TALLINNA TEHNIKAKÕRGKOOL

Reio Kuusk

DETAILI ''HARK 5377/125 XL'' SURVEVALUVORMI PROJEKTEERIMINE JA TEHNOLOOGIA

LÕPUTÖÖ

Mehaanikateaduskond

Masinaehituse eriala

Tallinn 2010

SISUKORD

EESSÕNA

Masinaehitus on strateegiline ja pikkade traditsioonidega tööstusharu, millest sõltuvad paljud teised eluvaldkonnad. Tegemist on suure lisaväärtusega teadusmahuka valdkonnaga, mis varustab kõiki teisi majandusvaldkondi masinate, tootmissüsteemide, komponentide, nimetatud toodetega seotud teenuste ning vajaliku tehnoloogia ja erialaste teadmistega. Masinaehitus annab olulise panuse ka jätkusuutlikusse aregusse, sest võimaldab tõhusamat tootmist ning seeläbi ressursside kasutamise lahtisidumist majanduskasvust.

Euroopa Liidu arvele langeb peaaegu pool maailma toodangust, Euroopa on on maailma suurim masinate tootja ja eksportija. Euroopa masinaehitus on maailmas juhtpositsioonil.

Masinaehitustööstuse üks olulisemaid valdkondi on survevaluvormide valmistamine plastitööstustele. Survevaluvormide valmistamise protsess on aeganõudev ja täpne töö. Survevalu suur tootlikus ja vormide pikk eluiga seavad vormitootjatele ette täpsed ja kindlad nõuded vormide valmistamiseks. Detailide kvaliteet ja vastavus nõuetele sõltub vormitootja professionaalsusest, millest omakorda selgub konkurentsivõime antud valdkonnas.

Lõputöös on kirjeldatud survevaluvormi projekteerimise käik ja käsitletud erinevaid probleeme, millega puutuvad kokku konstruktor ja tehnoloog ning kuidas on lahendatud survevaluvormi templi valmistamise tehnoloogia.

Töö eesmärgiks on luua ülevaade survevaluvormi konstruktsioonist ja templi valmistamise tehnoloogiast. Tootele "Hark 5377/125 XL" on esitatud tellija poolt rida nõudmisi, millele tuleb survevaluvormi valmistamisel tähelepanu pöörata. Vormide valmistamise juures on kujunenud välja teatud võtted ja iseärasused, mida ilma praktilise kogemuseta ei ole võimalik kindlaks määrata. Paraku ei pea teoreetilised tõekspidamised alati paika ja nii on ka antud töö puhul võimalik paralleelina välja tuua erinevaid töötlemise võimalusi.

SISSEJUHATUS

Antud lõputöö teema on valitud koostöös Osaühinguga Sumar Tools. Ettevõte on asutatud 1991. aastal ja kuulub 100 % erakapitalile. 50 % osakapitalist kuulub Saksa eraisikule ja teine pool Eesti eraisikule. Põhitegevus on survevaluvormide, stantside ja rakiste projekteerimine ning valmistamine. Enamus toodangust eksporditakse Soome, Rootsi, Taani ja Saksamaale. Ettevõte omab ISO 9001:2000 sertifikaati. 2010 aasta seisuga töötab firmas 27 inimest.

Ettevõtte 2009 aasta müügitulu oli umbes 21 miljonit krooni ja sellest kasum 1,2 miljonit krooni.

Lõputöös on toodud ülevaade töödest, millega puutuvad igapäevaselt kokku konstrukorid, tehnoloogid ja tootmisjuht. Töö koosneb sissejuhatusest, valmistatava detaili analüüsist, kasutatava survevalumasina kirjeldusest, survevaluvormi konstrueerimisest ja projekteerimisest, templi valmistamise tehnoloogiast, majanduslikust osast, kokkuvõttest ja lisadest.

Antud toote puhul kasutatakse külgtemplite või külgmatriitsidega vormi, kuna toode on keerulise geomeetriaga.

Allpool on toodud välja mõningad tellija poolsed nõudmised vormi valmistamisel (vt lisa 2):

Valumasin:	Arburg 570 C 2000 kN
Toode:	Fork 5377/125 XL (TENTE-Rollen GmbH)
	PA 6 GF 40 Akulon K224PG8/kahanemisega 1,1 %
Pesade arv:	1
Moodustatavad pinnad:	Templi- ja matriitsplaatide materjal Orvar Supreme, eelkarastatud kõvaduseni HRC 56...58
Jahutus:	Jahutuskanalid läbimõõduga Ø 10 mm
	Jahutusniplid DME-Reform-EOC St 11 13- M14x1.5
Toide:	Kuumkanal Dura Deci (Mold-Master)
Valupuks ja tsentreerimine valamisel:	Valupuks raadiusega R 40 mm, äärik läbimõõduga Ø 125 mm

1. DETAILI ANALÜÜS

1.1. Analüüsi eesmärk ja alused

Planeeritava tegevuse eesmärk on analüüsida detaili "Hark 5377/125 XL" erinevaid näitajaid ja saadud tulemuste põhjal valida survaluvormi töömeetod, vormis suurus, jahutussüsteem ja materjalid vormi valmistamiseks. Detaili analüüs sisaldab:

- määrata detaili maht
- detaili mahu jargi määrata vormi suurus
- määrata lahutuspinnad
- määrata materjali omadused
- hinnata detaili kuju ja mõõtmeid

[1: 8-9]

Detaili valmistusmaterjaliks on konstruktsioonipalst Polüamiid PA 6 GF 40 Akulon K224PG8 (vt lisa 1). Materjal saadakse diamiinide ja orgaaniliste dihapete polükondensatsioonireaktsiooni tulemusena. Polüamiidid ehk nailonid on väga tugevad ja kõvad materjalid ning neil on hea abrasiivkulumiskindlus. Lisaks on nad elastsed ja kõrge löögisitkusega, kemikaali- ja lahustikindlad, kuid tundlikud fenoolide suhtes. Materjali probleemideks on suur kristallumisest tingitud mahukahanemine ja järelkahanemine toatemperatuuril.

Polüamiid PA 6-l on suurim veeimavusvõime kõigist polüamiididest. Antud materjali anorgaaniliseks täiteaineks on grafiit. Täiteained suurendavad plastide tugevust ja muudavad nad odavamaks. Polüamiidi PA 6 GF 40 Akulon K224PG8 omadused ja töötemperatuurid on järgmised:

- Plasti sissesurve temperatuur 220....280°C
- Tihedus g = 1,43 g/cm^3
- Kahanemine 0,25 - 1,1 %
- Survepinge 110…170 N/mm^3
- Katkevenivus 4,5...8,5 %
- Erisoojus 2,08 kJ/(kg*K)

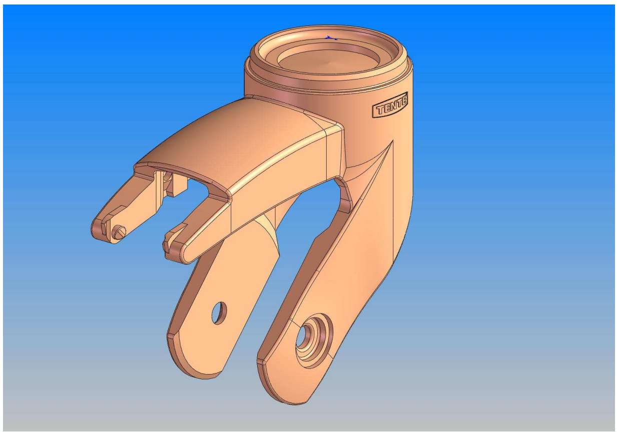
[2: WWW]

Vormi suuruse määramisel on vajalik selgitada välja detaili maht. Valuvormi maksimaalsed mõõdud sõltuvad lisaks:

- valumasina mõõtudest, millega on määratud plasti ühe sissepritse suurus, s.o sulaplasti hulk, mis pressitakse vormi valusõlme käigukruvi ühe käiguga
- ühe tsükli jooksul plastifitseeritava plasti mahust
- valumasina poolte survejõust, mis võtab vastu vormis protsessi käigus tekkiva surve
- valumasina juhtsammaste vahelisest kaugusest

1.2. Detaili ''Hark 5377/125 XL'' analüüs

Detail "Hark 5377/125 XL" on oma mõõtmetelt suur, keerulise konstruktsiooniga ja paksuseinaline, seetõttu tuleks arvestada materjali kahanemist (vt joonist 1). Igale materjalile antakse teatud kahanemise protsent. Et saadav toode oleks nõutud mõõtmetega ja hälbed lubatud tolerantside piires, peab tempel ja matriits olema suurema või väiksema mõõduline.



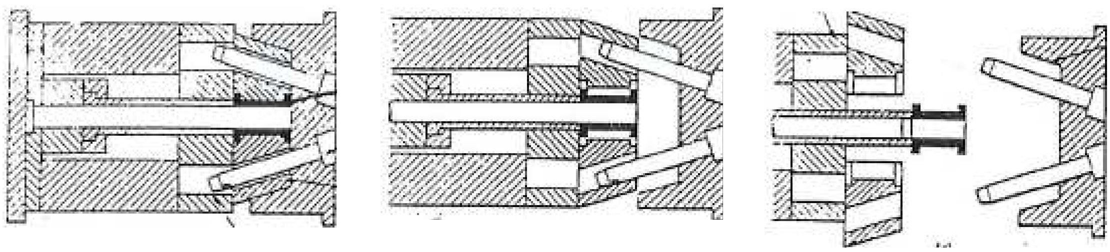
Joonis 1. Detail "Hark 5377/125 XL"

Detaili erinevate osade kahanemine sõltub detaili geomeetriast ja survevalu parameetritest. Konkreetse detaili seinapaksusi arvestades on oluliseks ohuks kahanemislohkude tekkimine, mis mõjutab detaili välisilmet ja mõõtmeid.

Antud detail on keerulise geomeetriaga ja tellija poolt on esitatud rida nõudmisi mõõtude tolerantsidele. Vastavalt sellele teostatakse arvestus materjali kahanemisele 0,5 %. Valitud protsent rahuldab tootele esitatud nõuded ja seetõttu ei ole vaja pesade täiendavat mõõtmete muutmist teha, et kompenseerida erinevaid kahanemisi detaili eri osades.

Plasti surumisel pesasse voolab see ümber takistuste ja seejärel saavad eraldunud plasti voolud uuesti kokku ning seal tekib detailile liitejoon, kuna sulaplast ei suuda enam täielikult ühineda. Liitejooned on olulised detaili nõrgestavad elemendid, nende asukohta saab määrata sisselaske asukoha ja toitekanali tüübi valimisega. Liitejoone asukoht tuleb valida nii, et see avaldaks minimaalset mõju detaili omadustele.

Antud detaili valmistamiseks peab kasutama kaldsammastega valuvormi, kuna avad ja taskud ei asu lahutuspinnal (vt joonist 2). Külgmatriitsid või tempel saavad liikumise kaldsammastelt ja liiguvad vormi avanemissuunaga risti ning peavad olema pesast eemaldatud enne valandi väljatõukamist.



Joonis 2. Kaldsammastega valuvormi tööpõhimõte

[3: WWW]

Detaili analüüsi üheks olulisemaks punktiks on valatava detaili mahu määramine, et saada vormi sissepritsitava materjali maht. Summeerides detaili mahu ja kanalisüsteemimahu saadakse sissepritsitava materjali kogus. Vormi mahu järgi valitakse survevalumasin, mille parameetrid on piisavad vormi täitmiseks. Vormi mahu teada saamiseks on vaja detaili maht välja arvutada. Antud detaili prototüüp on olemas ja seega teatakse detaili massi, mis on 122,5 grammi. Materjali tihedus on 1,43 g/cm^3(vt. lisa 1). Jagades detaili massi ja materjali tiheduse saadakse detaili maht, mis on 85,67 cm^3.

2. KASUTATAVA SURVEVALUMASINA PARAMEETRID

Termoplastide levinum töötlemismeetod on survevalamine. Iga toote jaoks projekteeritakse spetsiaalne survevaluvorm. Valuvorm koosneb enamasti kahest vormipoolest, liikuvast ja liikumatust, millised on kinnitatud survevalumasina külge.

Survevalumasina valik sõltub otseselt sulatusprotsessi tootlikkusest. Plastmassi sulatamise tootlikkus (kg/h) peab vastama tunni jooksul valatavate toodete kogumassile.Liiga madal tootlikkus pikendaks valutsükli aega. Liialt kõrge tootlikkuse puhul pikeneb plastmassi kuumutussilindris oleku aeg ja sellega on seotud risk, et tekib plastmassi termolagunemine.

Termolagunemine halvendab plastmassi mehaanilisi ja keemilisi omadusi. Ideaalne on variant, kus sulatatava plastmassi mass ületab 20...30 % detaili massi.

Tellija soovis, et projekteeritaks selline vorm, mis sobiks kasutamiseks survevalumasinal Arburg 570 C 2000 kN (vt joonist 3). Antud masin on valmistatud Saksamaal Arburgi tehases.

Joonis 3. Survevalumasin Arburg 570 C 2000kN

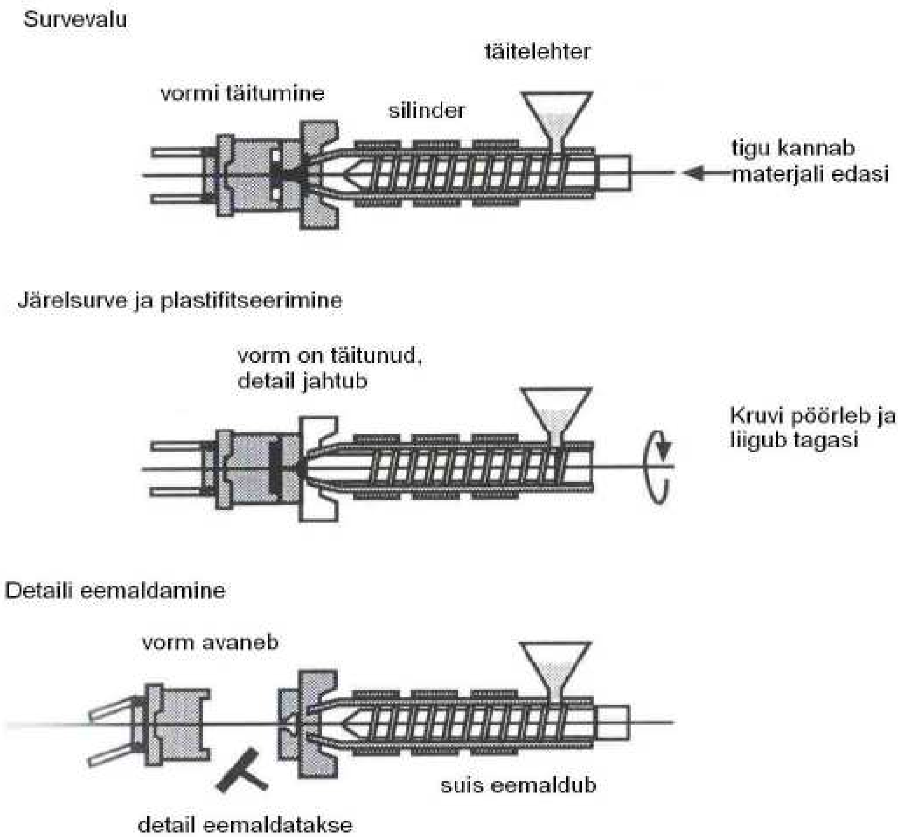
[4: WWW]

Survevalumasina põhiparameetrid:

- maksimaalne sissesurutava plasti maht 474 cm^3
- kinnisurumisjõud 2000 kN
- pingi vertikaalsuunaline juhtsammaste vaheline kaugus 950 mm
- horisontaalsuunaline juhtsammaste vaheline kaugus 700 mm
- plasti sissepritsesurve 2470 bar
- avamiskäik 650 mm

Vormi kogumaht on 85,67 cm^3 ja minimaalne kinnisurumisjõud 790 kN vastavalt arvutustele (vt punkti 3.2). Vormi külgede mõõtmed on 496x296 millimeetrit, avanemiskäik 155 millimeetrit (vt punkti 3.3). Nendest andmetest järeldub, et need näitajad on kõik väiksemad, kui survevalumasina parameetrid, mistõttu saab seda vormi esitletud pingis ekspluateerida.

Survevaluprotsessi tööpõhimõte koosneb kolmest etapist (vt joonist 4).



Joonis 4. Survevaluprotsessi tööpõhimõte

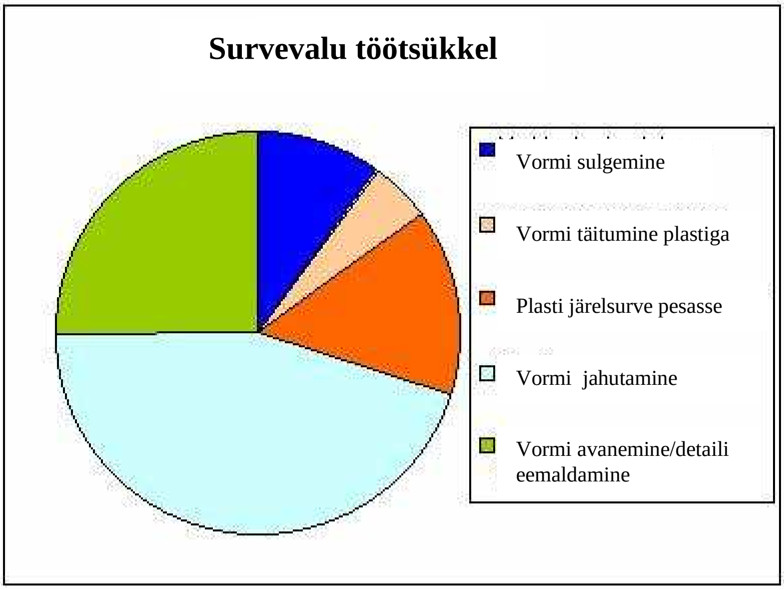
[5: WWW]

Esimeses etapis toimub vormi täitumine, mille jooksul survevalumasina sulgemissõlm on vormi pooled tihedalt sulgenud nii, et sulaplast ei saaks tungida vormipoolte vahele. Silindris kuumutamise (100...270°C) ja pöörleva teoga tekitatud rõhu (50...400 MPa) toimel muutub termoplast voolavaks. Kuumutatud valusõlm liigub oma suulisega tihedalt vastu vormi valupuksi ja pressib sulaplasti läbi valukanali survevaluvormi. Tiguvõllis olev sulgurrõngas takistab materjali tagasivoolu vormist silindrisse. Silinder lõpeb suulisega, mille abil saab reguleerida plasti voolu hulka valukanalite süsteemi.

Teises etapis toimub plastifikatsioon ja surve hoidmine koos plasti lisamisega, et kompenseerida vormis tahkuva plasti kahanemise tõttu valandi mahu vähenemist. Vormi surutud kuum materjal tardub jahtudes (vormi temperatuur 30...80°C) ning omandab vormipesa kuju. Survet hoitakse valandi tahkumiseni, samal ajal toimub järgnevaks tsükliks vajaliku plasti plastifikatsioon.

Viimases etapis toimub väljatõukamine, kui valand on piisavalt tahknenud (survevaludetail kõveneb vormis suurusest olenevalt 20...120 sekundit). Vorm avaneb oma lahutuspinnalt nii, et valand ja valukanalite jäägid jäävad vormi liikuva poole külge. Valumasina piiraja käivitab valuvormi tõukurite süsteemi, tõugates valandi välja.

Igal etapil on kindel aeg operatsiooni sooritamiseks. Joonisel 5 on näha kogu vormimise tsükkel ja kujundlikult ajad, mis kuluvad iga etapi läbimiseks.



Joonis 5. Survevalu töötsükkel

[6: WWW]

3. VORMI PÕHIPARAMEETRITE MÄÄRAMINE

3.1. Pesade arvu määramine

Pesade arv on määratud kindlaks tellija poolt, kes on eelnevalt enda jaoks arvutanud välja vajaliku pesade arvu. Antud vormi valmistamise juures arvestatakse ühe pesaga, kuna detail on suhteliselt suur ja keerulise geomeetriaga. Mitmepesalise vormi valmistamise ei ole otstarbekas, kuna vormi mõõdud ja kaal lähevad suureks ning vormi valmistamine kallimaks. Omakorda muudab see vormi transportimise ja seadistamise pressile aeganõudvaks.

Vormi pesa maht on 85,67 cm^3 ja see on ka kogu vormi maht, kuna tegemist on ühepesalise vormiga, millel puudub valukanalite süsteem. Antud vormi puhul kasutatakse ketastoitekanalit. Antud toitekanali eeliseks on see, et puuduvad külmliitejooned, sest pesa täitumine toimub ühtlaselt. Puuduseks võib lugeda seda, et hiljem on vajalik toitekanal eemaldada.

Survevalumasina sissepritse silindri maht on 474 cm^3, millest piisab vormipesa täimiseks.

3.2. Kinnisurumisjõu arvutus

On mitmeid tegureid, mis mõjutavad vormipoolte kokkusurumisjõudu – valandi projektsioonpind, detaili paksus, kanali pikkus, sissepritsimise rõhk ja sissepritsimise kiirus. Minimaalne kinnisurumisjõud saadakse vastavalt pesa rektiivjõudu arvestades, mis tuleneb pesa ja kanali projekteeritud pindalast ja maksimaalsest survejõust.

$$F = A \times p \qquad [7: 260]$$

kus A - pesa pindala cm^2;

p - sissepritse surve bar.

Pesa projektsiooni pindala A=~32 cm^2, valumasina sissepritsesurvejõud p=2470 (24700 N/ cm^2).

Kasutades valemist $F = A \times p$ saame, et $F = 32 \times 24700 = 790kN$

Kuna minimaalne kinnisurumisjõud 790<2000 kN, siis vorm on sobilik antud näitajate poolest valitud survevalumasinale Arburg 570 C 2000 kN.

3.3. Avamiskäigu määramine

Avanemiskäigu pikkuse määravad ära detaili ja sisselaskekoonuse mõõtmed. Avanemiskäik ei tohiks olla liiga pikk, kuna sellest sõltud tsükliaeg. Pikk tsükliaeg tõstab detaili oma hinda.

Antud vormi puhul puudub pikk sisselaskekoonus, kuna on kasutatud spetsiaalset kuumutatavat sisselaskesüsteemi, milles hoitakse plast kindlal temperatuuril. Detaili enda kõrgus on 123 millimeetrit ja järelikult on avanemiskäik 123 millimeetrit. Kuid tavaliselt ei kasutata minimaalset avanemiskäiku vaid võetakse suurem, sest kui detaili vormist välja lükatakse, siis võib juhtuda, et see vajub viltu ja jääb vormi vahele kinni. Soovituslikuks minimaalseks avanemiskäiguks võetakse 155 millimeetrit.

3.4. Vormi mõõtmete määramine

Vormi gabariitmõõtmete määramise aluseks võetakse vormi moodustavate detailide andmed ja tellijapoolne informatsioon (vt. lisa 2). Antud vormi puhul on tellija esitanud täpse informatiooni, mida tuleb hoolega jälgida. Andmete muutumisel konsulteeritakse ja lepitakse muutused tellijaga kokku.

Vormi mõõtmete määramisel analüüsitav informatsioon on järgmine:

- detaili mõõtmed ja maht
- detaili paigutus vormis
- jahutuskanalite mõõdud ja paigutus
- tõukurite, sammaste ja pukside mõõtmed ning paigutus

Vormiplaatide paksuse määramisel tuleb arvestada töötsükli ajal esinevaid jõude, mis mõjuvad plaatidele. Antud vormi plaatide paksused on määratud nende funktsioonidest (pesa sügavus, jahutuskanalite paigutus jne.).

Tellija nõudel peab antud vorm olema ühe pesaline. Detail on oma kujult keerulise konstruktsiooni ja geomeetriaga. Vastavalt detaili asetusele vormis on survevaluvormi tüüp kaldsammastega ja vajab nii templi, kui matriitsi jahutamist. Kuna detail on suhteliselt väikese ristlõikepindalaga, ei ole plaatide arvutust deformatsioonile läbipaindel vaja arvutada.

Vormi gabariitmõõtmeteks on 496x296 millimeetrit. Mõõtmed sõltuvad survevalumasina juhtsammaste vahelistest mõõtmetest. Kui antud mõõtmeid ei jälgita, siis vorm ei pruugi mahtuda valumasina juhtsammaste vahele. Plaadid valitakse firmalt Meusburger.

