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Classification and Exchange of Industry Standards using OWL Ontologies

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Aibel is a leading service company within the oil, gas and offshore wind industries. We provide our customers with optimal and innovative solutions within engineering, construction, modifications and maintenance throughout a plant's entire life cycle. Aibel has used semantic technologies to support it's business since 2013, and since 2015 the Material Master Data (MMD) ontology and system has been in use for all capital projects. The MMD ontology is based on OWL 2 and uses ISO 15926-14 as upper ontology. Today, MMD consists of 370 domain-specific ontologies, defining a total of 200.000 classes. The Aibel/OntoCommons use case represents a potential future extension of the MMD ontology.

Representing industrial standards as OWL ontologies

Engineers rely heavily on industrial standards for the specification and design of all engineered artefacts. There is an enormous amount of such standards for materials, dimensions, safety, governmental requirements, and so on. Aibel uses OWL ontologies for organising standards, engineering designs and storehouse inventory. In this use case we translate material grade standards to OWL ontologies.

TABLE 2 Chemical Requirements ^A												
UNS Designa- tion ^B	Type ^c	С	Mn	Р	S	Si	Ni	Cr	Мо	Ν	Cu	Others
S31200		0.030	2.00	0.045	0.030	1.00	5.5-6.5	24.0-26.0	1.20-2.00	0.14-0.20		
S31260		0.030	1.00	0.030	0.030	0.75	5.5-7.5	24.0-26.0	2.5-3.5	0.10-0.30	0.20-0.80	W
												0.10-0.50
S31500		0.030	1.20-2.00	0.030	0.030	1.40-2.00	4.2-5.2	18.0-19.0	2.50-3.00	0.05-0.10		
S31803		0.030	2.00	0.030	0.020	1.00	4.5-6.5	21.0-23.0	2.5-3.5	0.08-0.20		
S32003		0.030	2.00	0.030	0.020	1.00	3.0-4.0	19.5-22.5	1.50-2.00	0.14-0.20		
S32101		0.040	4.0-6.0	0.040	0.030	1.00	1.35-1.70	21.0-22.0	0.10-0.80	0.20-0.25	0.10-0.8)
S32202		0.030	2.00	0.040	0.010	1.00	1.00-2.80	21.5-24.0	0.45	0.18-0.26		
S32205	2205	0.030	2.00	0.030	0.020	1.00	4.5-6.5	22.0-23.0	3.0-3.5	0.14-0.20		
S32304	2304	0.030	2.50	0.040	0.040	1.00	3.0-5.5	21.5-24.5	0.05-0.60	0.05-0.20	0.05-0.6)
S32506		0.030	1.00	0.040	0.015	0.90	5.5-7.2	24.0-26.0	3.0-3.5	0.08-0.20		W
												0.05-0.30
S32520		0.030	1.5	0.035	0.020	0.80	5.5-8.0	24.0-26.0	3.0-5.0	0.20-0.35	0.5-3.00	
S32550	255	0.04	1.50	0.040	0.030	1.00	4.5-6.5	24.0-27.0	2.9-3.9	0.10-0.25	1.50-2.5)
S32707		0.030	1.50	0.035	0.010	0.50	5.5–9.5	26.0–29.0	4.0–5.0	0.30–0.50	1.0	Co 0.5–2.0

Ontology patterns following ISO 15926-14 upper ontology

Material grades are represented as OWL individuals using a rich pattern for qualities and datums as described

Data input by domain experts using simple spreadsheets

Data is provided by SMEs using simple spreadsheets formats prepared by ontology experts.

	A	В	C	D	E	F	G	н	1	J	K	L	M	N	0	P	Q	R	S	T
1	Class ID		Chemical content by weight % a					as given in ASTM A790.			Note: there's a footnote in the standard f			or <u>Cev</u> more than 0,41 on		41 on thes	n these materials.			
2			Matr. no		С		Si		Mn		Ρ		S		N	9),	(Cu	
3	Subject	Label	Grade	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
4	X101211334	Super Duplex Grade 32750	32750		0.03			1		2	0.035	5	0.015	5 O.:	2 0.35	5 24	26	5		
5	X101211335	Super Duplex Grade 32760	32760		0.03			1		1	0.035	5	0.015	i 0.1	2 0.3	3 24	26	6 O.5	i :	1
6																				
7																				
8																				
9																				
10																				
I←	I ← I ← I ← I ← I ← I ← I ← I ← I ← I ←																			

Exploit ontology reasoning for discovering overlapping industry standard specifications

By reasoning over the OWL class representation we can discover relationships between different material grades and material grade standards.

