (savings for end user makes machine more valuable)
 - "Snowball Affect" (smaller drives, heat exchangers, etc.)
 - Dropping below "Tier"



Operating Costs

- Energy Savings (Same Work, Less Energy)
 - Fuel Consumption Liter/kW-hr (Gallon/HP-hr)
 - Electrical Energy Savings
 - Cost/kW-hr
 - Peak Shaving



- Productivity Gains (More Work, Same Energy)
 - Lift Larger Buckets, Bend Larger Sheet, Increase Conveyor Speeds, etc.





Fuel Savings

• Rough Estimating:



- Fuel Consumption ≈ 0.26 liter/kW-hr
 - (Save 1 kW for 1 hour, save 0.26 liter of fuel) -OR-
- Fuel Consumption ≈ 0.05 gal/HP-hr

(Save 1 HP for 1 hour, save 0.05 gallon of fuel)

Example:

Improve Power Consumption by 3 kW (2 HP) 3kW x 8hrs/day x 5day/week x 50 weeks x 0.26liter/kW-hr x \$0.80/liter

=\$1,280/year !



Electrical Savings

- Electricity Charged \$/kW-hr:
 - Utility Rates Vary
 - By Region
 - Residential vs. Commercial vs. Industrial (\$0.12 vs. \$0.11 vs. \$0.07)
 - Premiums for Peaks

Example:

Improve Power Consumption by 3 kW (2 HP) 3kW x 24hrs x 5day/week x 50 weeks x \$0.07/kW-hr





Heat Load Reduction

- Heat Load Reduction
 - Lower Heat Load Saves Upfront Costs



- 1 kW = 57 BTU/min (1 HP = 43 BTU/min)
- From Earlier Example
 - 3 kW savings (3kW less heat rejection)
 - 3 kW x 57 BTU/min = <u>172 BTU/min Less Cooling</u>
- Smaller Coolers \rightarrow Smaller Fans (less power to drive)





ROI - Return on Investment

- Payback on Extra Cost Invested
 - Example from Previous:



Extra Cost of Components = \$2,000Savings in Operating Costs = $$1,280/yr^*$ ROI = $$2,000 \div $1,260 = 1.58$ yrs (1yr-7mos)

- Decision Point Varies by Company
 - 1 Year: "No Brainer, Just Do It!"
 - 2 Year: "Probably a Good Deal"
 - 3 Year: "Hmm...Let's Talk About it Some More"



*End User Sees the Savings, Need to consider machine value

Showing the Value Added

- Challenge:
 - How to Explain/Convince Tech Solutions
 to Non-Technical Decision Makers
 - Schematics Can Be... Boring
- Tools Available to Help Provide Information





Power on Demand (System Comparison)



Summary

- Challenges For Hydraulics Will Be Met
- Evaluate Complete System Picture
 - Technology Cost Can Offset Other Drivers
- Hydraulic Technologies Continuing To Evolve
 - Sophisticated Products And Control Options
 - Provide Improvements In System Performance (More Power To The Ground)
- EH Will Continue to Grow
 - Electronics Intelligence Hydraulic Brawn