Kõikidel plaatidel on oma tootekood, mille järgi on neid võimalik üksteisest eristada ning kindlaks teha, mis materjalist nad on. Kõikide kasutatud detailide nimetused ja koodid on toodud survevaluvormi tükitabelis (vt lisa 24) ja firma Meusburger kodulehel.

[8: WWW]

Survevalumasina juhtsammaste vahelised mõõdud ja plaatide kinnitusmõõdud on näha masina tehnilistes andmetes firma kodulehel.

[4: WWW]

4. VORMI STANDARDOSADE MÄÄRAMINE

Vormi standardosadeks on tõukurid, sambad, puksid, poldid, hülsid, aaspolt, tihendid, väljatõukajad, jahutussüsteemi osad jne.

Vormi standardosade valikul lähtutakse tellija nõuetest, kuid juhul kui neid nõudeid pole, siis lähtutakse valikul vormi suurusest ja standarditest ning majanduslikust põhimõttest. Standardosad valitakse etteantud standardmõõtmete hulgast. Juhul, kui on vaja näiteks kindla mõõduga tõukurit, siis töödeldakse vastavalt vajalikule mõõdule. Antud juhul valitakse osad firma Meusburger kataloogist.

[8: WWW]

5. PESA ASETUS VORMIS JA MÕÕDUD

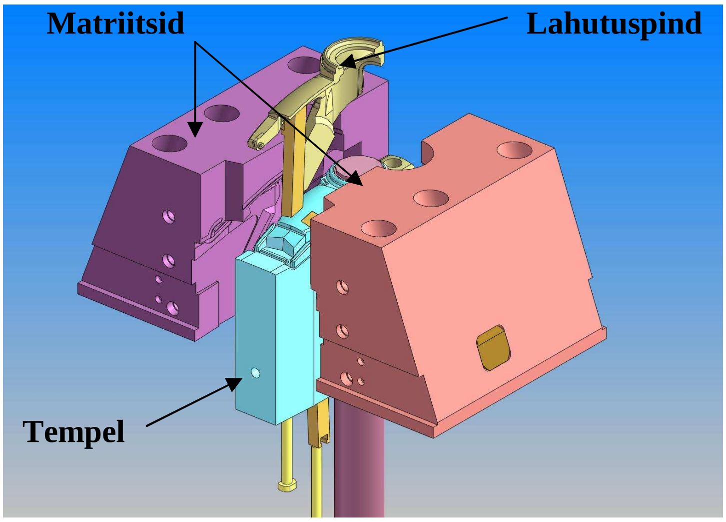
5.1. Pesa asetuse määramine

Tootele tuleb leida selline asend, et teda oleks võimalik eraldada vormist võimalikult lihtsalt, vigastamata seejuures toote pinda ja kuju. Pesa peab olema vormis paigutatud nii, et pesa täitumine sulamassiga toimuks üheaegselt. Pesa paigutus vormis määrab ära vormiploki suuruse, tööpõhimõtte ja seal esinevate jõudude asetuse. Pesa paigutatakse vormi sümmeetriliselt vormi tsentrite suhtes.

Antud detail paigutatakse vormi keskele vertikaalselt ja kasutatakse kaldsammastega survevaluvormi, Vormi sulgedes liiguvad külgmatriitsid kokku moodustades vormipesa. Matriitside keskele jääb tempel. Templi sees asetsevad tõukurid, mis tõukavad detaili pärast valutsüklit vormist välja. Külgmatriitsid saavad liikumise kaldsammastelt. Antud vormi puhul kasutatakse tehnoloogilisi kaldsambaid, milliste mõõtmed võltuvad valandi vabastamiseks vajalikust jõust ja külgmatriitside kaalust. Vormi täitmiseks kasutatakse ketastoitekanalit.

5.2. Lahutuspindade määramine

Lahutuspindade määramisel tuleb arvestada detaili geomeetriat ja erinevaid tasapindu ning seejärel leitakse kõige ratsionaalsem asend lahutuspinna suhtes. Detaili asendist lahutuspinna suhtes sõltub vormi keerukus ja tehnoloogilisus olemasoleva pingipargi juures. Detaili "Hark 5377/125 XL" valmistamiseks kasutatakse ühte lahutuspinda horisontaalsuunal. Lahutuspinna moodustavad külgmatriitsid, mis sulgevad vormipesa (vt joonist 6).



Joonis 6. Detaili Hark lahutuspind

5.3. Pesa mõõtmete määramine

Pesa mõõtmete määramisel tuleb lähtuda detaili mõõtudest, valukalletest ja materjali kahanemisest. Kuna tellija nõutud materjali kahanemine on 0,5 %, siis tuleb arvesse võtta seda, et soovitud mõõtudega detaili saamiseks korrutatakse toode kahanemisprotsendiga, mille tulemusena muutuvad detaili mõõdud kahanemise võrra suuremaks. Kogu arvutuse protsessi viib läbi SolidWork tarkvara programmis olev vastav käsklus.

Täielikult jahtunud detailil on 0,5 % väiksemad mõõtmed kui pesal ning detail on võtnud nõutud mõõtmed.

[6: WWW]

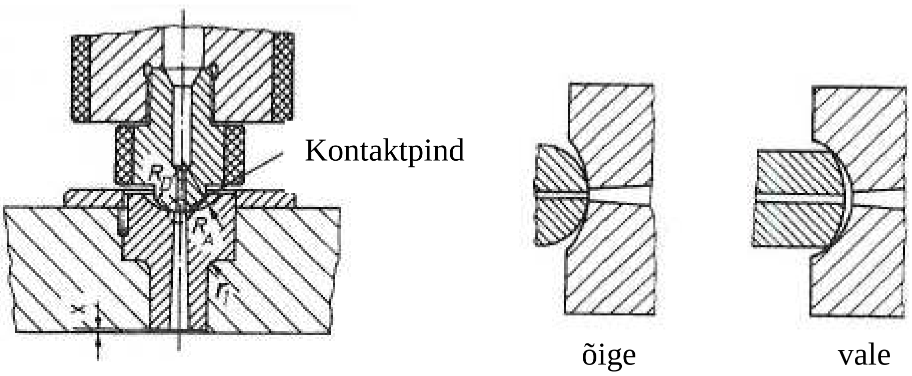
6. VALUSÜSTEEMI PROJEKTEERIMINE

Valusüsteemi moodustavad valukanal, toitekanal ja suubumispuks. Valukanalite süsteem juhib valumasina suulisest saabuvat sulaplasti vormi pesasse. Oma geomeetria, mõõtmete ja vormi pesasse suubumise viisiga mõjutab ta oluliselt vormi täitumise protsessi ja detaili kvaliteeti. Antud juhul on tegemist ühepesalise vormiga, millel puudub valukanalite süsteem.

6.1. Valupuks

Valusüsteemi esimeseks elemendiks on valukoonus, mis moodustatakse valupuksis. Peale vormi sulgemist surutakse masina suuline vastu vormi valupuksi, nii et sulaplast saaks voolata valupuksi. Nende omavaheline ühendus peab olema nii tihe, et takistada materjali vahelejooksu.

Vahelejooksu on võimalik vältita, kui valupuksi kontaktpind valitakse suurema raadiusega sfääriline pind. Et vältida tõkise tekkimist suulise ja valupuksi kontaktpinnal, tuleks tagada järgmised tingimused (vt joonist 7):



Joonis 7. Valumasina suulise ja valupuksi sfääriline kontaktpind

[3: WWW]

$$R_D + 1 < R_A \qquad [1: 160]$$

kus R_D - suulise sfääri raadius mm;

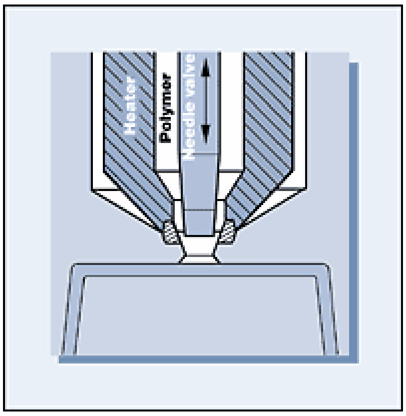
R_A - valupuksi sfääri raadius mm.

Antud juhul on vastav tingimus täidetud:

$$R_D + 1 < R_A = 35 + 1 < 40$$

Valupuksi raadius antakse ette tellija poolt, kuna see peab sobima tellija valumasinaga.

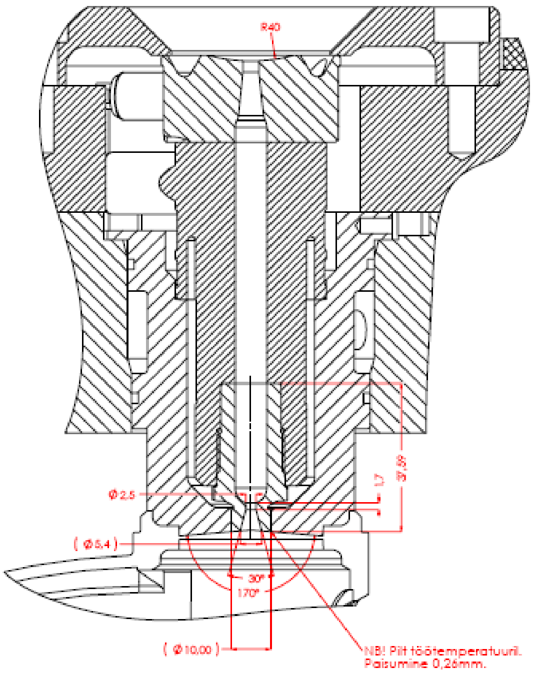
Antud süsteemi puhul kasutatakse kuumakanaliga täitesüsteemi, mis on antud ette tellija poolt. Kasutatakse firma Mold-Master Dura Deci tüüpi väliselt kuumutatavat kuumakanali süsteemi (vt joonist 8).



Joonis 8. Väliselt kuumutatav kuumakanali süsteem

[9: WWW]

Süsteemil on siseneval poolel puksi raadius R 40 millimeetrit ja väljuval osal raadius R 2,5 millimeetrit kaldega 30° (vt joonis 9). Kuumakanali süsteemis hoitakse plast kogu survetsükli vältel voolamistemperatuuril. Antud süsteemi kasutatakse keeruliste detailide valmistamise juures. Väliselt kuumutatav kuumakanali süsteemis on plast homogeensem ja on väiksemad rõhukaod võrreldes seestpoolt kuumutatava süsteemiga.



Joonis 9. Mold-Master Dura Deci kuumakanali süsteem

6.2. Suubumis- ehk toitekanal

Tegemist on ühepesalise vormiga, millel puudub valukanalite süsteem. Kuumakanalist liigub sulaplast otse edasi toitekanalisse. Toitekanal töötab drosselina, ning peab olema rõhutatult õhema ristlõikega, et lihtsustada valandi eraldumist peatoitekanalist ehk kuumakanali süsteemist. Toitekanal peaks olema kohas, kus valand ei deformeeruks ja oleks vähenähtav.

Antud detaili valmistamiseks kasutatakse ketastoitekanalit. Ketastoitekanalit kasutatakse, kuna antud süsteemi puhul toimub pesa ühtlane täitumine kogu ristlõike ülatuses, puuduvad külmliitejooned ja valandil on hea mehaaniline tugevus. Hiljem on vajalik toitekanali eemaldus detaili küljest (vt joonis 10).

Joonis 10. Ketastoitekanal

[10: WWW]

7. VORMI VENTILEERIMINE

Vormi täitumisel pressitakse sulaplast surve all vormipesasse, mis tõrjub välja sinna kogunenud õhu. Kui õhk ei saa väljuda on vormi täitumine takistatud ja kokkusurutud õhk võib kuumeneda (300°....400°C), jättes valandi servadele või nurkadesse tumedad põletuse plekid. Vormi ventileerimine sõltud valandi kujust ja asetusest vormis ning toitekanali tüübist. Kahjustuste vältimiseks tehakse ventileerimiskanalid, et juhtida üleliigne õhk vormi pesast välja. Kanalid tehakse võimalikult kaugele sisselaskesüsteemist. Antud juhul kasutatakse ketassisselaset ja vormipesa täitub üheaegselt, seega freesitakse ventileerimiskanalid pesa kaugemasse otsa, kuna kaugemas otsas on õhu välja pääsemisega raskusi. Rohkem kanaleid ei freesita, kuna vorm koosneb paljudest detaili moodustavatest elementidest ja väljalükkajatest, siis nende avade ja lahutuspindade kaudu pääseb õhk vormist välja.

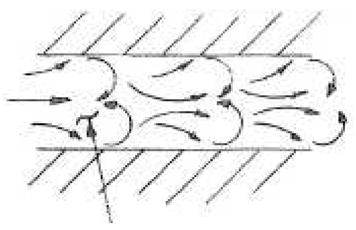
[7: 307]

8. JAHUTUSSÜSTEEMI PROJEKTEERIMINE

8.1. Jahutussüsteemi tüübi määramine

Jahutussüsteemi eesmärk on valandile kuju andmise järel pesasse voolanud sulaplast jahutada kiiresti ja ühtlaselt. Jahutamine mõjutab oluliselt valandi mahulise kahanemise kulgemist, toote mehaanilisi omadusi ja kujumuutusi. Ühtlane jahutamine on vajalik toote kvaliteedi tagamiseks. Jahutamise kiirusest sõltuvad majanduslikud näitajad, kui toimub kiire jahutamine, siis on omakorda ka tsükliaeg väiksem.

Ühtlase jahutamise tagamiseks peab jahutuskanalid paigutama tihedalt ümber vormi pesa. Jahutussüsteemi tüübi valik sõltub vormi ehitusest, detaili kujust ja mõõtmetest. Jahutuskanalid puuritakse või freesitakse. Kanalitel peab olema suur pinnakaredus, et tagada jahutusvedeliku turbulentne voolamine (vt joonist 11). Turbulentne voolamine tagab parema soojusvahetuse.

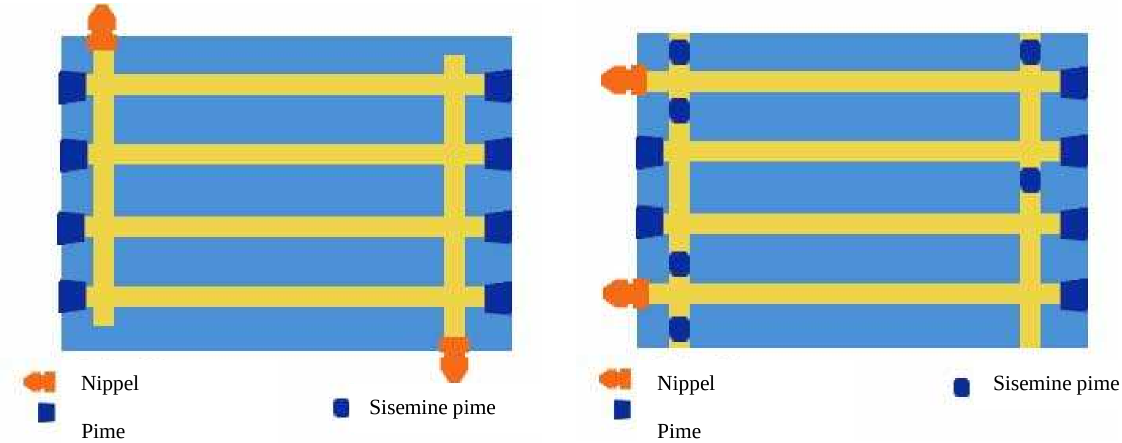


Turbulentne voolamine

Joonis 11. Turbulentne voolamine jahutuskanalis

[3: WWW]

Jahutuskanalite tihe paigutus ja jahutusvedeliku turbulentne voolamine optimaalse kiirusega ümber valuvormi pesa tagab pesa kvaliteetse jahtumise vormis. Kasutatakse paralleelset või järjestikulist jahutussüsteemi (vt joonist 12).



Joonis 12. Paralleel ja järjestikuline jahutussüsteem

[11: WWW]

Antud vormi puhul kasutatakse templisse ja matriitsidesse puuritud jahutusvõrku. Kanalid tuleks paigutada nii, et nad omavahel ühinedes moodustaksid ühtse veevõrgu. Kanalite otstesse tuleb paigaldada tellija nõuetele vastavad niplid, et ühendada vorm jahutussüsteemiga.

8.1.1. Jahutuskanali asukoha määramine

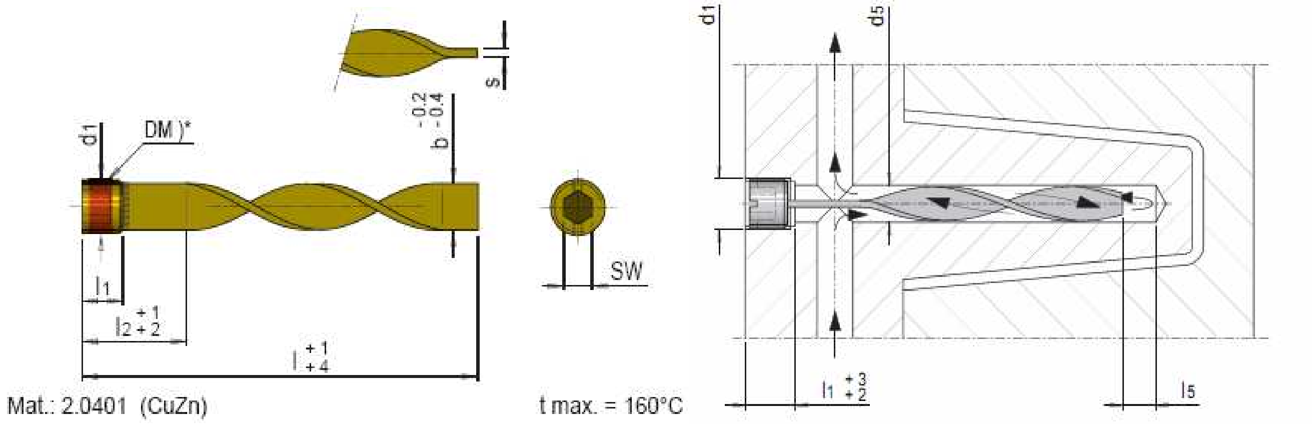
Antud vormi puhul jahutatakse nii matriitse, kui templit. Matriitsidesse puuritakse kanalite võrgustik, mis ühendatakse vormi plaadis oleva jahutuse süsteemiga. Kanalite asukoha määramisel tuleb arvestada mitte ainult pesa paigutust, vaid ka tõukurite, templite, sammaste, pukside jne. paigutust. Templit jahutatakse seespoolt, kuhu puuritakse samuti kanalid ning mis ühendatatkse alumise vormiplaadiga. Templi sisse asetatakse eraldi torutõukur, kus sees on samuti jahutuskanal. Torutõukuri sisse paigaldatakse pronksist jahutusvedeliku suunav spiraal (vt. joonist 13). Spiraal suunab jahutusvedeliku templi tippu, et toimuks efektiinve jahutus detaili seestpoolt. Jahutust saab veelgi kiirendada kasutades kõrge soojusjuhtivusega materjale, nagu näiteks berülliumpronksi.

8.1.2. Jahutuskanalite ristlõikekuju ja mõõtmete määramine

Antud vormi puhul kasutatakse ringikujulise ristlõikega jahutuskanaleid. Ringikujulise ristlõikega kanali eeliseks on see, et neid on lihtsam töödelda ja vedeliku voolu takistus on väiksem.

Jahutuskanali läbimõõt valitakse vastavalt detaili gabariitmõõtmetele ja mahule nii, et see suudaks valutsükli ajal tekkinud soojushulka vormist ja täitematerjalist välja viia. Kanalite pikkused sõltuvad pesa asetusest vormis.

Konkreetse vormi puhul võetakse jahutuskanalite läbimõõduks vastavalt tellija nõudmistele 10 millimeetrit.



Joonis 13. Jahutussüsteemi spiraal ja tööpõhimõte

[8: WWW]

9. TEMPLI PROJEKTEERIMINE

9.1. Templi kuju määramine

Tempel moodustab detaili sisemise osa. Templi kuju määratakse vastavalt detailiosa kujule, mille ta moodustab. Templi kinnitamiseks moodustatakse spetsiaalne tald, kuhu tempel kinnitub. Templi kuju sõltub detaili geomeetriast, paigutusest vormis, lahutuspindade asukohast ja vormi üldisest tööpõhimõttest. Antud detaili valmistamise juures moodustab tempel detaili sisemise osa.

Tempel on valmistatud spetsiaalsest vormitööstusele valmistatud kõrgvastupidavast legeerterasest Orvar Supreme firmalt Uddeholm. Seda materjali iseloomustab väga kõrge kuumus- ja mõranemiskindlus. Materjalil on hea sitkus ja plastsus igas suunas.

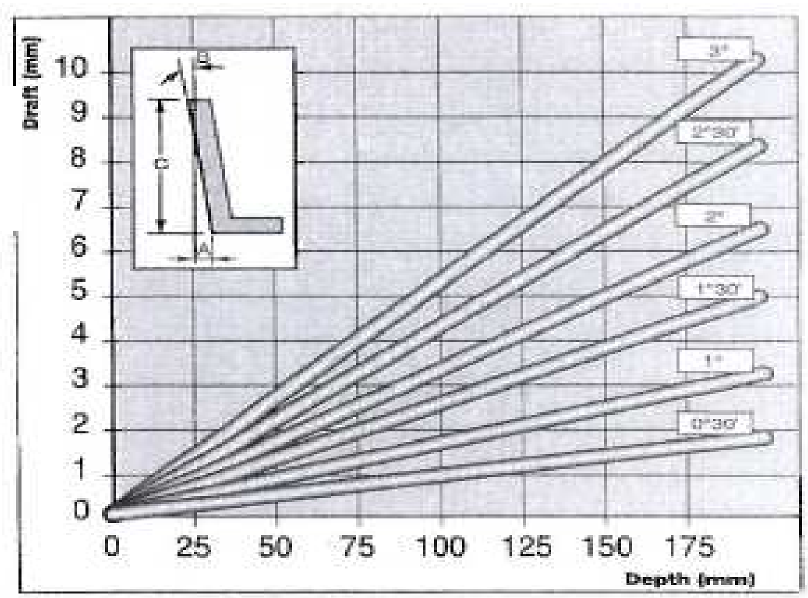
Lisas 14 on toodud Orvar Supreme materjali täpsemad omadused ja informatsioon.

9.2. Templi mõõtmete määramine

Templi mõõtmete määramisel arvestatakse detaili materjali kahanemisega. Kahanemisel materjal tõmbub kokku. Templi mõõtmed arvutatakse kahanemise protsendiga.

10. VÄLJATÕUKESÜSTEEMI PROJEKTEERIMINE

Piisavalt tahkunud valand tõugatakse survevaluvormist välja tõukurite süsteemiga, mis koosneb tõukurite kinnitusplaadist, varrastõukuritest ehk väljalükkajatest, torutõukurist. Tahkunud valandi survevaluvormist väljatõukamise edukus sõltub valuvormi pesa taganurgast. Soovitatav on vähemalt 1° taganurk tagada kõigil valanditel. Sõltuvalt valandi kujust ja seina paksusest võib väiksematel valanditel olla taganurk ka 30', kuid suuremad valandid nõuavad 2°...3° taganurka. Joonisel 14 on toodud taganurga A suurus sõltuvalt valandi kõrgusest. Samuti karedate külgseintega valandite taganurk peab olema suurem kui siledamate külgseintega valanditel.



Joonis 14. Survevaluvormi pesa taganurk

[7: 279]

Tõukurid asetatakse valandi jäigematesse kohtadesst, et mitte vigastada toodet. Tõukur võib jätta valandile jälje, mis ei rahulda tellija nõudmisi. Tõukurid kinnitatakse tõukurplaadile.

Antud vormi puhul kinnitatakse tempel ja matriitsid vormi liikuvale poolele. Valandi väljatõikamiseks kasutatakse tõukureid ja tõuketoru. Need tõukurid projekteeritakse spetsiaalselt templi sisse. Tõukurid saavad oma liikumise tõukurvarrastelt, mis kinnitatakse omakorda tõukeplaadile. Tõukurvardad ja tõuketoru saavad oma liikumise tõukeplaadilt.

