Additive Manufacturing
for Cold work tools?

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But what about the cold work tooling sector, is there a market for additive manufacturing also there?

With the increasing demands for light weight products, more and more advanced high strength steel sheets are being used. This places a higher demands on the tool steel used to punch, form and trim the sheet metal parts and also on the quality of the parts, so there are no burrs or stress concentrations that can risk the use and life of the produced part.

Could there be any use for additive manufacturing for this kind of tooling applications?

There are some important aspects to consider:

The most important property of a cold work tool steel is the good wear resistance. Wear resistance is usually achieved by a significant amount of carbides within a hardened microstructure. The formation of carbides is driven by specific alloying elements and controlled by the carbon content. Therefore, cold work tool steel grades are highly alloyed steel grades and have a high carbon content.

This high alloying content is making the cold work tool steels difficult to process within additive manufacturing. The main issue is caused by the high crack-susceptibility of these alloys during rapid solidification, as in welding, and that is why cold work tool steels are non-weldable materials which makes it hard for powder-bed AM technologies which are based on “welding principles” using a high energy beam for melting. In addition, segregation effects during solidification and subsequent heat treatments can lead to inhomogeneous distribution of carbides, which can lead to poorer wear properties and should be prevented.

This makes it hard to use such grades especially for laser-based AM and to be able to work which such grades normally pre-heating to quite high temperatures is needed, which can be a problem for AM with the most common laser powder bed additive machines.

However, using GE Additive Arcam’s electron beam melting (EBM) process offers new possibilities for the additive manufacture of cold work tool steels.

The GE Additive Arcam EBM ecosystem, Spectra H EBM system, powder handling and powder recovery solution.

EBM is a hot AM process were the electron beam can be used for both, for heating if it is defocused and for melting if it focused. This allows the possibility to control and keep the temperature during processing on a certain level to prevent crack formation.

In addition, EBM is a vacuum process and offers protection of the material and the powder against contamination. The precise process control secures the tight chemistry of the desired alloy is kept within its specification. High solidification rates during melting lead to a fine and homogenous microstructure which is necessary for both, carbide formation and distribution.

GE Additive Arcam EBM HT processing of Uddeholm Vanadis 4 Extra at 950°C

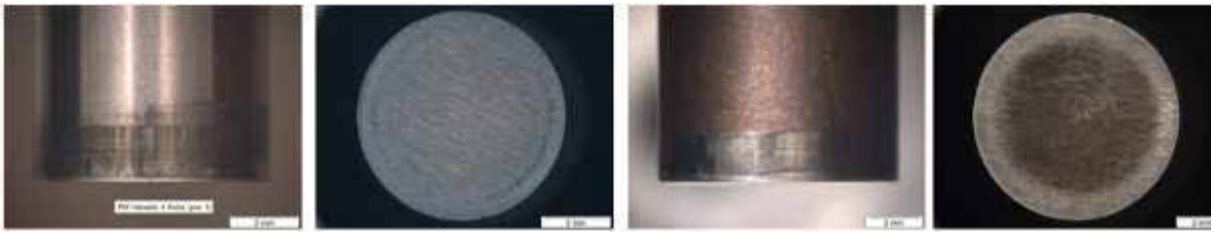
To unlock the potential of EBM for cold work tool steels, Uddeholm and GE Additive have developed the Uddeholm Vanadis 4 Extra powder material for EBM.

Uddeholm Vanadis 4 Extra Superclean is chromium-molybdenum-vanadium alloyed steel, originally developed as a PM-grade, has been modified and adapted to the EBM process. The excellent material properties of the PM version were kept and led to excellent wear resistance and good toughness, superior to traditional cold work tool steel such as D2.

By using the right conditions during EBM processing and subsequent heat treatments it is possible to achieve an hardened microstructure with fine dispersed vanadium carbides which gives excellent wear properties combined with a good toughness.

The hardness of the Uddeholm Vanadis 4 Extra reaches 64 HRC with a compressive strength of 2700 MPa, and a toughness of 20J.

The EBM processed material has also been tested in both punching and embossing operations where both the wear properties of the tool and the quality of the produced parts are very similar to the Vanadis 4 Extra PM-grade.



Comparision of wear of punches after 100 000 shots of CP1180 HD 1.5 mm sheet material,
Uddeholm Vanadis 4 Extra PM-grade to the left and EBM processed on the right

From a technical aspect are additive manufactured cold work tools performing at least as well as conventionally produced tools? What are the benefits?

As cooling is not required for cold work tool will they not benefit from the possibilities of making more complex designs and cooling channels. So the benefits come from elsewhere.

Some of the tools have a design that require extensive machining, where up to 75% of the material will be removed. For these parts using AM can save both time, cost and energy.

Processing route for EBM AM processing of V4E, starts with a CAD model, powder and a GE Additive EBM system

As material batches from steel mills normally is quite large and many cold work tools are quite small can the availability of the right material grade, in the right size, at the right time be tricky and for that can additive manufacturing be a good complement to the traditional tool making when the availability of raw material is a problem.

Instead of spending time chasing the right raw material, tying up capital and damaging cash flow, these tools can be printed with same properties as for the traditional tools.

So, there are definitely cold work applications where AM would be an interesting option and can be a competitive solution, both from a technology and a financial point of view.

Uddeholm Vanadis 4 Extra SuperClean is a chromium-molybdenum-vanadium alloyed steel which is characterized by:

- Very good ductility
- High abrasive-adhesive wear resistance
- High compressive strength
- Good dimensional stability during heat treatment and in service

Typical analysis	C %	Si %	Mn %	Cr %	Mo %	V %
	1,4	0,4	0,4	4,7	3,5	3,7

	Hardness, HRC	Unnotched Impact toughness, J	Compressive strength, MPa	Young modulus, GPa
EBM Processed	64	20	2700	225

Manufacturing solutions for generations to come

SHAPING THE WORLD®

We are shaping the world together with the global manufacturing industry. Uddeholm manufactures steel that shapes products used in our every day life. We do it sustainably, fair to people and the environment. Enabling us to continue shaping the world – today and for generations to come.

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