Annotation properties		Datatypes Ind		5	≡					
Classes	Object properties	Data p	roperties		Annotations Usage					
Class hierarc	hy: ASTM A 790 Grade S3	2550 Compliant Ob	oject	? ×	Annotations: ASTM A 790 Grade S32550 Compliant Object	2 🗆 🗖 🗵 🗵				
14 G+ 🛛				Inferred 👻	Annotations 🕂					
V Owl:Thin ASTN V ASTN	g M A 790 Grade S32550 Cor M A 790 Grade S32750 Cor	mpliant Object mpliant Object			rdfs:label ASTM A 790 Grade S32550 Compliant Object	@ X O				
	STM A 790 Grade S39277 N 10216-5 Seamless tube ASTM A 790 Grade S327 M A 790 Grade S39274 Cor 0216-5 Seamless tubes: 1	Compliant Object s; 1.4501; X2CrNiM 60 Compliant Object npliant Object 1.4410: X2CrNiMoN2	oCuWN25-7-4 t 25-7-4	I						
O AS	STM A 790 Grade S39277	Compliant Object			Description: ASTM A 790 Grade S32550 Compliant Object	2 🛛 🗖 🔍				
V 0 El	N 10216-5 Seamless tube	s; 1.4501; X2CrNiM 60 Compliant Objec	oCuWN25-7-4 +	ļ	Equivalent To 🕂					
					(has-PCA_100003568-Of-CHEBI_18291-In-PCA_100004019 only xsd:decimal[<= 1.5]) and (has-PCA_100003568-Of-CHEBI_25555-In-PCA_100004019 only xsd:decimal[>= 0.1]) and (has-PCA_100003568-Of-CHEBI_25555-In-PCA_100004019 only xsd:decimal[<= 0.25]) and (has-PCA_100003568-Of-CHEBI_26833-In-PCA_100004019 only xsd:decimal[<= 0.03]) and (has-PCA_100003568-Of-CHEBI_27573-In-PCA_100004019 only xsd:decimal[<= 1]) and (has-PCA_100003568-Of-CHEBI_27594-In-PCA_100004019 only xsd:decimal[<= 0.04]) and (has-PCA_100003568-Of-CHEBI_28073-In-PCA_100004019 only xsd:decimal[>= 24]) and (has-PCA_100003568-Of-CHEBI_28073-In-PCA_100004019 only xsd:decimal[<= 27]) and (has-PCA_100003568-Of-CHEBI_28112-In-PCA_100004019 only xsd:decimal[<= 4.5]) and (has-PCA_100003568-Of-CHEBI_28112-In-PCA_100004019 only xsd:decimal[>= 4.5]) and (has-PCA_100003568-Of-CHEBI_28112-In-PCA_100004019 only xsd:decimal[<= 6.5])	?®×0				

by ISO 15926-14. The rich format is suitable for data exchange and further processing.



 $X101211334 \sqsubseteq \forall hasSpecifiedAmountOfNitrogenAsMassFraction_pst.\, xsd: double[\geq 0.2, \leq 0.35]$

Generated OWL class representation for classification

From the rich format, a simpler format that is better suited for OWL reasoning is generated. Material composition is represented using class restrictions on generated "shortcut" datatype properties.





Data transformation pipeline driven by Reasonable Ontology Templates (OTTR)

OTTR (http://ottr.xyz) is language and framework for representing and instantiating modelling patterns. We use OTTR to represent the modelling patterns as OTTR templates and use the OTTR framework to translate the spreadsheet data into different OWL representations:

Spreadsheet data —tabOTTR \rightarrow OWL ontology of material grades —bOTTR \rightarrow OWL ontology for classification

OTTR template representing a pattern for chemical composition: a:ChemicalComposition[ottr:IRI ?materialGrade, ? xsd:string ?materialLabel, ottr:IRI ?chemicalElement, xsd:decimal ?value, ottr:IRI ?physicalQuantity, ottr:IRI ?scale, ottr:IRI ?provenance, ottr:IRI ?range] :: { o-rdfs:ResourceDescription(?materialGrade, ?materialLabel, none, none, none), ottr:Triple(?materialGrade, p14:hasPhysicalQuantity, _:quantity), o-rdf:Type(_:quantity, ?physicalQuantity), ottr:Triple(_:quantity, p14:hasQuality, _:quality), ottr:Triple(_:quantity, p14:chemicallyDeterminedAs, ?chemicalElement), a:Datum(_:quantity, p14:qualityQuantifiedAs, ?provenance, ?range, none, none, ?value, ?scale)





Impact

- Benefits. The MMD ontology and system provide a significant increase in the quality of engineering data used for design and procurement in EPC projects. In particular, duplicate component types are completely eliminated, resulting in reduced ordering of incorrect components and better utilization of warehouse stock across projects.
- The Aibel/OntoCommons use case has the potential to further increase the business benefits gained from MMD by providing a more fine-grained break-down of the details of material grade definitions. This can be utilized to find overlap between grade definitions.
- Challenges/obstacles for utilization of semantic technologies are lack of tool support, scalability of ontology development, lack of proven work methods for collaborative ontology development.



OntoCommons - Ontology-driven data documentation for Industry Commons, has received funding from the European Union's Horizon 2020 research and innovation programme under **Grant Agreement no. 958371**