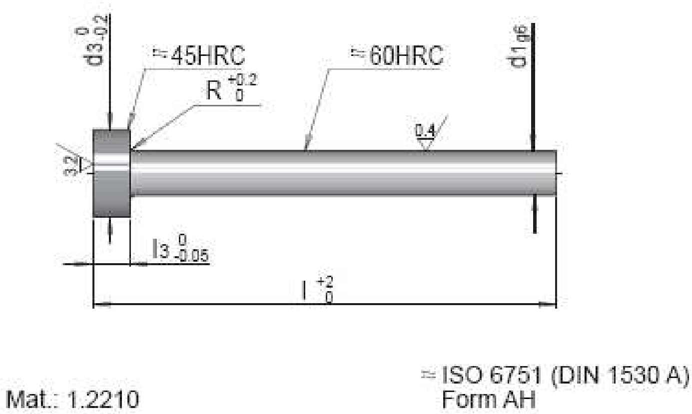
Pärast vormi täitumist plastiga vormipooled eraldatakse üksteisest. Matriitsid liiguvad valandist eemale, saades liikumise külgsammastelt. Seejärel hüdrosilinder lükkab tõukeplaadi koos tõukurplaadiga välja. Detail lükatakse pesast välja. Vormi sulgedes liiguvad plaadid koos tõukurite ja tõuketoruga oma esialgsesse asendisse ja on valmis järgmiseks tsükliks. Tõuketorul on all tihend, mis algasendis on vastu tõukurplaati ja tihendab jahutusvedeliku leket tõuketorust. Tõuketorusse projekteeritakse jahutussüsteem, mis jahutab templit seespoolt. Tõukurite ja tõuketoru tagasiviimine toimub vormipoolte sulgumisel tagasitõukurite abil.

10.1. Tõukurite asukoha määramine

Antud vormi puhul on asetatakse tõukurid templi sisse, et mitte vigastada detaili välimist pinda. Tõukurite asukoht on sobilik, kuna väljalükkamisel ei kaldu detail viltu. Tõukurid lükkavad detaili templi otsast maha seest poolt ja antud kohta võivad detailil jääda väljatõukamise jäljed, kuna tellijaga on antud variant kooskõlastatud.

10.2. Tõukurite ristlõike kuju ja mõõtmete määramine

Väljatõukesüsteem koostatakse erinevatest tõukuritest, tõuketorust ja tõukurvarrastest. Tõukurvardad tellitakse firmast Meusburger mõõtmetega 14x250 ja 6x160 (vt joonist 15).



Tõukuri 14x250 andmed:

R=0,8, l_3=7 mm, d_3=22 mm, d_1=14 mm, l=250 mm.

Tõukuri 8x160 andmed:

R=0,5, l_3=5 mm, d_3=14 mm, d_1=8 mm, l=160 mm.

Joonis 15. Tõukuri mõõtmete andmed

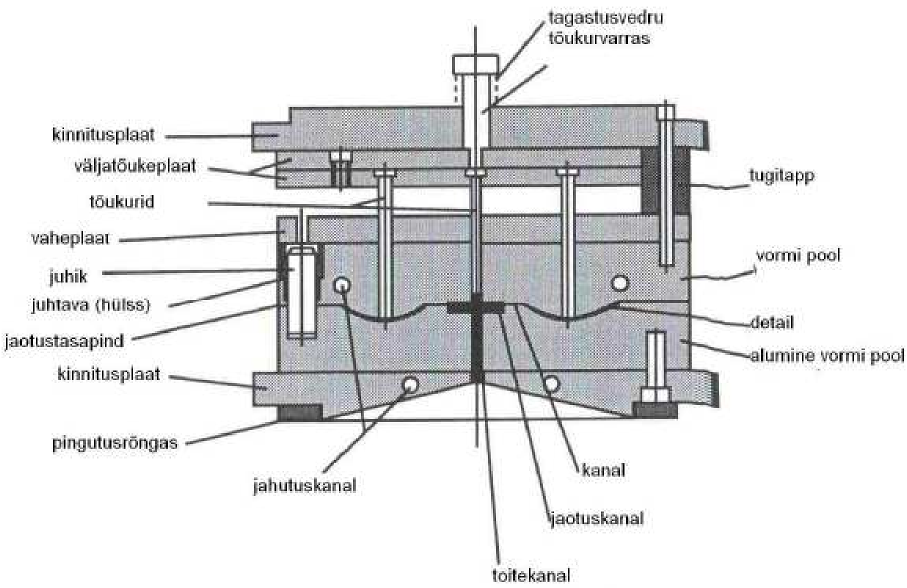
[8: WWW]

Tõuketoru ja tõukurid valmistatakse ettevõttes kohapeal (vt lisa 12 ja 15). Tõuketoru valmistatakse materjalist Grane ja mõõtudega Ø 40x370 millimeetrit. Tõukurid valmistatakse materjalist Unimax ja mõõtudega 14x14x210 millimeetrit. Mõlemad materjalid on firma Uddeholm toodang. Lisas 4 ja 7 on täpsem informatsioon materjalide omaduste kohta.

Antud tõukurite ristlõike pindala on piisavalt suur, et lükata detail pesast välja ilma, et nad kahjustaksid detaili pinda ja tungiksid detaili sisse.

11. VORMI DETAILIDE MATERJALID JA NENDE OMADUSTE MÄÄRAMINE

Survevaluvormi põhidetailide materjalide määramisel lähtutakse detaili funktsioonist vormis. Vormi põhidetailideks on äärik, kinnitusplaadid, matriitsplaadid, tempelplaat, vaheplaadid, klotsid ja traaversplaadid. Joonisel 16 on näha survevaluvormi põhidetailid.



Joonis 16. Survevaluvorm ja selle osad

[5: WWW]

Termiliselt töödeldakse vormi detaile, mis peavad vastu pidama kulumisele ja taluma suuri pingeid. Termilist töötlust vajavad matriitsplaadid, tempel, tõukurid ja kujumoodustajad. Matriitsid ja tempel peavad olema termiliselt töödeldud, kuna detailid töötavad kulumisele ja peavad tagama suurtel jõududel piisava jäikuse, et tagada kvaliteetne detail.

Matriitside ja templi materjaliks valitakse kõrgvastupidav legeerteras Orvar Supreme firmalt Uddeholm. Antud terasele on lisatud mangaani, kroomi, molübdeeni, vanaadiumi, räni. Täpsem info materjali kohta on toodud lisas 5. Materjali eeliseks teiste ees on töödeldavuse kiirus, kuna vormi valmistamise ajast moodustab metallide töötlemine 50%. Samuti karastamisel tekib materjalis vähem sisepingeid.

Vormi juures kasutatakse lisaks eelnimetatud metallile veel Impax, Unimax, Grane, Arne jne. metalle ning nende omadused ja informatsioon on toodud lisades 3, 4, 7 ja 8.

[12: WWW]

11.1. Vormi detailide täpsus ja pinnakaredus

Väljalükke tõukurid, kujumoodustajad, tempel, matriitsid ning nende avad peavad olema täpsusega H6, H7/g6, kuna sulaplast jookseb olenevalt survest läbi juba 0,03 millimeetrisest pilust. Kõikide vormi plaatide pinnad peavad olema töödeldud tasaparaleelselt täpsusega ±0,01 millimeetrit, et tagada plaatide omavaheline paigutus. Lisaks pesade geomeetrilisele täpsusele tuleb tagada ka pesa poolte omavaheline kokkusobivus, mille tagavad vormi juhtivad osad nagu juhtsambad ja juhtpuksid. Juhtsammaste ja juhtpukside avade mõõdud peavad olema täpsusega H7/g6 ja omavaheline asetus täpsusega H7. Matriitside ja templi pinnakaredus peab vastama tellija poolt esitatud nõuetele, mis on erosioontöötlusel Ra 1,6 μ (vt lisa 2).

12. VALMISTAMISE TEHNOLOOGIA

Vormi projekteerimise käigus käsitletakse ainult ühe vormidetaili valmistamise marsruuttehnoloogiat. Vaatluse alla võetakse detaili Core (templi) marsruuttehnoloogia, milles on välja toodud töötlusviisid, töötlemise järjekord ja kasutatavad pingid (vt. lisa 13).

Detaili töötlusviisidena kasutatakse freesimist, puurimist, lihvimist, termilist töötlemist, mahterosiooni ja traaterosiooni.

Lisas 9 tuuakse välja detaili valmistamise marsruuttehnoloogia.

13. ELEKTROODIDE PROJEKTEERIMINE

Elektroerosioonpinke kasutatakse nende eriliste töötlemisomaduste tõttu peamiselt survevaluvormide ja stantside vastutusrikaste detailide (matriitsid, templihoidjad, mahatõukurid jne.) valmistamiseks pärast termilist töötlust, aga ka kõvasulammaterjalide ja teiste raskesti töödeldavate detailide valmistamiseks.

Elektsoerosioontöötlemine põhineb elektroodide pinna purunemisel elektrilise impulsslaengu soojuslikul toimel. Purustatud pinnaosa kuju ja mõõtmed kopeerivad täpselt instrumendi kuju ja mõõtmed. Avade ja süvendite töötlemiseks määratud erosioonpinkides antakse instrumendile töödeldava detaili suhtes automaatne ettenihkeliikumine nii, et keskmine pinge või vooluimpulsi tugevus instrumendi ja detaili vahel jääks etteantud piiridesse. Läbi dielektriku tekib pidev elektrilahendus. Dielektrik, milleks on spetsiaalne industraalõli ja petrooli segu või petrool, antud segu tõstab protsessi efektiivsust, eemaldades metalliosaksesed töötsoonist ja jahutades samal ajal instrumenti.

Põhilised elektroodi materjalid süsinik- ja tööriistaterade töötlemisel on vask ja grafiit, kuid kasutatakse ka messingit ja alumiiniumi.

Vaskelektroodid sobivad nii eel- kui ka puhastöötlemiseks. Grafiitelektroodi positiivseks omaduseks on hea töödeldavus ning suur stabiilsus temperatuuri muutuste suhtes. Grafiidist elektroode kasutatakse eel- ja puhastöötlemisel, kuna nendega on võimalik saavutada pinnakaredust $Ra>1,6\ \mu m$. Grafiitelektrood tagab võrreldes vaskelektroodiga suurema tootlikkuse ja ta ise kulub vähem.

Antud juhul valmistatakse elektroodid grafiidist, nende kujud freesitakse välja arvjuhtimisfreespingis. Iga elektroodi valmistamiseks tehakse vastav töötlemise programm. Elektroodid töödeldakse koos sabaga, et tagada piisav täpsus saba ja elektoodi suhtes. Templi valmistamiseks kasutatakse erinevaid elektroode, kuna antud detaili kuju on keerulise geomeetriaga ja ühe elektroodi valmistamine ei ole otstarbekas ja võimalik. Pesade töötluse vastavad režiimid saadakse pingi režiimitabelitest. Traaterosiooniks kasutatakse tööpinke ROBOCUT α–1iA ja ROBOCUT α–0iA ning mahterosiooniks MAKINO EDNC 40.

14. MAJANDUSLIK OSA

Survevaluvormi majanduslikus osas arvestatakse kokku tootmiseks tehtud kulutused ja arvutatakse välja ligikaudne vormi väljamüügihind. Antud projekti puhul on täpsete rahaliste kalkulatsioonide esitamine raskendatud, kuna vajalike andmete nagu pinkide töötundide hinnad, juurdearvestuse koefitsendid jne. ei kuulu avalikustamisele. Seetõttu ei saa teha konkreetseid arvutusi vormi müügihinna leidmiseks, kuid ettevõtte nõusolekul on võimalik avaldada nii esialgselt planeeritud tundide arvuga kui ka tegelikult kulunud tundide arvuga vormi valmistamise hind ja valmistamisega seotud kulud.

Toote ehk vormi omahind sõltub paljudest teguritest. Vormi omahinna elementideks on:

- otsekulud
- muutuvad kulud
- püsikulud
- jaoskonna kulud
- tsehhi üldkulud
- ettevõtte üldkulud
- tootmisvälised kulud
- kaudsed kulud

Otsekulud on kulud, mida seostatakse vormi ehk tootega. Antud juhul on otsekuludeks põhikulud (tooraine, põhi- ja abimaterjalide maksumus, põhitööliste töötasu, seadmete ja tööpinkide amortisatsioon). Kaudsed kulud on kulud, millel puudub vahetu seos tootega. Tootmisvälised kulud on ettearvamatud kulud ja need võetakse 5% tootmise omahinnast.

Otseselt mõjutavad vormi hinda tellitavate materjalide ja standardosade hinnad, tööajakulu, tööliste palgad ja pingi töötundide arv.

Vormi valmistamise töömahukus hinnatakse pärast tellija käest saadud tootejooniseid ja esitatud nõudeid analüüsides ja varasematele kogemustele toetudes.

Vormi hinna moodustab suuresti töökulu, kuna ettevõttes on pingi tunnihind kindlaks määratud. Pingi tunnihind sisaldab endas kõiki ettevõttekulutusi, peale materjali omahinna ja standardosade hinna. Ettevõttekulutused on töölise palk, pingi ekspluatatsioonikulud, ettevõtte üldkulud ja kulutused juhtivpersonali töötasudele, elektrienergiale, ruumide rendile, seadmete amortisatsioonile, instrumentidele ning instrumentide korrashoiule.

Pärast vormi valmistamise töömahukuse hindamist arvutatakse välja vormi valmistamiseks vajalik hinnanguline töötundide hulk ja korrutatakse see pinkide töötundide maksumusega, mis esitatakse seejärel tellijale ning edasine sõltub müügiosakonna läbirääkimiste ja müügioskustest.

Antud vormi hinnanguliseks töötundide hulgaks arvutas ettevõte esialgselt 250 tundi (vt. tabel 1).

Kuna antud vorm on juba valmis ja tellijale üle antud, siis on tehtud ka statistika, kui palju kulus tegelikult aega vormi valmistamiseks. Vormi valmistamiseks kulunud tegelik tundide arv on toodud välja tabelis 2.

Tabel 1

Ettevõtte hinnanguliselt arvestatud töötunnid vormi valmistamiseks

Töötlusviis	Töötlemiseks kuluv tundide arv, h
Saagimine	10
Ettevalmistav freesimine	15
Ettevalmistav lihvimine	20
Koordinaatpuurimine	35
Treimine	25
Puurimine	20
NC-frees	20
Termiline töötlemine	25
Traaterosioon	20
Mahteronsioon	35
Luksepatööd (s.h. puurimine)	25
Kokku tunde:	**250**

Allikas: (Sumar Tools OÜ, 2010)

Tabel 2

Tegelikult kulunud töötunnid vormi valmistamiseks

Töötlusviis	Töötlemiseks kuluv tundide arv, h
Saagimine	7
Ettevalmistav freesimine	13
Ettevalmistav lihvimine	17
Koordinaatpuurimine	30
Treimine	22
Puurimine	16
NC-frees	22
Termiline töötlemine	20
Traaterosioon	25
Mahteronsioon	35
Luksepatööd (s.h. puurimine)	20
Kokku tunde:	**227**

Antud vormi puhul tuuakse eraldi välja materjalide ja standardosade hinnad. Tooriku kogu maksumuse arvestus toimub materjali maksumuse ja tooriku kaalu järgi. Antud juhul arvestatakse tooriku mõõtmeid ja selle materjali tihedust ning seejärel saadakse tooriku kaal. Materjali kogu hinnaarvestus on näha hinnaarvestuse tabelis (vt tabel 3). Tabelis on välja toodud detaili nimetus, detaili materjal, materjali maksumus (kr/kg), tooriku mõõtmed, tooriku kaal, tooriku hind ja toorikute kogumaksumus.

Standardosade hinnad on näidatud standardosade hinnaarvestuse tabelis (vt tabel 4). Kogumaksumus saadakse korrutades standardosa maksumus ja tüki hind ning seejärel kõikide osade hind kokku.

Tabel 3

Materjali kulu arvestus

Jrk. nr.	Detaili joonise nr.	Detaili nimetus	Detaili materjal	Materjali hind, kr/kg	Tooriku mõõtmed, mm	Tooriku kaal, kg	Tooriku hind, kr
1	V410.01	Core	Orvar	135	156x60x172	12,5	1687,5
2	V410.02	Slide A	Orvar	135	205x154x140 (2 tk)	34,5	9315
3	V410.03	Slide AA	Orvar	135	Ø35x115 (2 tk)	0,9	243
4	V410.04	Insert T	Orvar	135	30x40x116	1,1	148,5
5	V410.05	Insert M	Orvar	135	34x34x120	1,1	148,5
6	V410.06	Ejector	Grane	90	Ø45x370	4,7	423
7	V410.07	Bushing H	Orvar	135	Ø90x72	3,6	486
8	V410.18	Ejector base plate	2312/Holdmax	50	446x172x36	21,5	1075
9	V410.19	Guide block	Unimax	40	50x51x446	8,9	712
10	V410.20	Heel block	2312/Holdmax	50	175x160x132	29	2900
11	V410.21	Guiding stock	Grane	90	6x40x124	0,24	129,6
12	V410.22	Wear plate	Arne	90	6x150x74	0,25	90
13	V410.23	Support	Arne	90	12x17x150	0,24	43,2
14	V410.24	Locating ring 1	1730/UHB 11	40	Ø125x20	2	80
15	V410.25	Locating ring 2	1730/UHB 11	40	Ø125x21	2	80
16	V410.26	Strap lock	1730/UHB 11	40	12x18x145	0,25	10
17	V410.27	Support pillar	1730/UHB 11	40	Ø68x148	4,2	336

Tabeli 3 järg.

18	V410.28	Guide bushing	Bronze	150	Ø18x20	0,45	135
19	V410.29	Washer (e)	1730/UHB 11	40	Ø45x10	0,13	5,2
20	V410.30	Sleeve (e)	1730/UHB 11	40	Ø30x18	0,1	4
21	V410.31	Plate (e)	2311/Impax	40	Ø96x17	1	40
22	V410.32	Ejection adapter (e)	1730/UHB 11	40	Ø50x75	1,2	48
23	V410.33	Ange ejector	Unimax	40	14x14x210 (2 tk)	0,4	32
						Kokku:	**18 171, 50**

Tabel 4

Standardosade hinnaarvestus

Jrk. nr.	Pos. nr.	Detaili nimetus	Tellimiskood	Arv, tk	Tüki maksumus, kr	Kogu maksumus, kr
1	8	Cavity plate	F50 / 296 446 / 56 / 1730	1	3975	3975
2	9	Core plate	F50 / 296 446 / 46 / 2312	1	4867	4867
3	10	Support plate	P 296 446 /76 /2312	1	5195	5195
4	11	Riser 1	F70 / 296 446 / 60 / 96 / 1730	2	2145	4290
5	12	Riser 2	F70 / 296 446 / 60 / 56 / 1730	2	1643	3286
6	13	Clamp plate 1	P 296 496 /36 /2312	1	3552	3552
7	14	Clamp plate 2	P 296 496 /36 /1730	1	2505	2505
8	15	Insul. Plate 1	E1405/296 496/8	1	1080	1080
9	16	Insul. Plate 2	E1405/296 496/8	1	1080	1080
10	17	Ejector plate	F80/296 446/172/17/1730	1	1410	1410
11	34	Guide pusher	E1050/10/18-200	4	179	716
12	35	Angle pin	E1032 / 20 x 200	4	199	796
13	36	Angle pin	E1032 / 16 x 180	2	155	310
14	37	Retainer	E3060 / 20	4	908	3632
15	38	Retainer	E3060 / 16	2	819	1638
16	39	Locating guide pillar	E1000 /24- 136 / 155	3	570	1710
17	40	Locating guide pillar	E1000 /22- 136 / 155	1	570	570
18	41	Locating guide bush	E1100 / 24- 96	3	395	1185
19	42	Locating guide bush	E1100 / 22- 96	1	395	395
20	43	Centering sleeve	E1160 / 30 x 220	4	312	1248
21	44	Guide pillar (eject.)	E1010/24-36/ 195	2	470	940

22	45	Guide bush (eject.)	E1105/24-36	2	395	790
23	46	Thrust piece	E1250 / 12 / 22	8	18	144
24	47	Thrust piece	E1250 / 8 / 16	4	10	40
25	48	Ejector	E1710 / 14 x 250	4	246	984
26	49	Ang. Ejector foot	E1710 / 8 x 160	2	72	144
27	50	Spiral baffle	E 2102/1/2/400	1	191	191
28	51	O-ring	Ø 30,0 x 3,0	1	10	10
29	52	O-ring	Ø 20,0 x 2,5	2	7	14
30	53	Plug	ST11 13-M14x1,5	8	13	104
31	54	Label	65 x 100 x 1	1	50	50
32	55	Connectors base	Sheet metal	1	150	150
33	56	Mounting	9300240307	2	245	490
34	57	Pin socet	9330242601	1	210	210
35	58	Pin socet	9330242701	1	210	210
36	59	Limit switch	M 6600-11-k-y	2	220	440
37	60	Plug system	701510	1	300	300
38	61	Pin socet	700210	1	300	300
39	62	O-ring	Ø 54x 2.0	2	15	30
40	63	Hotrunner	NZMSDB2A048P	1	4500	4500
41	64	Eye bolt	M 16	1	67	67
42	65	Screw plug	E 2074/8/1/8	6	4	24
43	66	Screw plug	E 2074/10/1/4	2	5	10
44	67	Copper blank	E 2072/12	10	4	40

Tabeli 4 järg.

45	68	Screws DIN 912 12.9	M12-260	4	199	796
46	69		M12-60	8	11	88
47	70		M12-50	7	9	63
48	71		M12-40	4	8	32
49	72		M10-35	2	6	12
50	73		M10-30	8	5	40
51	74		M8-80	4	12	48
52	75		M8-40	14	4	56
53	76		M8-30	5	3	15
54	77		M8-20	8	2	16
55	78		M6-16	6	2	12
56	79		M5-8	4	4	16
57	80		M4-10	8	2	16
58	81	Screws DIN 7991 12.9	M6-16	12	2	24
59	82		M5-12	28	2	56
60	83		M5-6	2	3	6
					Kokku:	**54 918,00**

Vormi valmistamise tootmisomahind kujuneb välja eelkõige selle järgi, kui töömahukas on antud vormi valmistamine s.t., et kui ettevõttes on pingi töötunni hind paika pandud, siis on võimalik töökulu välja arvestada pingi töötundide järgi. Kuna antud juhul pole võimalik pingi töötundide hinda avaldada, siis võrreldakse hinnangulist töötundide hulka (250 tundi), mille põhjal tehti tellijale esialgne pakkumine, tegeliku töötundide hulgaga, mis saadi praktikas otseselt kulutatud töötundide kokku arvutamisel (227 tundi). Selgub, et esialgselt planeeriti rohkem tunde, kui tegelikult kulus ja sellest tulenevalt võib järeldada, et ettevõtte sai planeeritud kasumi 17 161,72 krooni ning lisaks veel täiendava kasumi 31 880,10 krooni, kuna tegelikult kulunud töötundide hulk oli väiksem kui algselt planeeriti.

Kokkuvõtteks saadi antud vormi tootmisest kasu 49 041,82 krooni, mis moodustas reliseerimishinnast 13,6% ning seda võib pidada rahuldavaks kasumiks. Vormi valmistamiseks esialgsed planeeritud kulutused on toodud tabelis 5 ja reaalsed kulutused tabelis 6.

Tabel 5

Vormi valmistamiseks esialgselt planeeritud kulutused

Jrk. nr.	Kulu nimetus	Kulud tootele
1	Materjal	18 171,50
2	Ostetud standardtooted	54 918,00
3	Põhitööliste töötasud	
	Põhitöötasu	
	Sotsiaalmaks	
	Töötukindlustus	
	Põhitöölitse palgafond	179 200,00
4	Seadmete tööga seotud kulud (energia, amortisatsioon, remont, abimaterjalid)	46 821,46
5	Tootmisomahind	326 890,00
6	Ettearvamatud tootmisvälised kulud	16 344,50
7	Täisomahind	343 234,50
8	Kasum 7%	17 161,72
9	Realiseerimishind	360 396,22

Tabel 6

Vormi valmistamise reaalsed kulud

Jrk. nr.	Kulu nimetus	Kulud tootele
1	Materjal	18 171,50
2	Ostetud standardtooted	54 918,00
3	Põhitööliste töötasud	
	Põhitöötasu	
	Sotsiaalmaks	
	Töötukindlustus	
	Põhitöölitse palgafond	162 713,00
4	Seadmete tööga seotud kulud (energia, amortisatsioon, remont, abimaterjalid)	41 995,00
5	Tootmisomahind	296 528,00
6	Ettearvamatud tootmisvälised kulud	14 826,40
7	Täisomahind	311 354,40
8	Kasum 13,6%	49 041,82
9	Realiseerimishind	360 396,22

KOKKUVÕTE

Detaili "Hark 5377/125 XL" survevaluvormi projekteerimine ja tehnoloogia

Käesoleva lõputöö eemärgiks oli luua ülevaade survevaluvormi projekteerimise etappidest ja konstrueerida survevaluvorm detaili "Hark 5377/125 XL" valmistamiseks. Antud eesmärgi täitmiseks on toetutud ettevõtte kogemustele ja teadmistele survevaluvormide valmistamise alal. Koostöös tellijaga on selgitatud välja vormi tööpõhimõte, kasutatavad põhikomponendid, pesade arv, mõõtmed ja kasutatav survevalumasin. Vormi valmistamise aluseks on tellija joonis detailist, mis on saadetud ettevõttele kas digitaalsel kujul sobivas formaadis või joonis, millel on vajalikud mõõdud ja parameetrid detailist. Edasi analüüsiti detaili põhjalikult, kuna sellest sõltuvad paljud survevalusüsteemi parameetrid ja tootmise tehnoloogiad. Projekteerimise käigus toodi välja vormi tähtsamad koostisosad ja püüti leida praktilisi vajadusi arvestades parim lahendus ning käsitleti vormi valmistamisega seotud küsimusi.

Projekteerimise käigus toodi välja ka templi valmistamise marsruuttehnoloogia. Kuna tegemist on üksiktootmisega, siis arvestati tehnoloogia väljatöötamisel kohalike tingimuste ja võimalustega. Ettevõttes spetsiaalset tehnoloogiat välja ei töötatud, kuna aeg tellimuse saamise ja valmistamise tähtaja vahel on viidud miinimumini. Põhiline tehnoloogia tehti arvuti abiga ehk siis töötlemise programmid freespinkidele ja elektroerosiooni pinkidele. Ülejäänud koostamistehnoloogia pandi paika töö käigus ettevõtte tsehhis kohapeal.

Projektis on käsitletud ka võimaluste piires majanduslikke nüansse, sest konkreetseid algandmeid omahinna arvestamiseks pole võimalik avaldada, kuid vormi realiseerimishinna ja tootmishinna vahet võib pidada rahuldavaks, kuna ettevõte sai antud tehingust kasu.

Antud vormi projekteerimise käigus tutvuti erinevate tehnoloogiate valikuga ja analüüsiti materjale, millest on valmistatud nii detail kui ka vorm. Arenevas tehnoloogilises ühiskonnas tuleb olla kursis kaasaegsete tehnoloogiate ja materjalidega. Ettevõttele on kasulikum vorm valmistada väiksemate kulutustega, aga seejuures vamistada toode kvaliteetne ja kliendi nõudmisi rahuldavalt.

SUMMARY

Design and technology of pressure-molded detail "Fork 5377/125 XL"

Purpose of this thesis was to create an overview of the design stages of compression-molded and to construct molding form of detail: "Hark 5377/125 XL" This objective is based on an enterprise experience and expertise in manufacturing injection molds. In cooperation with the customer was clarified form working principle, the main components used, the number of connectors, size and used injection molding machine. The basis of form preparation are contracting authority figure piece, which is sent to the company either in digital form in a suitable format, or drawing showing the dimensions and parameters for the necessary detail. After this detail was analysed depth, since on it many system parameters molding and manufacturing technologies depends on. The design process was to form the major component parts and tried to find the best solution taking into account the practical needs and addressing issues related to form manufacturing.

The design process was brought to the temple construction route technology. Since it is a single production is followed, in developing we considered local conditions and opportunities. The company special work out technology was not developed since the time period between the receipt of an order and construction has been minimized. The basic technology was done with the help of computer programs, namely the processing and milling machines for electro-erosion (EDM) machine. Remainder assembly technology were put into place during the company's factory work on the site.

The project has also been taken as far as the economic nuances. During form design process we learned variety of technologies, materials selection and analysis, which are used to made a detail as the form. In an evolving technological society must be familiar with modern technologies and materials, the company has made more useful form of lower costs, but also to manufacture quality product, which satisfy customer claim.

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Lisa 1

Materjali polüamiid PA 6 GF 40 Akulon K224PG8 andmed

DSM Engineering Plastics - Property Data

Akulon® K224-PG8

(PA6+Imod)-GF40

40% Glass Reinforced, Impact Modified

Properties	Typical Data	Unit	Test Method
RHEOLOGICAL PROPERTIES	dry / cond		
Molding shrinkage (parallel)	**0.25** / *	%	ISO 294-4
Molding shrinkage (normal)	**1.1** / *	%	ISO 294-4
MECHANICAL PROPERTIES	dry / cond		
Tensile modulus	**11500 / 6700**	MPa	ISO 527-1/-2
Stress at break	**170 / 110**	MPa	ISO 527-1/-2
Strain at break	**4.5 / 8.5**	%	ISO 527-1/-2
Flexural modulus	**10000 / -**	MPa	ISO 178
Flexural strength	**260 / -**	MPa	ISO 178
Charpy impact strength (+23°C)	**105 / 110**	kJ/m²	ISO 179/1eU
Charpy impact strength (-30°C)	**110 / 110**	kJ/m²	ISO 179/1eU
Charpy notched impact strength (+23°C)	**25 / 35**	kJ/m²	ISO 179/1eA
Charpy notched impact strength (-30°C)	**18 / 18**	kJ/m²	ISO 179/1eA
THERMAL PROPERTIES	dry / cond		
Temp. of deflection under load (1.80 MPa)	**200** / *	°C	ISO 75-1/-2
Temp. of deflection under load (0.45 MPa)	**215** / *	°C	ISO 75-1/-2
Coeff. of linear therm. expansion (parallel)	**0.2** / *	E-4/°C	ISO 11359-1/-2
Coeff. of linear therm. expansion (normal)	**0.65** / *	E-4/°C	ISO 11359-1/-2
ELECTRICAL PROPERTIES	dry / cond		
Relative permittivity (100Hz)	**3.5 / 14**	-	IEC 60250
Relative permittivity (1 MHz)	**3.3 / 4.5**	-	IEC 60250
Dissipation factor (100 Hz)	**90 / 3000**	E-4	IEC 60250
Dissipation factor (1 MHz)	**150 / 1200**	E-4	IEC 60250
Volume resistivity	**1E13 / 1E11**	Ohm*m	IEC 60093
Surface resistivity	* / **1E14**	Ohm	IEC 60093
Electric strength	**25 / 20**	kV/mm	IEC 60243-1
Comparative tracking index	* / **600**	-	IEC 60112
OTHER PROPERTIES	dry / cond		
Water absorption	**4.9** / *	%	Sim. to ISO 62
Humidity absorption	**1.5** / *	%	Sim. to ISO 62
Density	**1430 / -**	kg/m³	ISO 1183

29.03.2005

DSM Product

Unlimited. DSM

Lisa 2

Tellija nõuded survevaluvormi valmistamiseks

General Specification for Plastic Injection Molds

☒ Order

(Parts of the text in light grey are for this tool not relevant)

Supplier	:.
Article designation	: Fork 5377/125 XL
Article drawing No.	: TR 34541 + TR 34542 + TR 34543
Further exchangeable parts for following drawing No.	: are included in the scope of delivery
Definition of exchangeable parts	: 2 separate inserts for drawing No. TR 34542 + TR 34543
Injection material	: PA 6 GF 40 Akulon K224PG8

Allow for mold shrinkage	a) flat-rate for all dimensions %	☐
	b) individually according to dimension list TN 458	☐
	c) Allowance for criticel dimension	☐
	d) according to mold drawing	☐
	e) according to existing mold	☐
	f) will be done from the toolmaker	☒

Designation of resource	:
Tool No.	: F 7579
Number of cavities 5	: one cavety

Principle of mold design:	standard mold	☐
	stripping plate .	☐
	hot runner	☒
	split mold	☒
	3-plate mold	☐
	multi-level mold	☐

Injection molding machine	: Arburg 570 C 2000 kN

Lisa 2

Tellija nõuded survevaluvormi valmistamiseks

1. Design

TENTE supplies the design. ☐

The supplier prepares the design documents. ☒

1.1 Draft with information about thickness of plates and arrangement of cavities
a) according to reference drawing ☐
b) upon mutual assessment ☒

1.2 After approval of the draft, the design will be completed with all details in the form of a general drawing.

1.3 Design assessment meeting:
1 set of drawings is to be submitted for the assessment meeting.
The design principle is reviewed and approved.
A dimensional check is not carried out.
The design assessment does not release the supplier from its duty to guarantee functional safety.
A protocol of the design assessment meeting including any modifications of / supplements to the drawing is performed.

1.4 Only after approval of the design by TENTE, production is permitted to start.

1.5 After approval of the mold and entry of all corrections, the documentation consisting of general drawing, component drawing of wear parts, and parts list will be sent to TENTE.

Circuit diagrams for hot runner molds are included in the scope of delivery.

1.6 A detailed report of progress has to be sent to TENTE every two weeks.
Content:
Tool design.
Manufacturing of single tool components.
Sampling of the tool.

1.7 Documentation of resources according to TN 450.10

Tellija nõuded survevaluvormi valmistamiseks

2. Inserts

If latch elements are used, they are to be arranged as to allow either inserting the parts manually from the side or automatically from the top.

2.1 Allocation of the parts to be inserted and the corresponding mold half.

Parts designation	Article drawing No.	Injection side	Ejector side

2.2 The parts are inserted manually. ☐

2.3 The parts are inserted automatically. ☐

2.4 Holding the insert by means of resilient retaining pins
a) radial arrangement ☐
b) axial arrangement ☐
number
position

Being engaged, the pins are at stop.

2.5 Venting must be ensured for insert parts.
The insert part must not cover the separation line of the mold insert.
The separation line has to be as close as possible to the joint.

2.6 Is the size of the mold as well as the selected machine suited for insertions?
Distance of front edge up to machine center = mm
Distance of front edge up to furthest cavity = mm
Checked: ☐

3. Fitting Dimensions of Mold acc. to TN 470.02

4. General Information about Mold Design

4.1 All edges without function are to be provided with edge breakage feature or radius.

4.2 In order to facilitate dismounting of the plates, they are to be provided with milled edges on four sides. Dimensions 30x45°; 5 deep.

4.3 M16 threaded holes in each plate of a weight >20 kg

4.4 Attachment from the form: **Clamping edge in front and back** with tensing bracket (36 mm thick)

4.5 In case taps are located underneath the mold, 4 spacers have to be installed under each mold half to prevent the taps from any damage when setting down the mold.

4.6 A transport bridge with eyebolts (mold must hang horizontally) is included in the scope of delivery.

4.7 There are basically to use two insulating boards at the mould.
The screws which are under it must be accessible without disassembly of the insulating clamp.
(clearing hole in insulating board)

4.8 Screwing of the center bolt retaining plate is effected from the clamping side so that the thread is in the center bolt retaining plate.
Reason: adjusting of the center bolt at assembled mold is maintained

4.9 Full-hardening - 56-58 HRc - of center bolts, ejector pipes, guide bushes, sprue bushes, etc. material 2842 (snug fits not on full length)

4.10 Mold plates for inserts – material 2311/2312 without heat treatment.

4.11 Intermediate plate – material 2311/2312 without heat treatment. In order to avoid deflection of the intermediate plate, the following is to be observed:
a) properly dimensioned plate thickness: = 76 mm
b) additional supports.

4.12 Additional centering pieces: ☐
Centering pieces and mold plates are to be marked since the centering pieces are manufactured in pairs.

4.13 Exchangeable parts: ☒
Principally, the holder for exchangeable parts has to be hardened.
Additional, hardened external inserts are required. ☐

- The feed slopes of the outer member are to be provided with additional radii.
- Article markings (material, article designation) are to be provided on the inserts.
- Month and year stamps are to be installed in every exchangeable insert.

4.14 By the adjustment of the cavity all parts must have a **sufficient** and e**qual wall** .

5. Mold Design – Slide Followers Mold

5.1 Forming slides and Non-forming slides:
full hardening in vacuum of material (1.2767 / 1.2343) 54 HRC.
Slides with lubricating ashes provided.

5.2 Number of cavities per slide: ☐

5.3 Lock thrust pieces full hardening of material (1.2842 / 1.2510) (52-54 HRC), grinding, and screwing down from outside (thread in thrust plate)

5.4 Height and lateral guiding for slides with hardened ledges.
Full hardening (52-54 HRC) and grinding of material (1.2842 / 1.2767)

Tellija nõuded survevaluvormi valmistamiseks

5.5 Design of tumbler

Morticed locking key with robust hardened counter lock.

5.6 End position locking by means of pin or stop piece to ensure that the slides do not exceed end position.

6. Mold Design – 3-Plate Molds

6.1 Design opening so that parts fall out safely.

6.2 Select the arrangement of the latch element and draw-in bolts so that the runner can be removed, finished parts can fall down, and insert parts can be inserted without hindrance. It must be possible to remove the runner in both directions, to the top (automatic removal) and to the side (manual removal).

6.3 Number of latch elements: 4

6.4 A sprue claw is to be mounted behind each sprue cone.

6.5 The minimum diameter of the sprue cone must be at least 5 mm, with a demolding incline of 1.5 degrees.

6.6 The actuator bar should be assembled en a way that the bar can be dismounted without removing of any other plate.

7. Mold Design – Multi-Level Mold

8. Mold Design – Hot Runner Molds

8.1 Hot runner system: Dura Deci

Manufacturer: Fa. Mold Masters

The hot runner system is externally heated enabling the speedy change of material and color in the mold (no cold pre-chamber).

In case reinforced material is used, armored hot nozzles have to be installed.

Always use non-insulated thermal elements.
Circuit diagrams for hot runner molds are included in the scope of delivery.

Electric resistance of the thermal element including the cable for hot runners must not exceed 8 Ohm.

Connector pin assignment for hot runner system:

TN 475.21 1-12 heating zone 220V	☒
TN 475.22 13-24 heating zone 220V	☐
TN 475.23 1-12 heating zone 220V+24V mixed	☐
TN 475.24 13-24 heating zone 220V+24V mixed	☐

Numbering of cavities and electrical connections TN 475.30

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Terminal box according to:

TN 475.32	1-12 heating zone 220V	☒
TN 475.33	1-12 heating zone 220V from moldbreadth =>296mm	☐

Parts list for plugs (sheets 1-4) TN 475.40

8.2 Install guide bolts on ejection side and guide bushes on injections side.
8.3 Hot runner frame plates - material 2311/2312 without thermal treatment

8.4 Insulating plates (asbestos-free) – plate thickness:

8.5 For MOLD-MASTERS hot runner systems, it should be noted that no deflection occurs of the injection side. The backing plate of 36 mm in thickness for the injection side is to be manufactured from 2312.

8.6 In order to avoid injection molding of material into the clearance between backing plate and hot runner spreader, the centering ring has to be positioned as closely as possible at the sprue bush.

8.7 Number of heating positions : 1

220 volts : 1

24 volts :

Number of nozzles : 1

220 volts : 1

24 volts :

8.9 Position and arrangement of nozzles :

For inclined nozzles, observe the following:
Fix the hot runner to the mold plate by means of pins of 16 in diameter.
Effect bore holes of 12 in diameter into mold plate for pin access.
Guide bushes without centering collar.

8.10 Installation of electric power cables in hot runner systems is effected in cable ducts of 18 mm in width. The cable ducts of externally-heated systems are located in the intermediate plate on the injection side; those of internally-heated systems in the backplate of the hot runner plate. The cables are to be joined to cable looms using heat-resistant tie wraps and insulating material.
The cables are to be fastened in the channels by means of clips.
Please note: For metrological reasons, the cables of temperature sensors must not be shortened.

Tellija nõuded survevaluvormi valmistamiseks

9. Sprue System

9.1 The depth of immersion of the machine nozzle should be as small as possible (about 10 mm – 15 mm). Replace the short standard machine nozzle by a longer machine nozzle only if absolutely required.

9.2 Heated sprue bushes on cold runner only if absolutely required, for this makes automatic sprue removal more difficult.

9.3 Smallest diameter of sprue cone in sprue bush = 4,5 mm
The sprue diameter has to correspond to the spreader cross section.

9.4 Natural balancing has to be ensured by equal flow distances.

9.5 Sprue type
Sprue gating ☐
3-plate pin-point gating ☐
Hot-runner and cold-runner spreader ☐
Provide possibility of manual removal ☐
Hot runner pin-point gating ☒
- Nozzle outlet diameter 2,5 mm

9.6 Gate type
Diaphragm gate ☒
Film gate ☐
Tunnel gate with cylindrical outlet
Diameter (drawing enclosed) ☐

Number of gate points:
For reasons of stability, an odd number of gate points should be selected
in case of thin center bolts ☐

9.7 Outlets
Gate openings are to be designed as to ensure that the jet is not directed into free space but towards a core (air pockets are avoided)

9.8 Needle seal nozzles ☐
In case needle seal nozzles are used, venting for hydraulics is to be provided.

9.9 Gate

Cross section : round . ☐
: trapezoidal ☐
Surface : polished in flow direction ☐
: erosion rough (for PU) Ra: 6.3 µ . ☐

9.10 Separation of sprue
Direct injection onto part (no sprue) ☒
Injection onto spreader with tunnel gate ☐
Transition from spreader to tunnel gate has to be provided with a radius ☐

- The spreader is automatically separated from the mold and falls out of the machine together with the article. Sprue and article must show unequivocal geometric differences to enable separation. How to realize separation? ☐

- Automatic separation of sprue and workpiece, sprue is removed automatically, parts fall down. ☐

10. Forming Parts

10.1 Interchangeability of forming parts must be guaranteed.

10.2 A separate mold insert has to be provided for each cavity.

10.3 Mold inserts: full hardening in vacuum of material 1.2343 (54 HRC).

10.4 Manufacturing of mold inserts
a) Preliminary works
b) Hardening and tempering
c) Mold inserts with circulating cooling system are to be nickel-plated
d) Grinding of snug fits
e) Erosion of contour (roughing, finishing)
f) Perform surface finish as requested

10.5 Edges that are not in the cavity range are to be provided with radii, bevels, or undercuts.

10.6 The holder diameter of mold inserts is to be provided with a bevel on the feed face (exception: areas in cavity).

10.7 Feed incline for packing rings at bores always 3x15°.

10.8 The stability of mold inserts must be guaranteed. Thin walls are to be avoided. (Please note: mold inclines and radii reduce the available surface.)

10.9 Projection of mold inserts: 0.2 mm per side

10.10 Secure cylindrical mold inserts against torsion by means of milled grooves and alignment pins.

10.11 Mold approval

Mold approval according to article drawing ☒

Special solution: ☐

10.11.3 Mold approval for parts made of polyurethane ☐
Since this material is very liquid, it involves particular risk of formation of burrs. Mold-release snug fits are to be manufactured with little clearance. Appropriate measures are to be taken to ensure sufficient airing.

Perform mold release inwards. ☐

10.12 Inserts with external circulating cooling system are to be stepped on the outside diameter (diameter difference at least 2 mm).

11. Surface of Mold Inserts

11.1	High-polished	☐
11.2	Polished (grain size 400)	☐
11.3	Polished (grain size 240)	☐
11.4	Ground	☐
11.5	Erosion rough Ra: 1,6 µ (VDI 3400	☒
11.6	to article drawing	☒

12. Marking of Article

12.1	Cavity number (not on ejector pin)	☒
12.2	Article designation (see article drawing)	☐
12.3	TENTE symbol (see article drawing)	☒
12.4	Material information (see article drawing)	☒
12.5	Year and month stamp: Month of delivery and current year are to be set.	
12.5.1	Standard specification according to TN 473.10 Order No. for year mark Order No. for month mark	☐
12.5.2	The stamps are to be installed in every exchangeable insert.	
12.6	Shore hardness stamp: The respective Shore hardness must be adjustable and legible.	☐
12.6.1	Take the Shore hardnesses to be indicated from the article drawing.	☐

13. Venting

13.1 Take appropriate measures to let the air off the cavities: Air vent gap, air vent bores, air vent ring grooves are to be incorporated by machines and led to the outside.

13.2 In case of pocket bores in the mold, provide air vent pins.

14. Cooling/ Tempering

14.1 Cooling is to be designed for the shortest possible cycle time. It is aimed at maintaining the cooling circuit cross section from inlet to outlet at a constant level. The cooling circuit cross section should be 10 mm in diameter.

14.2 Recesses and grooves of the cooling system are to be provided with radii.

14.3 Connection and sealing nipples, DME- Reform-EOC St 11 13- M14x1.5 (sunk-in if possible). The accessibility of the cooling connections must be ensured (cross-beams to consider)

14.4 The mold should include the cooling systems below:

	ejector-side	Injektor-side
- with cooled cores	☒	☒
- separate cooling for each mold cavity	☒	☒
- common cooling for ... pieces of mold cavities	☐	☐
- use of cooling pins	☐	☐
- separate gate tempering for Mold-Masters hot runner molds		☐
- stripper plate, cooled		☐
- backing plate, cooled	☐	☐
- intermediate plate, cooled		☐
- mold plate, cooled	☒	☒
- mold slides, cooled	☒	☐
- mold jaws, cooled		☐
- sprue cone, cooled	☒	

14.5 Temperature sensor: ☐

14.5.1 Type Manuf.

14.5.2 Position:
Distance of temperature sensor from cavity mm
The position is to be specified during the design assessment. One temperature sensor on the injection side and one on the ejector side.

15. Demolding

- Round ejector pins	☐
- Round ejector pins, torsion-proof	☒
- Flat ejector	☐
- Ejector sleeve	☐
- Stripper plate	☐
- Sprue lifting plate (3-plate mold)	☐
- Hydraulic core puller	☐
- Forced ejection	☐
- Thread ejection with electric drive	☐
- Decomposition core	☐
- slanting ejector	☒

16. Ejection

16.1 For ejector fitting dimensions, please see machine data sheet.

16.1.1 TENTE supplies the ejector coupling.

16.1.2 Number of transmission bolts to ejector plate

one ☐ two ☐ four ☒

16.1.3 The reference diameter for the transmission bolts has to be as large as possible (see machine data sheet).

16.2 Fasten the ejector plates with sufficient number of screws (near the ejector).

16.3 Ejector presser plates – material 2311/2312. In order to avoid deflection of the ejector presser plate, it must be of sufficient thickness.
Selected plate thickness: 22 mm

16.4 The ejector plates are to be provided with two centered guides (self-lubricating bushings) that are mounted horizontally.

16.5 Ejectors must not be used in the area of functional surfaces of articles.

16.6 Design of ejector pins:
Fully-hardened, cylindrical head, ground shaft.

16.7 For reasons of stability, ejector pins of small diameter have to be shouldered at the shaft.

16.8 Ejector pins have to be numbered on the head.

16.9 Ejector pins with nonplanar face have to be torsion-proof.

16.10
- Ejector below each runner.
- Select an appropriate distance to the tunnel according to the material's elasticity.
- For stabilization of the sprue, the ejector pins in the sprue channel and in the individual ramifications of spider gates should be set back 3 mm from the sprue bottom. When required, these 3 mm can be formed as retaining claw. (Only applies to elastic materials.)

16.11 Separate return pins for all ejector planes.
All return pins are to be provided with a bevel.

Diameters of return pins : 14: ☒ 20: ☐

Number of return pins : 4: ☒ 6: ☐ 8: ☐

16.12 Slide molds and molds with core puller have to be designed so that the ejection system is moved back when the slides dip (e.g. by means of return springs).

16.13 Ejector return unit ☐

16.14 Return springs ☐

16.15 Springs: acc. to TN 6.2
Coil springs are to be installed so that 70% of max. allowed spring force will not be exceeded.

16.16 For slide molds with their slides and for core pullers with there cores being in the ejector zone, two limit switches (one at the top, one at the bottom) are required to monitor the end positions of the ejector plates ☒

Limit switch	: by Schmersal type M 6600-11-k-y
Plug system	: by Walther Procon/ socket housing with longitudinal locking bow, order No. 701510
Pin socket	: order No. 700210

16.17 Provide a retaining groove on the ejector side to avoid adhering to the injection side. ☐

16.18 In case of small cold-runner spreaders, the ejector chamber is to be covered on top. ☐

17. Marking of the Mold

17.1 Also imprint the cavity number beside the cavity (on injection side only).

17.2 Inputs and outputs of tempering connections are to be marked.

17.3 Each heating position is to be marked on the terminal box including power and voltage.

17.4 If a mold produces several variants, the exchangeable parts in the mold have to be recognizable from outside. ☐
◎ NL 44
◎ diam. 23
◎ = M8 thread for identifying marking of variant with Allen screw.
Example

17.5

Formnummer	: F 7579 1- fach
Heißkanalsystem	: Mold-Masters
Bauart, Thermofühler	: nicht isoliert
Spannung	: 220 V
Regal Nr.	:
Artikelbezeichnung	: Gabel 5377/125 XL
Zeichnungsnummer	: TR 34541
Material	: PA 6 mit 40% Glasfaser
Einbauhöhe	: mm
Gewicht	: Kg
Wechselteile	: TR 34542
	: TR 34543
	:
	:

17.6 All hardened parts are to be marked with the No. of Material and the hardness.

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18. Sign-off of Parts

18.1 TENTE is committed to sign-off 2 weeks after receipt of the mold at the latest and to notify the result of the dimensional check in writing. ☐
Should this deadline not be met, the stipulated deadline for acceptance will be extended correspondingly.
The term for contractual penalty will then start from the new deadline.

18.2 Sign-off …100……. Parts incl. freight charge are included in price. ☒
The required test material is provided at no charge. Documentation for the parts subjected to sign-off includes a list of the most important sprue parameters as well as a test certificate of all article dimensions.

18.3. Mold filling studies are necessary to ensure that all cavities are filled simultaneously and evenly. The injection parts of the filling study are to be provided.

19. Using Services of the Mold Repair Department of TENTE

If services of TENTE's mold repair department are used for adaptation work or corrections, the supplier will be charged 30.00 EUR per hour.
The supplier shall in advance confirm the take-over of costs.

20. Acceptance

20.1 Prior to final assembling, initial acceptance of the mold is effected by TENTE on the premises of the mold manufacturer.
TENTE is to be notified about the respective date in good time.

20.2 Our inspection department is responsible for acceptance of dimensions and quality of the plastic parts. Only our article drawing is decisive – not the specimens we handed over. The supplier will be informed in writing of the result of the dimensional check within one week.

20.3 Acceptance date is the date when dimensional stability and surface quality of the parts are certified by the test report, the performance test of the mold has been carried out, and any deficiencies have been corrected.

Acceptance date = start of warranty
= start of period of payment for total payment, further partial payments and installment payments
= end of possible contractual penalty

20.4 The stipulated and penalized deadline shall be the deadline for acceptance of mold and part.

Lisa 2

Tellija nõuded survevaluvormi valmistamiseks

21. Deadlines Date

21.1	Completion of the construction	till	: 20.08.10
21.2	Testing of the mold by the supplier	till	: 08.10.10
21.3	Delivery of mold in TENTE	till	: 15.10.10
21.4	Contractual penalty	from	: 18.10.10

22. Contractual Penalty:

In case of non-observance of the above date (points 21.2 + 21.3), a contractual penalty according to the applicable General Purchasing Conditions will be charged.

23. Warranty

Warranty: 24 month, for at least 100.000 shot.
The limitation period restarts, if the supplier provides subsequent performance or accepts claims based on damages of any kind.

This applies to all deficiencies that are due to faulty material, poor design, or improper workmanship.
Excluded are those deficiencies that are due to natural wear and tear.

24. Purchasing Conditions

The Purchasing Conditions as amended shall apply (www.tente.com)

Metalli Uddeholm Arne andmed

General

Arne general purpose oil-hardening tool steel is a versatile manganese-chromium-tungsten steel suitable for a wide variety of cold-work applications. Its main characteristics include:

- Good machinability
- Good dimensional stability in hardening
- A good combination of high surface hardness and toughness after hardening and tempering.

These characteristics combine to give a steel suitable for the manufacture of tooling with good tool-life and production economy.

Arne can be supplied in various finishes including hot-rolled, pre-machined, fine-machined and precision ground. It is also available in the form of hollow bar.

Typical analysis %	C 0,95	Mn 1,1	Cr 0,6	W 0,6	V 0,1
Standard specification	AISI O1, W.-Nr. 1.2510				
Delivery condition	Soft annealed approx. 190 HB				
Colour code	Yellow				

Applications

Tools for	Material thickness	HRC
Cutting Blanking, punching, piercing, cropping, shearing, trimming clipping	up to 3 mm (1/8") 3– 6 mm (1/8–1/4") 6–10 mm (1/4–13/32")	60–62 56–60 54–56
Short cold shears		54–60
Clipping and trimming tools for forgings	Hot Cold	58–60 56–58
Forming Bending, raising, drawing, rim rolling, spinning and flow forming		56–62
Small coining dies		56–60
Gauges, measuring tools Turning centres Guide bushes, ejector pins, high duty, small/medium drills and taps Small gear wheels, pistons, nozzles, cams		58–62

Properties

PHYSICAL DATA

Hardened and tempered to 62 HRC. Data at ambient temperature and elevated temperature.

Temperature	20°C (68°F)	200°C (375°F)	400°C (750°F)
Density			
kg/m³	7 800	7 750	7 700
lbs/in³	0,282	0,280	0,278
Modulus of elasticity			
N/mm²	190 000	185 000	170 000
kp/mm²	19 500	19 000	17 500
tsi	12 500	12 200	11 200
psi	28×10^6	27×10^6	25×10^6
Coefficient of thermal expansion			
per °C from 20°C	–	$11,7 \times 10^{-6}$	$11,4 \times 10^{-6}$
per °F from 68°F	–	$6,5 \times 10^{-6}$	$6,3 \times 10^{-6}$
Thermal conductivity			
W/m °C	32	33	34
Btu in/ft² h °F	222	229	236
Specific heat			
J/kg C	460	–	–
Btu/lb. °F	0,11	–	–

COMPRESSIVE STRENGTH

The figures are to be considered approximate.

Hardness HRC	Compressive strength Rm N/mm²	Rc0,2 N/mm²
62	3000	2200
60	2700	2150
55	2200	1800
50	1700	1350

Clipping and edging tool in Arne tool steel to clip and form edge of 0,914 mm (0,036") thick stainless steel container approx. 254 x 152 x 203 mm (10" x 6" x 8").

Metalli Uddeholm Arne andmed

Heat treatment

SOFT ANNEALING

Protect the steel and heat through to 780°C (1435°F). Then cool in the furnace at 15°C (27°F) per hour to 650°C (1200°F), then freely in air.

STRESS-RELIEVING

After rough machining the tool should be heated through to 650°C (1200°F), holding time 2 hours. Cool slowly to 500°C (930°F) then freely in air.

HARDENING

Preheating temperature: 600–700°C (1110–1290°F)
Austenitizing temperature: 790–850°C (1450–1560°F)

Temperature °C	Temperature °F	Soaking* time minutes	Hardness before tempering
800	1470	30	approx. 65 HRC
825	1520	20	approx. 65 HRC
850	1560	15	approx. 63 HRC

**Soaking time = time at austenitizing temperature after the tool is fully heated through.*

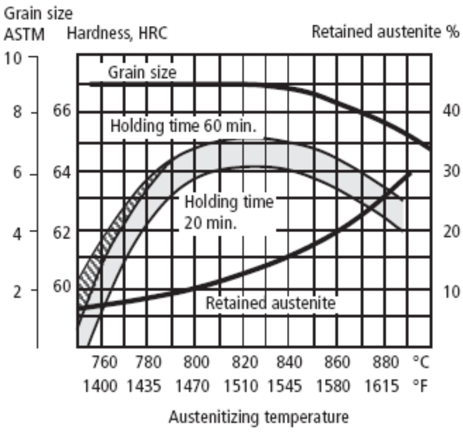
Protect the part against decarburization and oxidation during hardening.

QUENCHING MEDIA

- Oil
- Martempering bath. Temperature 180–225°C (360–435°F), then cooling in air.

Note: Temper the tool as soon as its temperature reaches 50–70°C (120–160°F).

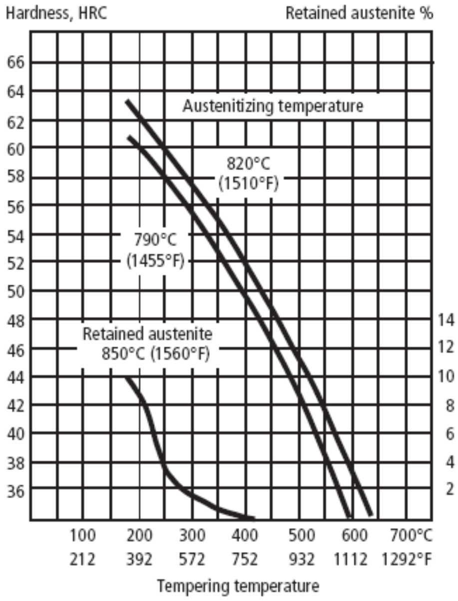
Hardness as a function of hardening temperature



TEMPERING

Choose the tempering temperature according to the hardness required by reference to the tempering graph. Temper twice with intermediate cooling to room temperature. Lowest tempering temperature 180°C (360°F). Holding time at temperature minimum 2 hours.

Tempering graph



MARTEMPERING

Tools at austenitizing temperature are immersed in the martempering bath for the time indicated, then cooled in air to not lower than 100°C (210°F). Temper immediately as with oil-quenching.

Austenitizing temperature °C	Austenitizing temperature °F	Temp. of martemp.bath, °C	Temp. of martemp.bath, °F	Holding time in martemp. bath minutes	Surface hardness prior to tempering (obtained by martempering)
825	1520	225	435	max. 5	64±2 HRC
825	1520	200	390	max. 10	63±2 HRC
825	1520	180	355	max. 20	62±2 HRC
850	1560	225	435	max. 10	62±2 HRC

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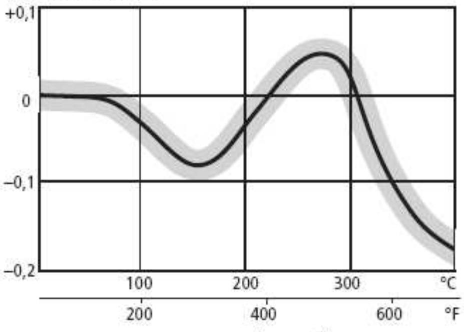
DIMENSIONAL CHANGES DURING HARDENING

Sample plate, 100 x 100 x 25 mm, 4" x 4" x 1"

		Width %	Length %	Thickness %
Oil hardening from 830°C (1530°F)	min.	+0,03	+0,04	–
	max.	+0,10	+0,10	+0,02
Martempering from 830°C (1530°F)	min.	+0,04	+0,06	–
	max.	+0,12	+0,12	+0,02

DIMENSIONAL CHANGES DURING TEMPERING

Plancha de muestra, 100 x 100 x 25 mm



Note: The dimensional changes on hardening and tempering should be added together. Recommended allowance 0,25 %.

Blanking tool made from fine-machined Arne tool steel.

SUB-ZERO TREATMENT AND AGING

Pieces requiring maximum dimensional stability should be sub-zero treated and/or artificially aged, as volume changes may occur in the course of time. This applies, for example, to measuring tools like gauges and certain structural components.

Sub-zero treatment

Immediately after quenching the piece should be sub-zero treated to between –70 and –80°C (–95 to –110°F), soaking time 3–4 hours, followed by tempering or aging. Sub-zero treatment will give a hardness increase of 1–3 HRC. Avoid intricate shapes as there will be risk of cracking.

Aging

Tempering after quenching is replaced by aging at 110–140°C (230–285°F). Holding time 25–100 hours.

Metalli Uddeholm Arne andmed

Machining recommendations

The following tables give machining data for Arne in soft annealed condition. Hardness 190 HB. The data are to be considered as guiding values, which must be adapted to existing local conditions.

TURNING

Cutting data parameters	Turning with carbide: Rough turning	Turning with carbide: Fine turning	Turning with high speed steel: Fine turning
Cutting speed (v_c) m/min f.p.m.	160–210 525–690	210–260 690–850	20–25 65–80
Feed (f) mm/r i.p.r.	0,2–0,4 0,008–0,016	0,05–0,2 0,002–0,008	0,05–0,3 0,002–0,01
Depth of cut (a_p) mm inch	2–4 0,08–0,2	0,5–2 0,02–0,08	0,5–3 0,02–0,10
Carbide designation ISO	P20–P30 Coated carbide	P10 Coated carbide or cermet	—

MILLING

Face and square shoulder milling

Cutting data parameters	Milling with carbide: Rough milling	Milling with carbide: Fine milling
Cutting speed (v_c) m/min f.p.m.	170–250 560–820	250–290 820–950
Feed (f_z) mm/tooth inch/tooth	0,2–0,4 0,008–0,016	0,10–0,2 0,004–0,008
Depth of cut (a_p) mm inch	2–5 0,08–0,2	–2 –0,08
Carbide designation ISO	P20–P40 Coated carbide	P10–P20 Coated carbide or cermet

End milling

Cutting data parameters	Type of milling: Solid carbide	Carbide indexable insert	High speed steel
Cutting speed (v_c) m/min f.p.m.	150–190 490–620	160–220 525–720	25–30[1] 80–100[1]
Feed (f_z) mm/tooth inch/tooth	0,03–0,2[2] 0,0012–0,008[2]	0,08–0,2[2] 0,003–0,008[2]	0,05–0,35[2] 0,002–0,014[2]
Carbide designation ISO	K20, P40	P20–P30	—

[1] *For coated end mills v_c = 45–50 m/min. (150–160 f.p.m.)*
[2] *Depending on radial depth of cut and cutter diameter.*

DRILLING

High speed steel twist drill

Drill diameter mm	Drill diameter inch	Cutting speed (v_c) m/min	Cutting speed (v_c) f.p.m.	Feed (f) mm/r	Feed (f) i.p.r.
– 5	–3/16	15–17*	49–56*	0,08–0,20	0,003–0,008
5–10	3/16–3/8	15–17*	49–56*	0,20–0,30	0,008–0,012
10–15	3/8–5/8	15–17*	49–56*	0,30–0,35	0,012–0,014
15–20	5/8–3/4	15–17*	49–56*	0,35–0,40	0,014–0,016

* *For coated HSS drills v_c = 26–28 m/min. (85–90 f.p.m.)*

Carbide drill

Cutting data parameters	Type of drill: Indexable insert	Solid carbide	Taladro con Brazed carbide[1]
Cutting speed (v_c) m/min f.p.m.	200–220 655–720	110–140 360–460	70–90 230–295
Feed (f) mm/r i.p.r.	0,05–0,25[2] 0,002–0,01[2]	0,10–0,25[2] 0,004–0,01[2]	0,15–0,25[2] 0,006–0,01[2]

[1] *Drills with internal cooling channels and brazed carbide tip*
[2] *Depending on drill diameter*

GRINDING

General grinding wheel recommendation for Arne is given below. More information can be found in the Uddeholm publication "Grinding of Tool Steel".

Type of grinding	Wheel recommendation: Soft annealed condition	Wheel recommendation: Hardened condition
Face grinding straight wheel	A 46 HV	A 46 HV
Face grinding segments	A 24 GV	A 36 GV
Cylindrical grinding	A 46 LV	A 60 KV
Internal grinding	A 46 JV	A 60 IV
Profile grinding	A 100 LV	A 120 JV

Lisa 3

Metalli Uddeholm Arne andmed

Welding

Good results when welding tool steel can be achieved if proper precautions are taken during welding (elevated working temperature, joint preparation, choice of consumables and welding procedure). If the tool is to be polished or photo-etched, it is necessary to work with an electrode type of matching composition.

Welding method	Working temperature	Consumables	Hardness after welding
MMA (SMAW)	200–250°C	AWS E312 84.52 UTP 67S Castolin 2 Castolin N 102	300 HB ESAB OK 53–54 HRC 55–58 HRC 54–60 HRC 54–60 HRC
TIG	200–250°C	AWS ER312 UTPA 67S UTPA 73G2 Castotig 5	300 HB 55–58 HRC 53–56 HRC 60–64 HRC

Electrical-discharge machining

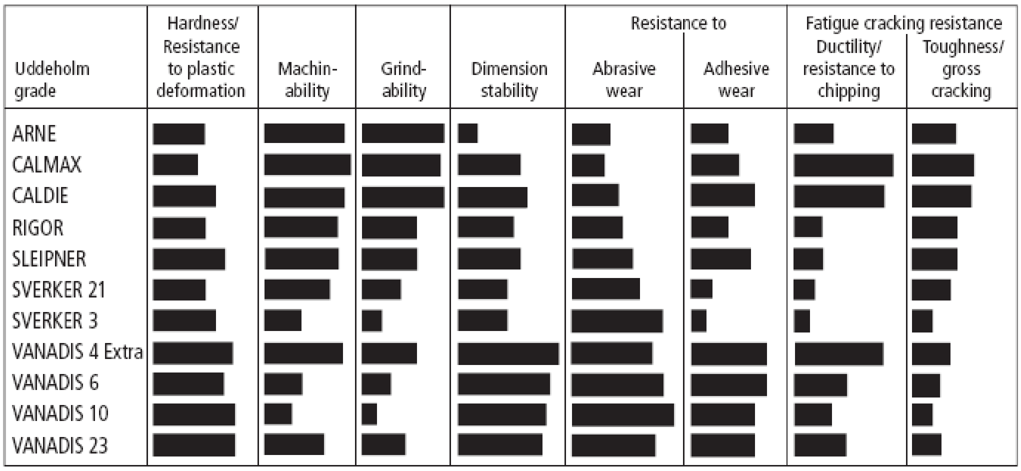
If spark-erosion, EDM, is performed in the hardened and tempered condition, the tool should then be given an additional temper at approx. 25°C (50°F) below the previous tempering temperature.

Further information

Please contact your local Uddeholm office for further information on the selection, heat treatment, application and availability of Uddeholm tool steels.

Relative comparison of Uddeholm cold work tool steel

MATERIAL PROPERTIES AND RESISTANCE TO FAILURE MECHANISMS



Lisa 4

Metalli Uddeholm Grane andmed

General

Grane is a Chromium-Nickel-Molydenum-alloyed steel which is characterized by

- high toughness
- high hardness
- good stability in hardening
- high resistance to wear
- good polishing properties
- good machinability.

Typical analysis %	C 0,55	Si 0,3	Mn 0,5	Cr 1,0	Ni 3,0	Mo 0,3
Standard specification	(AISI L6)					
Delivery condition	Soft annealed to approx. 230 HB.					
Colour code	Orange/White					

Applications

The excellent combination of toughness and wear resistance offered by Grane enables it to be used for a great many tooling applications, both hot and cold. It is widely used for moulds in the plastics industry and for a variety of heavy-duty tools exposed to severe pressure, shock loading or bending stresses.

The relatively high hardness (max. 56 HRC) obtainable with Grane, makes it especially suitable for long-life moulding tools, which also require a good level of toughness.

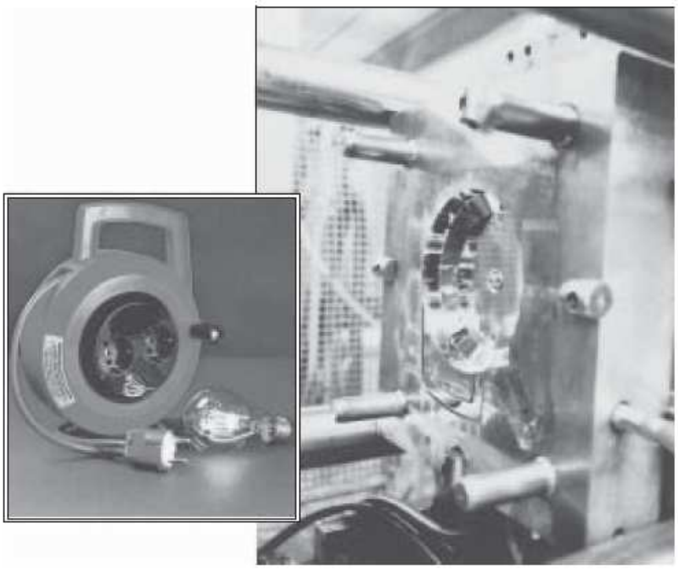
Application	HRC
Moulds for plastics:	
Injection moulds for:	
– thermoplastic materials	50–56
– thermosetting materials	50–56
Compression/transfer moulds	50–56
Shear blades (hot)	50–54
Shear blades (cold)	52–56
Drop forging dies	37–47
Cold stamping dies	40–50
Cold pressing tools; bending tools	52–56
Coining dies (cold)	52–56
High-strength constructional parts	40–56

Properties

PHYSICAL DATA

Hardened and tempered to 54 HRC. Data at room and elevated temperatures.

Temperature	20°C (68°F)	200°C (390°F)	400°C (750°F)
Density, kg/m^3	7 880	7 850	7 800
lbs/in^3	0,284	0,283	0,282
Modulus of elasticity N/mm^2	200 000	190 000	170 000
tsi	12 900	12 260	10 970
psi	$29,0 \times 10^6$	$27,6 \times 10^6$	$24,7 \times 10^6$
Coefficient of thermal expansion /°C from 20°C	–	$10,8 \times 10^{-6}$	$11,9 \times 10^{-6}$
/°F from 68°F		$6,0 \times 10^{-6}$	$6,6 \times 10^{-6}$
Thermal conductivity W/m °C	–	29	33
Btu in/(ft^{2}h °F)	–	202	229
Specific heat, J/kg °C	460	–	–
Btu/lb. °F	0,110		



Metalli Uddeholm Grane andmed

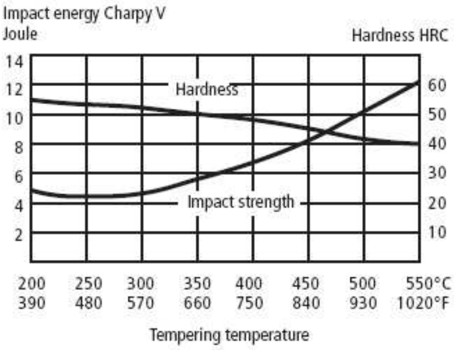
TENSILE STRENGTH AT ROOM TEMPERATURE

The tensile strength values are to be considered as approximate only. All specimens were taken from a bar Ø 25 mm (in the rolling direction). Hardened in oil from 850 ± 10°C (1560 ± 20°F) and tempered twice to the hardness indicated.

Hardness	56 HRC	43 HRC
Tensile strength Rm N/mm² psi	 2 050 297 000	 1 400 203 000
Yield point Rp 0,2 N/mm² psi	 1 670 242 000	 1 300 189 000

IMPACT STRENGTH AT ROOM TEMPERATURE

The impact energy values are to be considered as approximate. The specimens were taken from a bar 250 x 80 mm (9,85 x 3,15"). They were austenitized 30 minutes at 840°C (1540°F), air quenched and tempered twice.



Mould for production of cullanders,

Heat Treatment

SOFT ANNEALING

Protect the steel and heat through to 770°C (1420°F). Then cool in the furnace at 10°C (20°F) per hour to 600°C (1110°F), then freely in air. Reheat to 650°C (1200°F) – holding time 10 h. Furnace cooling to 500°C (930°F), then freely in air.

STRESS-RELIEVING

After rough machining the tool should be heated through to 650°C (1200°F), holding time two hours. Cool slowly to 500°C (930°F), then freely in air.

HARDENING

Preheating temperature: 600–700°C (1110–1290°F).
Austenitizing temperature: 800–860°C (1470–1580°F), but usually 840°C (1550°F).

Temperature °C	Temperature °F	Soaking time* minutes	Hardness before tempering (HRC)
800	1470	30	57± 2
825	1520	30	58±2
860	1580	30	59±2

** Soaking time = time at hardening temperature after the tool is fully heated through.*

Protect the part against decarburization and oxidation during hardening.

QUENCHING MEDIA

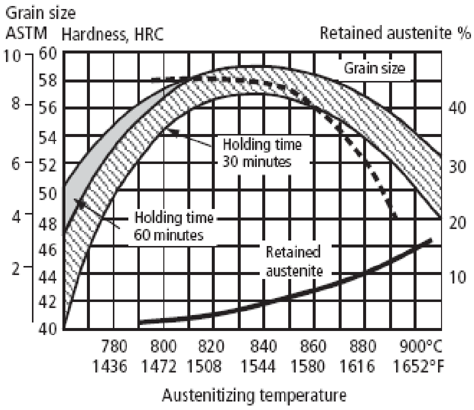
- High speed gas or circulating atmosphere
- Fluidized bed or martempering bath at 200–550°C (390–1020°F) for 15–30 minutes, then cool in air.
- Oil

In order to obtain optimum properties, the cooling rate should be as fast as is concomitant with acceptable distortion. Temper immediately when the tool reaches 50–70°C (120–160°F).

Lisa 4

Metalli Uddeholm Grane andmed

Hardness, grain size and retained austenite as a function of the austenitizing temperature

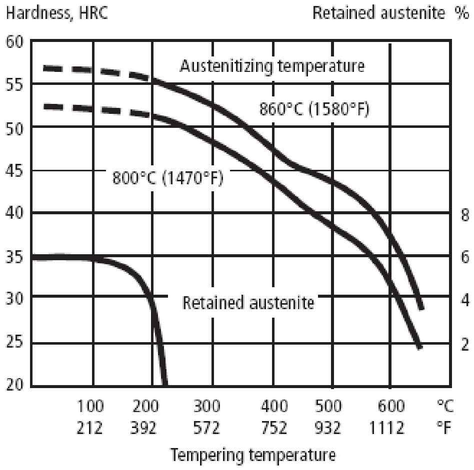


TEMPERING

Choose the tempering temperature according to the hardness required by reference to the tempering graph. Temper twice with intermediate cooling to room temperature. Lowest tempering temperature 180°C (360°F). Holding time at temperature minimum 2 hours.

To avoid "temper brittleness" do not temper in the range 300–350°C (570–660°F).

Tempering graph



Above curves are valid for small samples. Achieved hardness depends on mould size.

DIMENSIONAL CHANGES DURING HARDENING AND TEMPERING

The dimensional changes during hardening and tempering vary depending on temperatures, type of equipment and cooling media used during heat treatment.

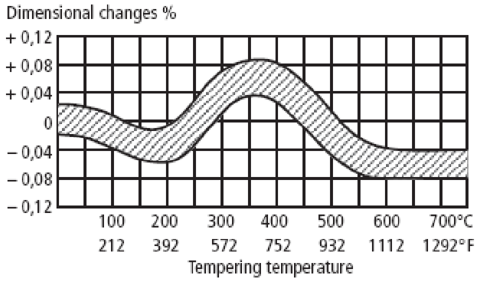
The size and geometric shape of the tool is also of essential importance.

Thus, the tool shall always be manufactured with enough working allowance to compensate for dimensional changes. Use 0,15% as a guideline for Grane.

An example of dimensional changes on a plate, hardened under ideal conditions, 100 x 100 x 25 mm (4" x 4" x 1") are shown below.

Hardening from 825°C (1520°F)		Width %	Length %	Thick-ness %
Oil hardened	Min.	+ 0,06	+ 0,08	0
	Max.	+ 0,12	+ 0,13	+ 0,08
Martempered	Min.	0	+ 0,07	+ 0,05
	Max.	+ 0,01	+ 0,08	– 0,04
Air/Vacuum hardened	Min.	+ 0,02	– 0,01	+ 0,15
	Max.	+ 0,04	– 0,05	+ 0,15

DIMENSIONAL CHANGES DURING TEMPERING



Note: Dimensional changes during hardening and tempering should be added together.

NITRIDING

Prior to nitriding the tool should be hardened and tempered at a temperature at leas 20°C higher than the nitriding temperature.

Nitriding gives a hard surface which is very resistant to wear and erosion. A nitrided surface also increases the corrosion resistance. The surface hardness after nitriding at a temperature of 525°C (980°F) in ammonia gas will be approx. 600 HV.

Metalli Uddeholm Grane andmed

Nitriding temperature °C	°F	Nitriding time hours	Depth of case approx. in.	mm
525	980	10	0,008	0,20
525	980	30	0,012	0,30
525	980	60	0,016	0,40

NITRO-CARBURIZING

Nitro-carburizing of hardened and tempered Grane at 580°C (1080°F) will give a surface hardness of approx. 450 HV. After 2 hours' treatment, the hard layer will be approx. 0,15 mm (0,006 in.) thick.

Cutting data recommendations

The cutting data below are to be considered as guiding values which must be adapted to existing local conditions. More information can be found in the Uddeholm publication "Cutting data recommendations".

TURNING

Cutting data parameters	Turning with carbide Rough turning	Fine turning	Turning with high speed steel Fine turning
Cutting speed (v_c) m/min f.p.m.	150–200 490–655	200–250 655–820	20–25 65–80
Feed (f) mm/r i.p.r.	0,2–0,4 0,008–0,016	0,05–0,2 0,002–0,008	0,05–0,3 0,002–0,012
Depth of cut (a_p) mm inch	2–4 0,08–0,16	0,5–2 0,02–0,08	0,5–2 0,02–0,08
Carbide designation ISO	P20–P30 Coated carbide	P10 Coated carbide or cermet	–

MILLING

Face- and square shoulder milling

Cutting data parameters	Milling with carbide Rough milling	Fine milling
Cutting speed (v_c) m/min f.p.m.	140–230 460–755	230–270 755–886
Feed (f_z), mm/tooth inch/tooth	0,2–0,4 0,008–0,016	0,1–0,2 0,004–0,008
Depth of cut (a_p), mm inch	2–5 0,08–0,20	–2 –0,08
Carbide designation ISO	P20–P40 Coated carbide	P10–P20 Coated carbide or cermet

End milling

Cutting data parameters	Type of milling: Solid carbide	Carbide indexable insert	High speed steel
Cutting speed (v_c) m/min f.p.m.	110–140 360–460	130–180 430–600	30–35[1] 100–115[1]
Feed (f_z) mm/tooth inch/tooth	0,01–0,2[2] 0,0004–0,008[2]	0,06–0,2[2] 0,002–0,008[2]	0,01–0,35[2] 0,0004–0,014[2]
Carbide designation ISO	–	P20, P40	–

[1] For coated HSS end mill v_c = 50–55 m/min. (164–180 f.p.m.)
[2] Depending on radial depth of cut and cutter diameter.

DRILLING

High speed steel twist drill

Drill diameter mm	inch	Cutting speed (v_c) m/min	f.p.m.	Feed (f) mm/r	i.p.r.
– 5	–3/16	15–17*	49–56*	0,05–0,15	0,002–0,006
5–10	3/16–3/8	15–17*	49–56*	0,15–0,20	0,006–0,008
10–15	3/8–5/8	15–17*	49–56*	0,20–0,25	0,008–0,010
15–20	5/8–3/4	15–17*	49–56*	0,25–0,35	0,010–0,014

** For coated HSS drill v_c = 26–28 m/min. (85– 92 f.p.m.)*

Carbide drill

Cutting data parameters	Type of drill: Indexable insert	Solid carbide	Brazed carbide[1]
Cutting speed (v_c) m/min f.p.m.	200–220 655–720	120–150 390–490	70–90 230–295
Feed (f) mm/r i.p.r.	0,05–0,15[2] 0,002–0,006[2]	0,10–0,25[2] 0,004–0,01[2]	0,15–0,25[2] 0,006–0,01[2]

[1] Drill with internal cooling channels and brazed carbide tip.
[2] Depending on drill diameter.

GRINDING

A general grinding wheel recommendation is given below. More information can be found in the Uddeholm publication "Grinding of Tool Steel".

Wheel recommendation.

Type of grinding	Soft annealed condition	Hardened condition
Face grinding straight wheel	A 46 HV	A 46 HV
Face grinding segments	A 24GV	A 36 GV
Cylindrical grinding	A 46 LV	A 60 KV
Internal grinding	A 46 JV	A 60 JV
Profile grinding	A 100 KV	A 120 JV

Metalli Uddeholm Grane andmed

Electrical-discharge machining

If spark-erosion is performed in the hardened and tempered condition, the tool should then be given an additional temper at about 25°C (50°F) lower than previous tempering temperature.

Welding

Good results when welding tool steel can be achieved if proper precautions are taken to elevated working temperature, joint preparation, choice of consumables and welding procedure.

Welding method	TIG	MMA (SMAW)
Working temperature	225–275°C (440–520°F)	225–275°C (440–520°F)
Consumables	UTPA 73G2 UTPA 67S	UTP 73G2 UTP 67S
Hardness after welding	55–58 HRC	55–58 HRC

Further information is given in the Uddeholm brochure "Welding of Tool Steels".

Hard-chromium-plating

After hard-chromium-plating, the tool should be tempered for approx. 4 hours at 180°C (360°F) in order to avoid hydrogen embrittlement.

Photo-etching

Grane has a very homogeneous structure with a low content of non-metallic inclusions, having been subjected to the vacuum degassing process during manufacture. This ensures accurate and consistent pattern reproduction from the photo-etching process.

Further information is given in the Uddeholm brochure "Photo-etching of Tool Steel".

Polishing

Grane has good polishability in the hardened and tempered condition.

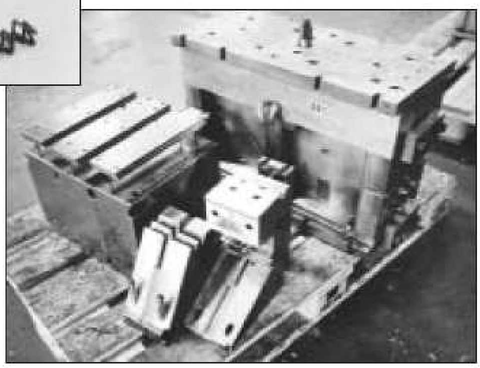
Each steel grade has an optimum polishing time which largely depends on hardness and polishing technique. Overpolishing can lead to a poor surface finish (e.g. an "orange peel" effect).

Further information is given in the Uddeholm brochure "Polishing of Tool Steel".

Further information

Please contact your local Uddeholm office for further information on the selection, heat treatment, application and availability of Uddeholm tool steels.

Mould for production of household articles.



Metalli Uddeholm Orvar Supreme andmed

General

Orvar Supreme is a chromium-molybdenum-vanadium-alloyed steel which is characterized by:

- High level of resistance to thermal shock and thermal fatigue
- Good high-temperature strength
- Excellent toughness and ductility **in all directions**
- Good machinability and polishability
- Excellent through-hardening properties
- Good dimensional stability during hardening.

Typical analysis %	C 0,39	Si 1,0	Mn 0,4	Cr 5,2	Mo 1,4	V 0,9
Standard specification	Premium AISI H13, W.-Nr. 1.2344					
Delivery condition	Soft annealed to approx. 180 HB					
Colour code	Orange					

IMPROVED TOOLING PERFORMANCE

The name "SUPREME" implies that by special processing techniques and close control, the steel attains high purity and a very fine structure. Further, Orvar Supreme shows significant improvements in isotropic properties compared to conventionally produced AISI H 13 grades.

These improved isotropic properties are particularly valuable for tooling subjected to high mechanical and thermal fatigue stresses, e.g. die casting dies, forging tools and extrusion tooling. In practical terms, tools may be used at somewhat higher working hardnesses (+1 to 2 HRC) without loss of toughness. Since increased hardness slows down the formation of heatchecking cracks, improved tool performance can be expected.

Orvar Supreme meets the North American Die Casting Association (NADCA) #207-2003 for **premium** high quality H-13 die steel.

Applications

TOOLS FOR DIE CASTING

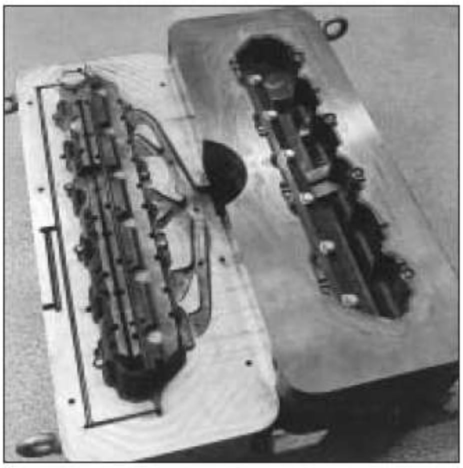
Part	Tin, lead zinc alloys HRC	Aluminium, magnesium alloys, HRC	Copper alloys HRC
Dies	46–50	42–48	(QRO 90 S)
Fixed inserts cores	46–52	44–48	(QRO 90 S)
Sprue parts	48–52	46–48	(QRO 90 S)
Nozzles	35–42	42–48	(QRO 90 S)
Ejector pins (nitrided)	46–50	46–50	46–50
Plunger, shot-sleeve (normally nitrided)	42–46	42–48	(QRO 90 S)
Austenitizing temperature	1020–1030°C (1870–1885°F)		1040–1050°C (1900–1920°F)

TOOLS FOR EXTRUSION

Part	Aluminium, magnesium alloys, HRC	Copper alloys HRC	Stainless steel HRC
Dies	44–50	43–47	45–50
Backers, die-holders, liners, dummy blocks, stems	41–50	40–48	40–48
Austenitizing temperature (approx.)	1020–1030°C (1870–1885°F)	1040–1050°C (1900–1920°F)	

TOOLS FOR HOT PRESSING

Material	Aust. temp. (approx.)	HRC
Aluminium, magnesium	1020–1030°C (1870–1885°F)	44–52
Copper alloys	1040–1050°C (1900–1920°F)	44–52
Steel	1040–1050°C (1900–1920°F)	40–50



Metalli Uddeholm Orvar Supreme andmed

MOULDS FOR PLASTICS

Part	Austenitizing temp.	HRC
Injection moulds Compression/ transfer moulds	1020–1030°C (1870–1885°F) Tempering 250°C (480°F)	50–52

OTHER APPLICATIONS

Application	Austenitizing temp.	HRC
Severe cold punching, scrap shears	1020–1030°C (1870–1885°F) Tempering 250°C (480°F)	50–52
Hot shearing	1020–1030°C (1870–1885°F) Tempering 1. 250°C (480°F) or 2. 575–600°C (1070–1110°F)	50–52 45–50
Shrink rings (e.g. for cemented carbide dies)	1020–1030°C (1870–1885°F) Tempering 575–600°C (1070–1110°F)	45–50
Wear-resisting parts	1020–1030°C (1870–1885°F) Tempering 575°C (1070°F) Nitriding	Core 50–52 Surface ~1000HV$_1$

Properties

All specimens are taken from the centre of a 407 x 127 mm (16" x 5") bar. Unless otherwise is indicated all specimens were hardened 30 minutes at 1025°C (1875°F), quenched in air and tempered 2 + 2 h at 610°C (1130°F). The hardness were 45 ± 1 HRC.

PHYSICAL DATA

Data at room and elevated temperatures.

Temperature	20°C (68°F)	400°C (750°F)	600°C (1110°F)
Density kg/m³ lbs/in³	7800 0,281	7700 0,277	7600 0,274
Modulus of elasticity MPa psi	210 000 30,5 x 10⁶	180 000 26,1 x 10⁶	140 000 20,3 x 10⁶
Coefficient of thermal expansion per °C from 20°C °F from 68°F	– –	12,6 x 10⁻⁶ 7,0 x 10⁻⁶	13,2 x 10⁻⁶ 7,3 x 10⁻⁶
Thermal conductivity W/m °C Btu in/(ft²h°F)	25 176	29 204	30 211

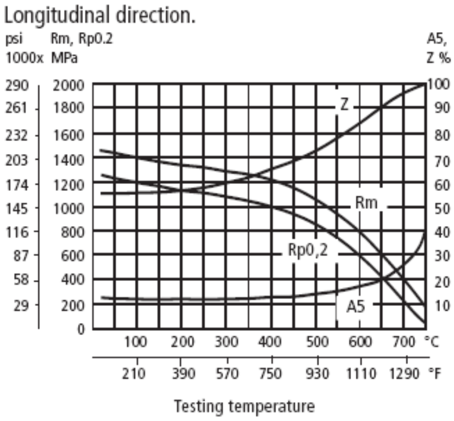
MECHANICAL PROPERTIES

Approximate tensile strength at room temperature.

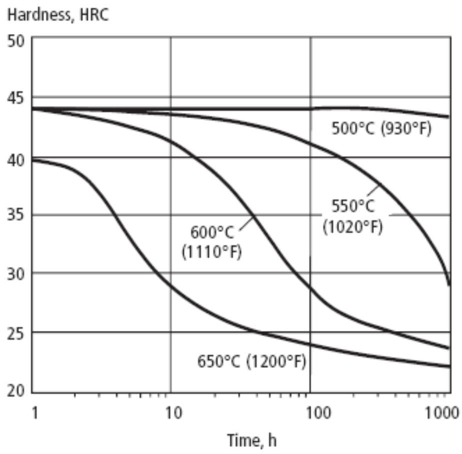
Hardness	52 HRC	45 HRC
Tensile strength Rm	1820 MPa 185 kp/mm² 117 tsi 263 000 psi	1420 MPa 145 kp/mm² 92 tsi 206 000 psi
Yield strength Rp0,2	1520 MPa 155 kp/mm² 98 tsi 220 000 psi	1280 MPa 130 kp/mm² 83 tsi 185 000 psi

Approximate strength at elevated temperatures

Longitudinal direction.



Effect of time at high temperatures on hardness

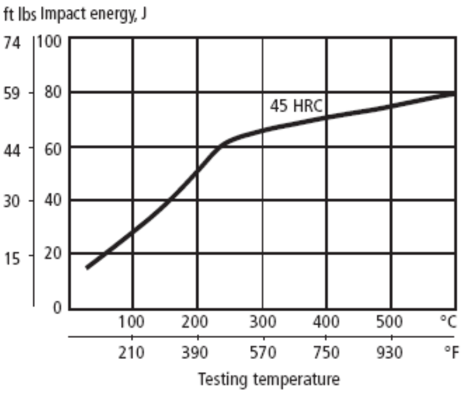


Lisa 5

Metalli Uddeholm Orvar Supreme andmed

Effect of testing temperature on impact energy

Charpy V specimens, short transverse direction.



Heat treatment– general recommendations

SOFT ANNEALING

Protect the steel and heat through to 850°C (1560°F). Then cool in the furnace at 10°C (20°F) per hour to 650°C (1200°F), then freely in air.

STRESS RELIEVING

After rough machining the tool should be heated through to 650°C (1200°F), holding time 2 hours. Cool slowly to 500°C (930°F), then freely in air.

HARDENING

Pre-heating temperature: 600–850°C (1110–1560°F), normally in two pre-heating steps.

Austenitizing temperature: 1020–1050°C (1870–1920°F), normally 1020–1030°C (1870–1885°F).

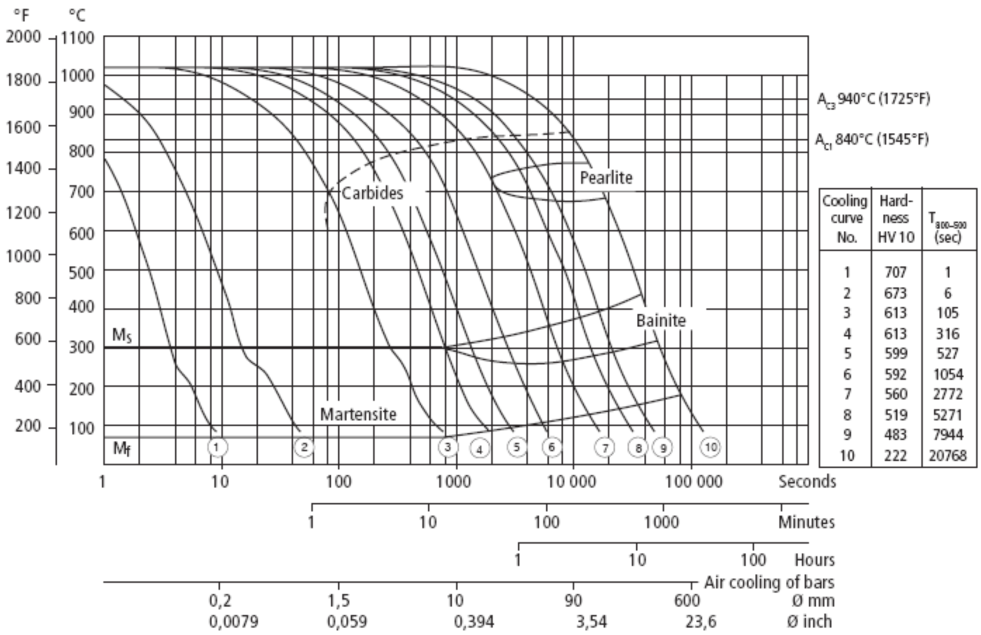
Temperature °C	°F	Soaking* time minutes	Hardness before tempering
1025 1050	1875 1920	30 15	53±2 HRC 54±2 HRC

** Soaking time = time at hardening temperature after the tool is fully heated through.*

Protect the part against decarburization and oxidation during hardening.

CCT graph

Austenitizing temperature 1020°C (1870°F). Holding time 30 minutes.



Cooling curve No.	Hard-ness HV 10	$T_{800-500}$ (sec)
1	707	1
2	673	6
3	613	105
4	613	316
5	599	527
6	592	1054
7	560	2772
8	519	5271
9	483	7944
10	222	20768

Metalli Uddeholm Orvar Supreme andmed

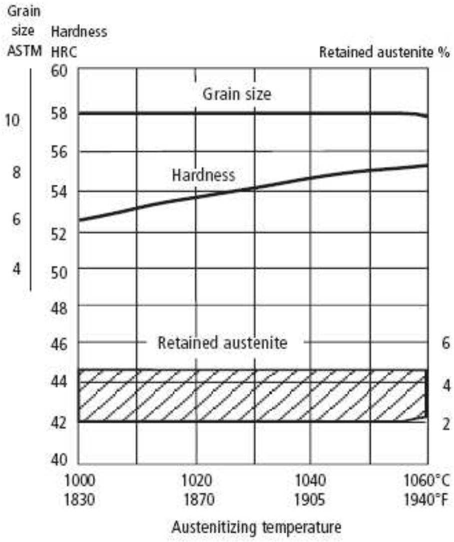
QUENCHING MEDIA

- High speed gas/circulating atmosphere
- Vacuum (high speed gas with sufficient positive pressure). An interrupted quench is recommended where distortion control and quench cracking are a concern
- Martempering bath or fluidized bed at 450–550°C (840–1020°F), then cool in air
- Martempering bath or fluidized bed at approx. 180–220°C (360–430°F) then cool in air
- Warm oil.

Note 1: Temper the tool as soon as its temperature reaches 50–70°C (120–160°F).

Note 2: In order to obtain the optimum properties for the tool, the cooling rate should be fast, but not at a level that gives excessive distortion or cracks.

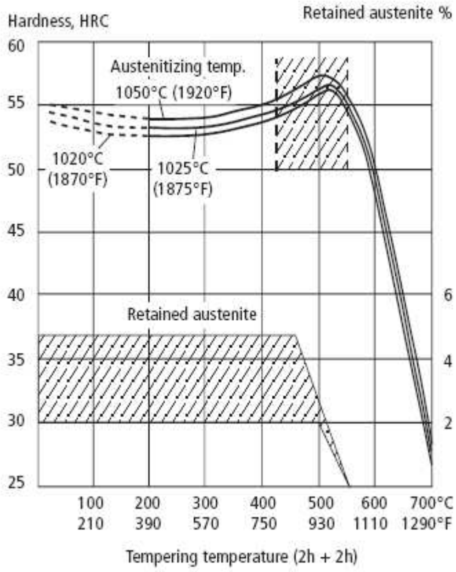
Hardness, grain size and retained austenite as functions of austenitizing temperature

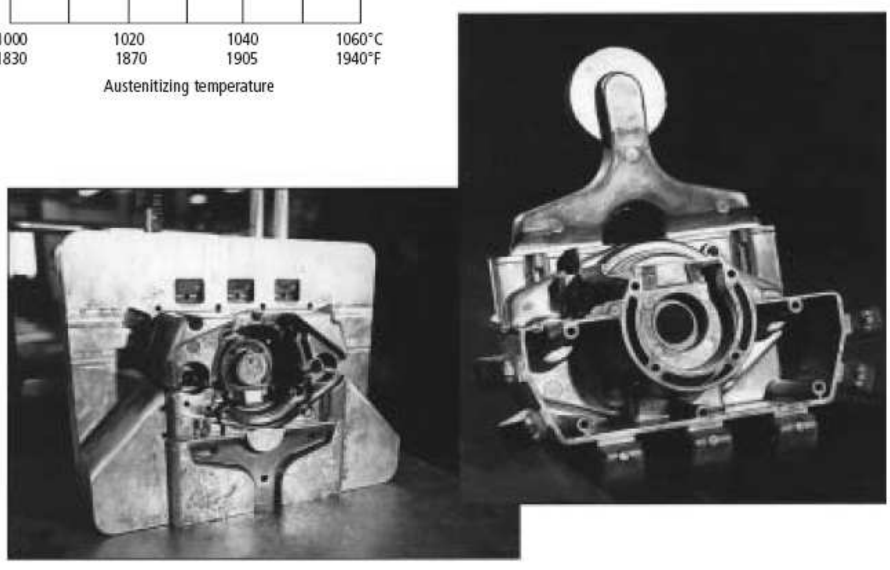


TEMPERING

Choose the tempering temperature according to the hardness required by reference to the tempering graph. Temper minimum twice with intermediate cooling to room temperature. Lowest tempering temperature 250°C (480°F). Holding time at temperature minimum 2 hours. To avoid "temper brittleness", do not temper in the range 425–550°C (800–1020°F), see graph.

Tempering graph

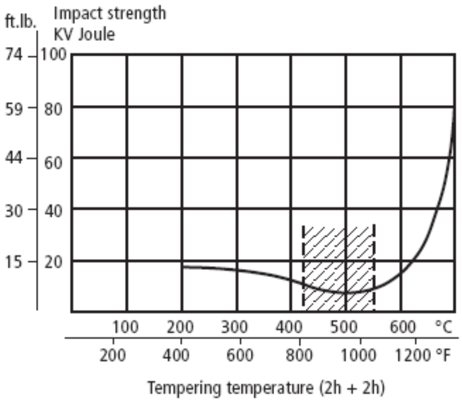




Metalli Uddeholm Orvar Supreme andmed

Approximate impact strength at different tempering temperatures.

Charpy V specimens, short transverse direction.



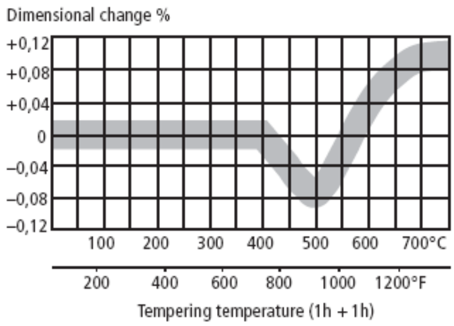
Tempering within the range 425–550°C (800–1020°F) is normally not recommended due to the reduction in toughness properties.

DIMENSIONAL CHANGES DURING HARDENING

Sample plate, 100 x 100 x 25 mm, 4" x 4" x 1".

		Width %	Length %	Thickness %
Oil hardened from 1020°C (1870°F)	Min.	–0,08	–0,06	±0
	Max.	–0,15	–0,16	+0,30
Air hardened from 1020°C (1870°F)	Min.	–0,02	–0,05	±0
	Max.	+0,03	+0,02	+0,05
Vac hardened from 1020°C (1870°F)	Min.	+0,01	–0,02	+0,08
	Max.	+0,02	–0,04	+0,12

DIMENSIONAL CHANGES DURING TEMPERING



Note: The dimensional changes in hardening and tempering should be added.

NITRIDING AND NITROCARBURIZING

Nitriding and nitrocarburizing result in a hard surface layer which is very resistant to wear and erosion. The nitrided layer is, however, brittle and may crack or spall when exposed to mechanical or thermal shock, the risk increasing with layer thickness. Before nitriding, the tool should be hardened and tempered at a temperature at least 25–50°C (45–90°F) above the nitriding temperature.

Nitriding in ammonia gas at 510°C (950°F) or plasma nitriding in a 75% hydrogen/25% nitrogen mixture at 480°C (895°F) both result in a surface hardness of about 1100 $HV_{0,2}$. In general, plasma nitriding is the preferred method because of better control over nitrogen potential; in particular, formation of the so-called white layer, which is not recommended for hot-work service, can readily be avoided. However, careful gas nitriding can give perfectly acceptable results.

Orvar Supreme can also be nitrocarburized in either gas or salt bath. The surface hardness after nitrocarburizing is 900–1000 $HV_{0,2}$.

DEPTH OF NITRIDING

Process	Time	Depth mm	Depth inch
Gas nitriding at 510°C (950°F)	10 h 30 h	0,12 0,20	0,0047 0,0079
Plasma nitriding at 480°C (895°F)	10 h 30 h	0,12 0,18	0,0047 0,0071
Nitrocarburizing – in gas at 580°C (1075°F)	2,5 h	0,11	0,0043
– in salt bath at 580°C (1075°F)	1 h	0,06	0,0024

Nitriding to case depths >0,3 mm (>0,012 inch) is not recommended for hot-work applications.

Orvar Supreme can be nitrided in the soft-annealed condition. The hardness and depth of case will, however, be reduced somewhat in this case.

Metalli Uddeholm Orvar Supreme andmed

Machining recommendations

The cutting data below are to be considered as guiding values, which must be adapted to existing local conditions.

More information can be found in the Uddeholm publication "Cutting data recommendation".

TURNING

Cutting data parameters	Turning with carbide: Rough turning	Turning with carbide: Fine turning	Turning with high speed steel: Fine turning
Cutting speed (v_c) m/min	200–250	250–300	25–30
f.p.m.	660–820	820–985	82–100
Feed (f) mm/r	0,2–0,4	0,05–0,2	0,05–0,3
i.p.r.	0,008–0,016	0,002–0,008	0,002–0,012
Depth of cut (a_p) mm	2–4	0,5–2	0,5–2
inch	0,08–0,16	0,02–0,08	0,02–0,08
Carbide designation ISO	P20–P30 Coated carbide	P10 Coated carbide or cermet	–

DRILLING

High speed steel twist drill

Drill diameter mm	Drill diameter inch	Cutting speed, v_c m/min	Cutting speed, v_c f.p.m.	Feed, f mm/r	Feed, f i.p.r.
– 5	–3/16	16–18*	52–59*	0,05–0,15	0,002–0,006
5–10	3/16–3/8	16–18*	52–59*	0,15–0,20	0,006–0,008
10–15	3/8–5/8	16–18*	52–59*	0,20–0,25	0,008–0,010
15–20	5/8–3/4	16–18*	52–59*	0,25–0,35	0,010–0,014

** For coated HSS drill v_c 28–30 m/min. (92–98 f.p.m.).*

Carbide drill

Cutting data parameters	Type of drill: Indexable insert	Type of drill: Solid carbide	Type of drill: Brazed carbide[1]
Cutting speed (v_c) m/min	220–240	130–160	80–110
f.p.m.	720–785	425–525	260–360
Feed (f) mm/r	0,03–0,10[2]	0,10–0,25[2]	0,15–0,25[2]
i.p.r.	0,001–0,004[2]	0,004–0,010[2]	0,006–0,010[2]

[1] Drill with internal cooling channels and brazed carbide tip.
[2] Depending on drill diameter.

MILLING

Face milling and square shoulder face milling

Cutting data parameters	Milling with carbide: Rough milling	Milling with carbide: Fine milling
Cutting speed (v_c) m/min	180–260	260–300
f.p.m.	590–850	850–985
Feed (f_z) mm/tooth	0,2–0,4	0,1–0,2
inch/tooth	0,008–0,016	0,004–0,008
Depth of cut (a_p) mm	2–5	–2
inch	0,08–0,20	–0,08
Carbide designation ISO	P20–P40 Coated carbide	P10–P20 Coated carbide or cermet

End milling

Cutting data parameters	Type of end mill: Solid carbide	Type of end mill: Carbide indexable insert	Type of end mill: High speed steel
Cutting speed (v_c) m/min	160–200	170–230	35–40[1]
f.p.m.	525–660	560–755	115–130[1]
Feed (f_z) mm/tooth	0,03–0,20[2]	0,08–0,20[2]	0,05–0,35[2]
inch/tooth	0,001–0,008[2]	0,003–0,008[2]	0,002–0,014[2]
Carbide designation ISO	–	P20, P30	–

[1] For coated HSS end mill v_c 55–60 m/min. (180–195 f.p.m.).
[2] Depending on radial depth of cut and cutter diameter.

GRINDING

A general grinding wheel recommendation is given below. More information can be found in the Uddeholm brochure "Grinding of Tool Steel" and can also be obtained from the grinding wheel manufacturer.

Wheel recommendation

Type of grinding	Soft annealed condition	Hardened condition
Face grinding straight wheel	A 46 HV	A 46 HV
Face grinding segments	A 24 GV	A 36 GV
Cylindrical grinding	A 46 LV	A 60 KV
Internal grinding	A 46 JV	A 60 IV
Profile grinding	A 100 LV	A 120 KV

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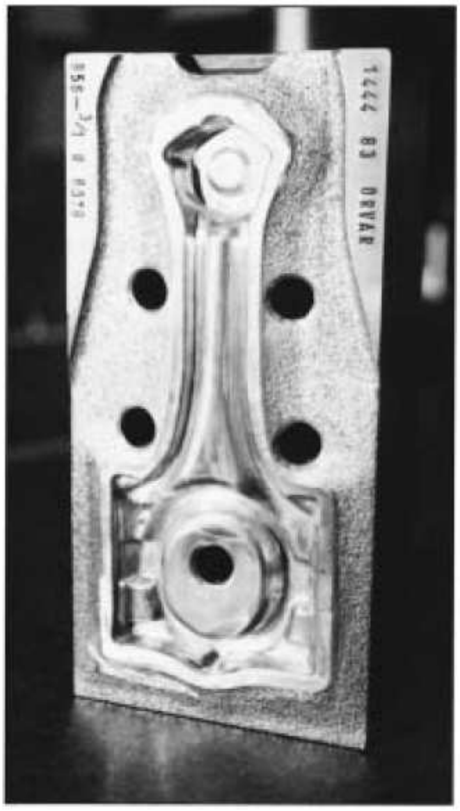
Welding

Welding of tool steel can be performed with good results if proper precautions are taken regarding elevated temperature, joint preparation, choice of consumables and welding procedure.

Welding method	TIG	MMA
Working temperature	325–375°C 620–710°F	325–375°C 620–710°F
Filler metal	QRO 90 TIG-WELD DIEVAR TIG-WELD	QRO 90 WELD
Cooling rate	20–40°C/h (35–70°F/h) the first 2–3 h then freely in air.	
Hardness after welding	50–55 HRC	50–55 HRC
Heat treatment after welding		
Hardened condition	Temper at 25°C (45°F) below the original tempering temperature.	
Soft annealed condition	Soft-anneal the material at 850°C (1560°F) in protected atmosphere. Then cool in the furnace at 10°C (20°F) per hour to 650°C (1200°F) then freely in air.	

More detailed information can be found in the Uddeholm brochure "Welding of Tool Steel".



Electrical-discharge machining

If spark-erosion is performed in the hardened and tempered condition, the white re-cast layer should be removed mechanically e.g. by grinding or stoning. The tool should then be given an additional temper at approx. 25°C (50°F) below the previous tempering temperature.

Hard-chromium plating

After plating, parts should be tempered at 180°C (360°F) for 4 hours within 4 hours of plating to avoid the risk of hydrogen embrittlement.

Photo-etching

Orvar Supreme is particularly suitable for texturing by the photo-etching method. Its high level of homogeneity and low sulphur content ensures accurate and consistent pattern reproduction.

Polishing

Orvar Supreme exhibits good polishability in the hardened and tempered condition. Polishing after grinding can be effected using aluminium oxide or diamond paste.

Typical procedure:

1. Rough grinding to 180–320 grain size using a wheel or stone.
2. Fine grinding with abrasive paper or powder down to 400–800 grain size.
3. Polish with diamond paste grade 15 (15µm grain size) using a polishing tool of soft wood or fibre.
4. Polish with diamond paste 8–6–3 (8–6–3µm grain size) using a polishing tool of soft wood or fibre.
5. When demands on surface finish are high, grade 1 (1µm grain size) diamond paste can be used for final polishing with a fibre polishing pad.

Further information

Please contact your local Uddeholm office for further information on the selection, heat treatment, application and availability of Uddeholm tool steels.

Metalli Uddeholm Uhb DIN 1.1730 andmed

General

Uddeholm's tool steel UHB 11 is an easily machinable carbon steel characterized by

- Good machinability
- Good mechanical strength.

UHB 11 is primarily intended to be used in the as-delivered condition. It is only to be heat treated for special applications.

Typical analysis	C 0,46	Si 0,2	Mn 0,7
Standard specification	W.-Nr. 1.1730		
Delivery condition	As rolled. Hardness approx. 200 HB		
Colour code	White		

Applications

- Punch holders
- Die holders
- Guide plates
- Backing plates
- Jigs
- Fixtures
- Simple bending dies
- Simple structural components.

Properties

Approximate values at room temperature.
Hardness 200 HB.

Tensile strength, Rm	640 N/mm² 65 kp/mm²
Yield strength, Rp0,2	340 N/mm² 35 kp/mm²
Reduction of area, Z	40 %
Elongation, A_5	20 %

Note: The given figures are typical values and shall not be considered as guaranteed values.

Heat Treatment

UHB 11 is intended to be used untreated, i.e. in the as-delivered condition.
For applications where the material must be hardened to a higher hardness, the following instructions should be followed.

SOFT ANNEALING

Temperature approx. 700°C (1290°F).
Protect the steel and heat through to 700°C (1290°F). Cool in furnace 25°C/h (78°F/h) to 600°C (1110°F) and subsequently freely in air. Hardness after soft annealing approx. 170 HB.

NORMALIZING

Normalizing temperature 840–870°C (1545–1066°F). Cooling in air.

STRESS RELIEVING

Temperature approx. 650°C (1200°F). After rough machining with chip-cutting tools, stress relieving may be advisable to minimize distortion if the tool is to be hardened. Holding time: 2 h after the entire piece has attained a temperature of approx. 650°C (1200°F). Cooling in furnace to approx. 500°C (930°F), followed by cooling in air.

HARDENING

Preheating temperature: 650°C (1200°F).
Austenitizing temperature: 820–870°C (1510–1600°F).
Holding time: 30 min. Protect against decarburization.

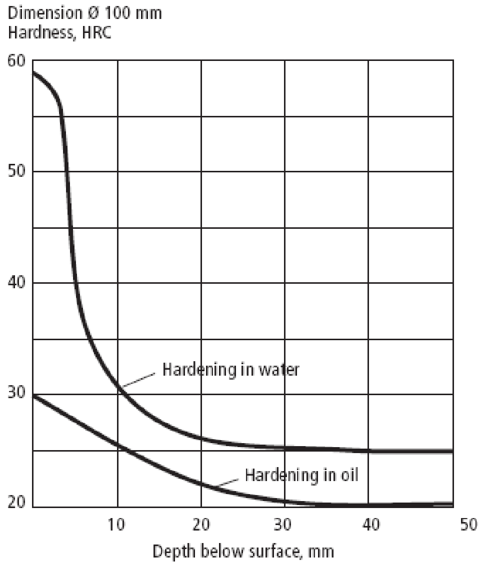
QUENCHING MEDIA

- Water
- Oil.

UHB 11 fine machined ready for delivery.

Metalli Uddeholm Uhb DIN 1.1730 andmed

Hardness as a function of depth under surface



TEMPERING

Tempering temperature and hardness.

Quenching media	Hardness, HRC, after tempering Holdig time 1 h. Approx. value					
	200°C 390°F	250°C 480°F	300°C 570°F	400°C 750°F	500°C 930°F	600°C 1110°F
Water	58	56	53	45	37	27
Oil	31	30	29	27	25	20

Austenitizing temperature 830°C.

FLAME AND INDUCTION HARDENING

UHB 11 can be flame or induction hardened to a hardness of 57 ±3 HRC. Water is normally used for quenching during continuous hardening. Temper immediately after hardening.

Cutting data recommendations

The cutting data below are to be considered as guiding values which must be adapted to existing local conditions. More detailed information can be found in Uddeholm "Cutting Data Recommendations".

TURNING

Cutting data parameters	Turning with carbide		Turning with high speed steel
	Rough turning	Fine turning	Fine turning
Cutting speed (v_c) m/min. f.p.m.	200–250 655–820	250–310 820–1017	25–30 82–98
Feed (f) mm/r i.p.r.	0,3–0,6 0,012–0,023	–0,3 –0,012	–0,3 –0,012
Depth of cut (a_p) mm inch	2–6 0,08–0,20	–2 –0,08	–2 –0,08
Carbide designation ISO	P20–P30 Coated carbide	P10 Coated carbide or cermet	–

DRILLING

High speed steel twist drills

Drill diameter Ø mm	Drill diameter Ø inch	Cutting speed (v_c) m/min.	Cutting speed (v_c) f.p.m.	Feed (f) mm/r	Feed (f) i.p.r.
–5	–3/16	20–22*	65–72*	0,08–0,20	0,003–0,008
5–10	3/16–3/8	20–22*	65–72*	0,20–0,30	0,008–0,012
10–15	3/8–5/8	20–22*	65–72*	0,30–0,35	0,012–0,014
15–20	5/8–3|4	20–22*	65–72*	0,35–0,40	0,014–0,016

For coated HSS drill v_c = 34–36 m/min. (111–118 f.p.m.).

Carbide drills

Cutting data parameters	Type of drill		
	Indexable insert	Solid carbide	Brazed carbide[1]
Cutting speed (v_c) m/min. f.p.m.	240–260 790–850	100–130 330–425	80–100 260–330
Feed (f) mm/r i.p.r.	0,05–0,25[2] 0,002–0,010[2]	0,10–0,25[2] 0,004–0,010[2]	0,15–0,25[2] 0,006–0,010[2]

[1] Drill with internal cooling channels and brazed carbide tip
[2] Depending on drill diameter

Metalli Uddeholm Uhb DIN 1.1730 andmed

MILLING

Face and square shoulder face milling

Cutting data parameters	Milling with carbide Rough milling	Fine milling
Cutting speed (v_c) m/min. f.p.m.	200–270 655–885	270–310 885–1017
Feed, (f_z) mm/tooth inch/tooth	0,2–0,4 0,008–0,016	0,1–0,2 0,004–0,008
Depth of cut, (a_p) mm inch	2–5 0,08–0,2	–2 –0,08
Carbide designation ISO	P20–P40 Coated carbide	P10–P20 Coated carbide

End milling

Cutting data parameters	Type of milling Solid carbide	Carbide indexable insert	High speed steel
Cutting speed (v_c) m/min. f.p.m.	160–200 525–655	190–230 625–755	35–40[1] 115–130[1]
Feed (f_z) mm/tooth inch/tooth	0,03–0,20[2] 0,001–0,008[2]	0,08–0,20[2] 0,003–0,008[2]	0,05–0,35[2] 0,002–0,014[2]
Carbide designation ISO	K10	P10–P20	–

[1] *For coated HSS end mill v_c = 55–60 m/min. (180–200 f.p.m.).*
[2] *Depending on radial depth of cut and cutter diameter.*

GRINDING

General grinding wheel recommendation is given below. More information can be found in the Uddeholm publication "Grinding of Tool Steel".

Grinding operation	Soft annealed condition	Hardened condition
Face grinding straight wheel	A 46 HV	A 46 HV
Face grinding segment	A 24 GV	A 36 GV
Cylindrical grinding	A 46 LV	A 60 KV
Internal grinding	A 46 JV	A 60 JV
Profile grinding	A 100 KV	A 120 JV

Welding

As is the case with most tool steels, the welding of UHB 11 is associated with a risk of cracking. In order to minimize the risk, welding should be carried out with preheating at 100–350°C (210–660°F).

Electrode: Unalloyed basic electrode for welding of unalloyed structural steel.

Note: Always use well dried basic electrodes. Welding can also be performed with an austenitic stainless electrode. The demand of preheating can be reduced but the filler metal does not reach the same hardness level as the base material when hardening.

Further information

Please contact your local Uddeholm office for further information on the selection, heat treatment, application and availability of Uddeholm tool steels.

Metalli Uddeholm Unimax andmed

General

Uddeholm Unimax is a chromium-molybdenum-vanadium alloyed tool steel which is characterized by:

- Excellent toughness and ductility in all directions
- Good wear resistance
- Good dimensional stability at heat treatment and in service
- Excellent through-hardening properties
- Good resistance to tempering back
- Good hot strength
- Good thermal fatigue resistance
- Excellent polishability

Typical analysis %	C 0,5	Si 0,2	Mn 0,5	Cr 5,0	Mo 2,3	V 0,5
Standard specification	None					
Delivery condition	Soft annealed to approx. 185 HB					
Colour code	Brown/grey					

Applications

Uddeholm Unimax is suitable for long run production moulds, moulds for reinforced plastics and compression moulding.

Uddeholm Unimax is a problem solver in severe cold work tooling applications such as heavy duty blanking, cold forging and thread rolling, where high chipping resistance is required.

Engineering and hot work applications requiring high hardness and toughness are also an option.

Properties

The properties below are representative of samples which have been taken from the centre of bars with dimensions 396 x 136 mm (15,6" x 5,35"), Ø 125 mm (4,93") and Ø 220 mm (8,67"). Unless otherwise indicated all specimens have been hardened at 1025°C (1875°F), gas quenched in a vacuum furnace and tempered twice at 525°C (975°F) for two hours; yielding a working hardness of 56–58 HRC.

Physical properties

Hardened and tempered to 56–58 HRC

Temperature	20°C (68°F)	200°C (390°F)	400°C (750°F)
Density, kg/m^3 lbs/in^3	7 790 0,281	–	–
Modulus of elasticity MPa psi	213 000 31,2 x 10^6	192 000 27,8 x 10^6	180 000 26,1 x 10^6
Coefficient of thermal expansion per °C from 20°C per °F from 68°F	– –	11,5 x 10^{-6} 6,3 x 10^{-6}	12,3 x 10^{-6} 6,8 x 10^{-6}
Thermal conductivity W/m °C Btu in/(ft^2h°F)	– –	25 174	28 195
Specific heat J/kg°C Btu/lb°F	460 0,11	–	–

Mechanical properties

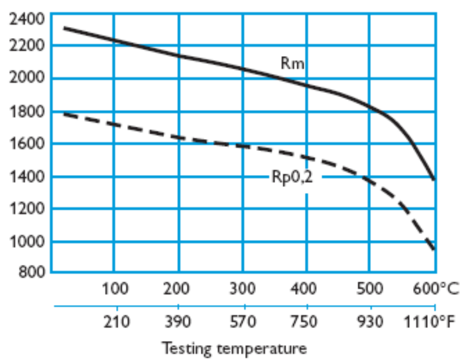
Approx. strength and ductility at room temperature at tensile testing.

Hardness	54 HRC	56 HRC	58 HRC
Yield strength, $R_{p0,2}$	1720 MPa	1780 MPa	1780 MPa
Tensile strength, R_m	2050 MPa	2150 MPa	2510 MPa
Elongation, A_5	9 %	8 %	8 %
Reduction of area, Z	40 %	32 %	28 %

Metalli Uddeholm Unimax andmed

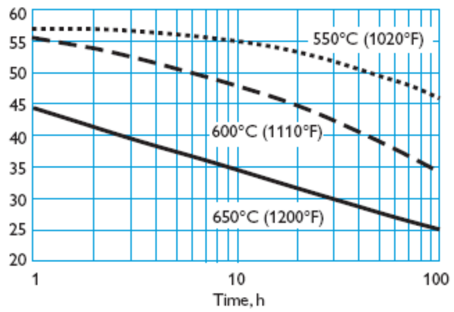
APPROXIMATE STRENGTH
AT ELEVATED TEMPERATURES

Longitudinal direction. The specimens were hardened from 1025°C (1875°F) and tempered twice at 525°C (975°F) to 58 HRC.



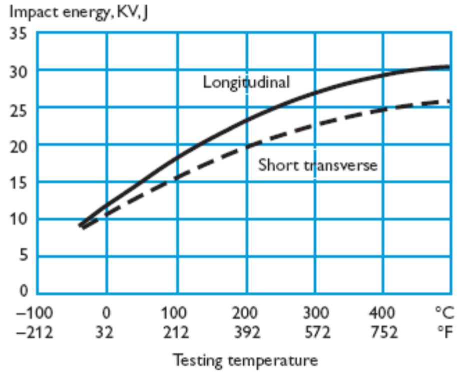
EFFECT OF TIME AT
HIGH TEMPERATURES ON HARDNESS

Initial hardness 57 HRC.



EFFECT OF TESTING TEMPERATURE
ON IMPACT ENERGY

Charpy-V specimens, longitudinal and short transverse direction. Approximate values for specimens from Ø 125 mm (4,9") bar.



Heat treatment—general recommendations

Soft annealing

Protect the steel and heat through to 850°C (1560°F). Then cool in furnace at 10°C (20°F) per hour to 600°C (1110°F), then freely in air.

Stress relieving

After rough machining the tool should be heated through to 650°C (1200°F), holding time 2 hours. Cool slowly to 500°C (930°F), then freely in air.

Hardening

Preheating temperature: 600–650°C (1110–1200°F) and 850–900°C (1560–1650°F).
Austenitizing temperature: 1000–1025°C (1830–1875°F), normally 1025°C (1875°F).
Holding time: 30 minutes

Temperature °C	°F	Soaking time minutes	Hardness before tempering
1000	1830	30	61 HRC
1025	1875	30	63 HRC

Soaking time = time at hardening temperature after the tool is fully heated through.

Protect the tool against decarburization and oxidation during austenitizing.

Quenching media

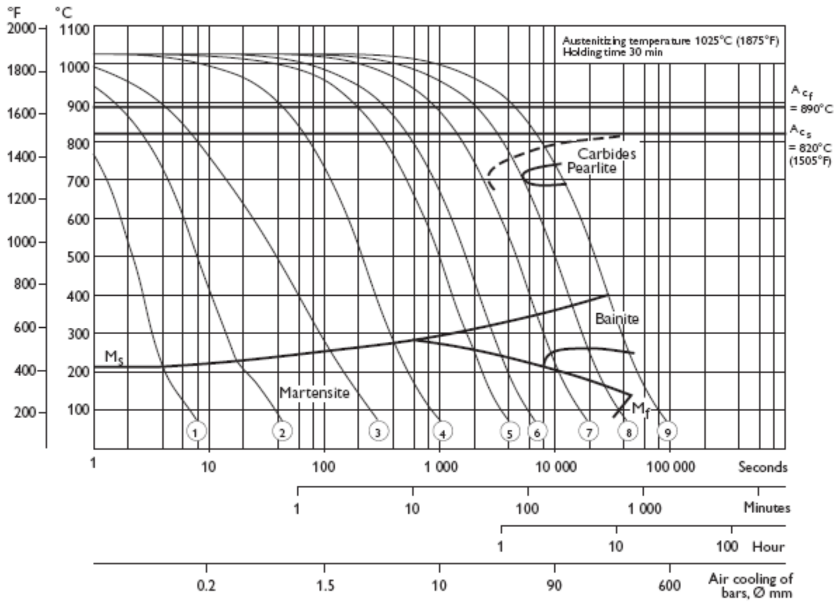
- High speed gas/circulating atmosphere.
- Vacuum furnace (high speed gas with sufficient overpressure).
- Martempering bath, salt bath or fluidized bed at 500–550°C (930–1020°F).
- Martempering bath at 200–350°C (390–660°F).

Note: Temper the tool as soon as its temperature reaches 50–70°C (120–160°F).

Metalli Uddeholm Unimax andmed

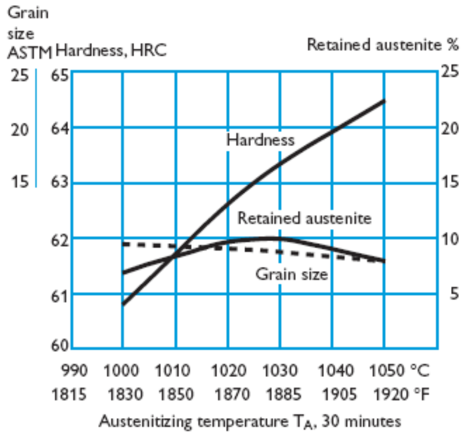
CCT GRAPH

Austenitizing temperature 1025°C (1875°F). Holding time 30 minutes.



Cooling Curve No.	Hardness HV 10	T800-500 (sec)
1	835	1
2	819	5
3	798	33
4	782	140
5	724	630
6	712	1064
7	674	2900
8	525	6250
9	476	13850

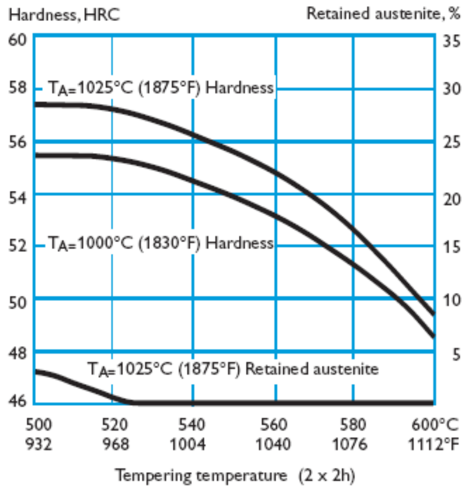
HARDNESS, GRAIN SIZE AND RETAINED AUSTENITE AS FUNCTIONS OF AUSTENITIZING TEMPERATURE



Tempering

Choose the tempering temperature according to the hardness required by reference to the tempering graph below. Temper at least twice with intermittent cooling to room temperature. The lowest tempering temperature which should be used is 525°C (980°F). The minimum holding time at temperature is 2 hours.

TEMPERING GRAPH



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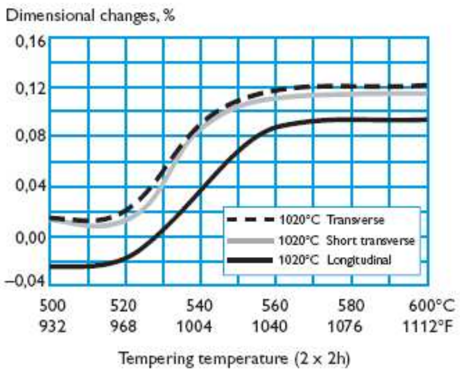
Dimensional changes during hardening and tempering

The dimensional changes have been measured after austenitizing at 1020°C/30 minutes (1870°F/30 minutes) followed by gas quenching in N_2 at a cooling rate of 1,1°C/second between 800–500°C (1470–930°F) in a cold chamber vacuum furnace. Specimen size: 100 x 100 x 100 mm (3,9" x 3,9" x 3,9").



Surface treatments

Tool steels may be given a surface treatment in order to reduce friction and increase wear resistance. The most commonly used treatments are nitriding and surface coating with wear resistant layers produced via PVD or CVD.

The high hardness and toughness together with a good dimensional stability makes Uddeholm Unimax suitable as a substrate steel for various surface coatings.

Nitriding and nitrocarburizing

Nitriding and nitrocarburizing result in a hard surface layer which is very resistant to wear and galling.

The surface hardness after nitriding is approximately 1000–1200 $HV_{0,2kg}$. The thickness of the layer should be chosen to suit the application in question.

PVD

Physical vapour deposition, PVD, is a method for applying wear-resistant surface coating at temperatures between 200–500°C (390–930°F).

CVD

Chemical vapour deposition, CVD, is a method for applying wear-resistant surface coating at a temperature of around 1000°C (1830°F).

Cutting data recommendations

The cutting data below are to be considered as guiding values which must be adapted to existing local conditions.

The recommendations in following tables are valid for Uddeholm Unimax in soft annealed condition ~185 HB

Turning

Cutting data parameters	Turning with carbide: Rough turning	Turning with carbide: Fine turning	Turning with high speed steel: Fine turning
Cutting speed (v_c) m/min	150–200	200–250	15–20
f.p.m.	490–660	660–820	50–65
Feed (f) mm/r	0,2–0,4	0,05–0,2	0,05–0,3
i.p.r.	0,008–0,016	0,002–0,008	0,002–0,012
Depth of cut (a_p) mm	2–4	0,5–2	0,5–2
inch	0,08–0,16	0,02–0,08	0,02–0,08
Carbide designation ISO	P20–P30	P10	–
US	C6–C5	C7	–
	Coated carbide	Coated carbide or cermet	

Milling

FACE- AND SQUARE SHOULDER MILLING

Cutting data parameters	Milling with carbide: Rough milling	Milling with carbide: Fine milling
Cutting speed (v_c) m/min	120–170	170–210
f.p.m.	390–560	560–690
Feed (f_z) mm/tooth	0,2–0,4	0,1–0,2
inch/tooth	0,008–0,016	0,004–0,008
Depth of cut (a_p) mm	2–4	0,5–2
inch	0,08–0,16	0,02–0,08
Carbide designation ISO	P20–P40	P10
US	C6–C5	C7
	Coated carbide	Coated carbide or cermet

Metalli Uddeholm Unimax andmed

END MILLING

Cutting data parameters	Type of milling: Solid carbide	Carbide indexable insert	High speed steel
Cutting speed (v_c) m/min f.p.m.	120–150 390–490	110–150 360–490	20–25[1] 66–80[1]
Feed (f_z) mm/tooth inch/tooth	0,01–0,20[2] 0,0004–0,008[2]	0,06–0,20[2] 0,002–0,008[2]	0,01–0,30[2] 0,0004–0,012[2]
Carbide designation ISO US	– 	P20–P30 C6–C5	– –

[1] For coated HSS end mill v_c 35–40 m/min. (115 –130 f.p.m.)
[2] Depending on radial depth of cut and cutter diameter

Drilling

HIGH SPEED STEEL TWIST DRILL

Drill diameter mm	inch	Cutting speed (v_c) m/min	f.p.m.	Feed (f) mm/r	i.p.r.
– 5	–3/16	15–20*	49–66*	0,05–0,10	0,002–0,004
5–10	3/16–3/8	15–20*	49–66*	0,10–0,20	0,004–0,008
10–15	3/8–5/8	15–20*	49–66*	0,20–0,30	0,008–0,012
15–20	5/8–3/4	15–20*	49–66*	0,30–0,35	0,012–0,014

[1] For coated HSS drill v_c ~35–40 m/min. (115–130 f.p.m.)

CARBIDE DRILL

Cutting data parameters	Type of drill: Indexable insert	Solid carbide	Brazed carbide[1]
Cutting speed (v_c), m/min f.p.m.	180–220 590–720	120–150 390–490	60–90 195–295
Feed (f), mm/r i.p.r.	0,03–0,10[2] 0,001–0,004[2]	0,10–0,25[2] 0,004–0,01[2]	0,15–0,25[2] 0,006–0,01[2]

[1] Drill with internal cooling channels and brazed carbide tip
[2] Depending on drill diameter

Grinding

A general grinding wheel recommendation is given below. More information can be found in the Uddeholm publication "Grinding of Tool Steel".

RECOMMEDED GRINDING WHEELS

Type of grinding	Soft annealed condition	Hardened condition
Face grinding straight wheel	A 46 HV	A 46 HV
Face grinding segments	A 24 GV	A 36 GV
Cylindrical grinding	A 46 LV	A 60 KV
Internal grinding	A 46 JV	A 60 IV
Profile grinding	A 100 LV	A 120 KV

Electrical Discharge Machining—EDM

Following the EDM process, the applicable die surfaces are covered with a resolidified layer (white layer) and a rehardened and untempered layer, both of which are very brittle and hence detrimental to die performance.

If EDM is used the white layer must be completely removed mechanically by grinding or stoning. After finish-machining the tool should be given an additional temper at approx. 25°C (50°F) below the highest previous tempering temperature. Further information is given in the Uddeholm brochure "EDM of Tool Steel".

Welding

Welding of die components can be performed, with acceptable results, as long as the proper precautions are taken during the preparation of the joint, the filler material selection, the preheating of the die, the controlled cooling of the die and the post weld heat treatment processes. The following guidelines summarize the most important welding process parameters. For more detailed information refer to Uddeholm's "Welding of Tool Steel" brochure.

Welding method	TIG	MMA
Preheating temperature	200–250°C (390–480°F)	200–250°C (390–480°F)
Filler material	UTP ADUR600 UTP A73G2	UTP 67S UTP 73G2
Maximum interpass temperature	350°C (660°F)	350°C (660°F)
Post weld cooling	20–40°C/h (45–70°F/h) for the first two hours and then freely in air.	
Hardness after welding	54–60 HRC	55–58 HRC
Post weld heat treatment		
Hardened condition	Temper at 510°C (950°F) for 2 h.	
Soft annealed condition	Soft-anneal according to the "Heat treatment recommendations".	

Further information

Please contact your local Uddeholm office for further information on the selection, heat treatment, application and availability of Uddeholm tool steels.

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Product programme for plastic moulding

UDDEHOLM MOULD STEEL IMPAX SUPREME (AISI P20, modified)	A prehardened Ni-Cr-Mo steel, supplied at 290–330 Brinell, with excellent polishing and photo-etching properties. Suitable for a wide range of injection moulds, blow-moulds, extrusion dies.
NIMAX	A low carbon steel, delivery hardness 360–400 HB. Excellent toughness, machinability and weldability. Good polishing and etching properties.
STAVAX ESR / MIRRAX ESR (AISI 420, modified)	Through-hardening stainless mould steels with good corrosion resistance and very good polishability.
POLMAX (AISI 420, modified)	A through-hardening stainless mould steel with good corrosion resistance and extremely good polishability.
CORRAX	A precipitation hardening steel with exceptionally good corrosion resistance, easy heat treatment and good weldability.
ORVAR SUPREME (AISI H13, improved)	A versatile through-hardening 5% Cr mould and die steel with good wear resistance and polishability.
VIDAR 1 ESR (AISI H11)	A 5% Cr mould and die steel with good through-hardening properties. Suitable for general hot work and plastic mould applications, specially large plastic moulds with requirements on high toughness in combination with very good polishability and texturing properties.
UNIMAX	A steel with very good hardenability, suitable for surface coating. The unique combination of toughness and wear resistance makes it suitable for long run moulding and moulding of reinforced plastics.
RIGOR (AISI A2)	A through-hardening steel, recommended for very long production runs of smaller, complicated mouldings.
ELMAX VANADIS 4 EXTRA VANADIS 6 VANADIS 10	Powder metallurgically produced mould steels characterized by very good dimension stability, good polishability and wear resistance. Elmax is corrosion resistant, Vanadis 4 Extra has the highest toughness and Vanadis 10 the best wear resistance. Recommended for long production runs of smaller and complicated shapes and/or abrasive plastics.
UDDEHOLM HOLDER STEEL HOLDAX (AISI 4130/35, modified)	A prehardened steel with very good machinability and high tensile strength.
RAMAX HH, RAMAX LH (AISI 420F, modified)	Prehardened stainless steels with good machinability, high tensile strength and good corrosion resistance.
ALUMINIUM ALUMEC	A high strength Al-alloy supplied at ~160 HB. Recommended for prototype moulds and for short runs with low demands on strength and wear resistance.
COPPER ALLOYS MOLDMAX HH MOLDMAX XL	High strength copper mould alloys with high thermal conductivity. For applications like pinch offs and neck rings for blow moulds, cores and inserts in injection moulds and injection nozzles and manifolds for hot runner systems.

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CHEMICAL COMPOSITION

UDDEHOLM MOULD STEEL	C	Si	Mn	Cr	Ni	Mo	V	S	SUPPLIED HARDNESS Brinell
	ANALYSIS %								
IMPAX SUPREME	0.37	0.3	1.4	2.0	1.0	0.2	–	<0.01	~310
NIMAX	0.1	0.3	2.5	3.0	1.0	0.3	–	–	~380
UNIMAX	0.5	0.2	0.5	5.0	–	2.3	0.5	–	185
ORVAR SUPREME	0.39	1.0	0.4	5.2	–	1.4	0.9	–	180
VIDAR 1 ESR	0.38	1.0	0.4	5.0	–	1.3	0.4	–	185
STAVAX ESR	0.38	0.9	0.5	13.6	–	–	0.3	–	215
MIRRAX ESR	0.25	0.35	0.55	13.3	1.35	0.35	0.35	+N	250
POLMAX	0.38	0.9	0.5	13.6	–	–	0.3	–	215
CORRAX	0.03	0.3	0.3	12.0	9.2	1.4	–	Al 1.6	~330
RIGOR	1.0	0.2	0.8	5.3	–	1.1	0.2	–	215
ELMAX	1.7	0.8	0.3	18.0	–	1.0	3.0	–	280
VANADIS 4 EXTRA	1.4	0.4	0.4	4.7	–	3.5	3.7	–	230
VANADIS 6	2.1	1.0	0.4	6.8	–	1.5	5.4	–	255
VANADIS 10	2.9	1.0	0.5	8.0	–	1.5	9.8	–	275
UDDEHOLM HOLDER STEEL									
HOLDAX	0.4	0.4	1.5	1.9	–	0.2	–	0.07	~310
RAMAX HH	0.12	0.2	1.3	13.4	1.6	0.5	0.2	0.1 +N	~340
RAMAX LH	0.12	1.0	1.45	14.0	0.36	0.2	0.1	0.13 +N	~290

PROPERTIES

PROPERTY	IMPAX SUPREME	NIMAX	UNIMAX	ORVAR SUPREME	STAVAX ESR	MIRRAX ESR	POLMAX	CORRAX	ELMAX	RIGOR	VANADIS 4 EXTRA	VANADIS 6	HOLDAX	RAMAX HH	RAMAX LH
Normal hardness HRC (HB)	(~310)	(380)	58	52	52	52	52	46	58	60	60	62	(~310)	(~340)	(~290)
Wear resistance	3	4	8	7	7	7	7	5	9	9	9	10	3	4	3
Toughness	9	10	6	6	5	6	5	7	4	3	5	4	4	3	3
Compressive strength	4	5	8	7	7	7	7	6	9	9	9	10	4	5	4
Corrosion resistance	2	2	3	3	9	9	9	10	7	2	2	2	2	8	8
Machinability**	5	5	7	9	8	8	8	3	3	4	5	3	7	6	7
Polishability	8	8	8	8	9	9	10	8	8	7	8	8	4	4	4
Weldability	6	7	4	4	4	4	4	6	2	2	2	2	6	5	6
Nitriding ability	6	5	8	10	–	–	–	–	–	8	8	8	5	–	–
Photo-etchbility	9	9	8	8*	8*	8*	8*	8*	8*	5	8	5	3	3	3

* *Special process required*

***Tested in delivery condition*

The properties of the main mould and holder steel grades have been rated from 1–10, where 10 is the highest rating. Such comparisons must be considered as approximate, but can be a useful guide to steel selection.

Note: It is not possible to make valid "total comparisons" between steel grades by adding their respective "points"—it is only intended that individual properties be compared.

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SPECIAL RECOMMENDATIONS

SPECIAL REQUIREMENT OR DEMAND		UDDEHOLM STEEL GRADE	HARDNESS HRC (HB)
LARGE MOULD SIZE	For automotive components, including panels, bumpers, fascias, etc.	ALUMEC IMPAX SUPREME NIMAX CORRAX MIRRAX ESR ORVAR SUPREME VIDAR 1 ESR	(~160) 33 (~310) ~380 36–46 36–50 36–50 36–50
	As above, with low demands on surface finish	HOLDAX RAMAX HH	33 (~310) 37 (~340)
HIGH SURFACE FINISH	For moulding optical/medical parts, clear covers/panels	STAVAX ESR MIRRAX ESR UNIMAX POLMAX ELMAX VANADIS 4 EXTRA ORVAR SUPREME VIDAR 1 ESR	45–52 45–50 50–58 45–52 58–60 58–62 45–52 45–52
COMPLEX SHAPES	1. For large automobile/household components	IMPAX SUPREME NIMAX CORRAX MIRRAX ESR	33 (~310) ~380 34–46 36–50
	2. For small parts with low wear demands	IMPAX SUPREME NIMAX CORRAX	33 (~310) ~380 34–46
	3. For small parts with high wear demands, e.g. electrical/electronic mouldings	RIGOR UNIMAX ORVAR SUPREME STAVAX ESR MIRRAX ESR ELMAX VANADIS 4 EXTRA VANADIS 6	60–62 56–58 50–52 50–52 45–50 58–60 58–62 60–64
ABRASIVE MOULDING MATERIALS	Reinforced/filled moulding materials; engineering resins	RIGOR UNIMAX ORVAR SUPREME STAVAX ESR MIRRAX ESR ELMAX VANADIS 4 EXTRA VANADIS 6	58–62 56–58 50–52 50–52 45–50 58–60 58–62 60–64

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SPECIAL RECOMMENDATIONS

SPECIAL REQUIREMENT OR DEMAND		UDDEHOLM STEEL GRADE	HARDNESS HRC (HB)
LARGE MOULD SIZE	For automotive components, including panels, bumpers, fascias, etc.	ALUMEC IMPAX SUPREME NIMAX CORRAX MIRRAX ESR ORVAR SUPREME VIDAR 1 ESR	(~160) 33 (~310) ~380 36–46 36–50 36–50 36–50
	As above, with low demands on surface finish	HOLDAX RAMAX HH	33 (~310) 37 (~340)
HIGH SURFACE FINISH	For moulding optical/medical parts, clear covers/panels	STAVAX ESR MIRRAX ESR UNIMAX POLMAX ELMAX VANADIS 4 EXTRA ORVAR SUPREME VIDAR 1 ESR	45–52 45–50 50–58 45–52 58–60 58–62 45–52 45–52
COMPLEX SHAPES	1. For large automobile/household components	IMPAX SUPREME NIMAX CORRAX MIRRAX ESR	33 (~310) ~380 34–46 36–50
	2. For small parts with low wear demands	IMPAX SUPREME NIMAX CORRAX	33 (~310) ~380 34–46
	3. For small parts with high wear demands, e.g. electrical/electronic mouldings	RIGOR UNIMAX ORVAR SUPREME STAVAX ESR MIRRAX ESR ELMAX VANADIS 4 EXTRA VANADIS 6	60–62 56–58 50–52 50–52 45–50 58–60 58–62 60–64
ABRASIVE MOULDING MATERIALS	Reinforced/filled moulding materials; engineering resins	RIGOR UNIMAX ORVAR SUPREME STAVAX ESR MIRRAX ESR ELMAX VANADIS 4 EXTRA VANADIS 6	58–62 56–58 50–52 50–52 45–50 58–60 58–62 60–64

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SPECIAL RECOMMENDATIONS

SPECIAL REQUIREMENT OR DEMAND		UDDEHOLM STEEL GRADE	HARDNESS HRC (HB)
LONG PRODUCTION RUNS	For thermoplastic parts, including disposable cutlery, containers and packaging	STAVAX ESR MIRRAX ESR UNIMAX ORVAR SUPREME VIDAR 1 ESR ELMAX VANADIS 4 EXTRA VANADIS 6	45–52 45–50 52–58 45–52 45–52 58–60 58–62 60–64
CORROSION RESISTANCE	1. For corrosive moulding materials, including PVC 2. For humid moulding/mould storage conditions 3. General resistance to surface staining/rusting 4. Resistance to corrosion of cooling channels	STAVAX ESR MIRRAX ESR ELMAX RAMAX HH RAMAX LH CORRAX	45–52 45–50 58–60 37 (~340) 32 (~290) 34–50
PHOTO-ETCHING	1. Prehardened steel	IMPAX SUPREME NIMAX	33 (~310) ~380
	2. Through-hardened steel	ORVAR SUPREME VIDAR 1 ESR STAVAX ESR MIRRAX ESR UNIMAX ELMAX VANADIS 4 EXTRA VANADIS 6	45–52 45–52 45–52 45–50 50–58 58–60 58–62 60–64
HIGH THERMAL CONDUCTIVITY	For injection and blow moulds, cores and inserts; parts for hot runner systems.	MOLDMAX HH MOLDMAX XL	~40 ~30

MOLDMAX® is a trade-mark registered of Brush Wellman Inc., Cleveland, Ohio.

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<table>
<tr><td colspan="2">Tallinna
Tehnikakõrgkool
Masinaehitusteaduskond</td><td colspan="3">MARSRUUTKAART</td><td colspan="2">Leht/lehti:
1/6</td></tr>
<tr><td colspan="2">Tähis:
V410.01</td><td colspan="3">Nimetus:
CORE</td><td colspan="2">Detaili mass:
10,57 kg</td></tr>
<tr><td colspan="5">Materjal (toorik):
ORVAR SUPREME (156 x 60 x 172)</td><td colspan="2">Tooriku mass:
12,56 kg</td></tr>
<tr><td>Oper. nr.</td><td colspan="4">Operatsiooni nimetus ja sisu</td><td colspan="2">Seade, rakis, töö- ja mõõteriistad</td></tr>
<tr><td>1</td><td colspan="4">Kooriv freesimine:

172 mm freesida mõõde 169,28 mm, jätta varu 0,6 mm,
156 mm freesida mõõde 149,06 mm, jätta varu 0,6 mm,
60 mm freesida mõõde 58,37 mm, jätta varu 6 mm</td><td colspan="2">Seade:
Vertikaalfreespink 6P13

Rakis:
Masinkruustangid
Jäigad toed

Tööriist:
ISO kinnitusega tsang: ISO 50x32x52
Freespea: Laupfrees, INGERSOLL 5N6L - 5N6L160R00
Kermisplaadid: KENNAMETAL -OFPT07L6AFENGB, materjal KC725M

Mõõteriistad:
Digitaalne nihik 300/0,01
Mõõdulint 5 m</td></tr>
<tr><td>2</td><td colspan="4">Horisontaalne tasapinnaline lihvimine:

Lihvida mõõde 169,28 mm, jätta varu 0,6 mm,
lihvida mõõde 149,06 mm, jätta varu 0,6 mm,
lihvida mõõde 58,37 mm, jätta varu 6 mm

Kontrollida, et detail oleks paralleelne ja mõõdus</td><td colspan="2">Seade:
Tasalihvpink 3Д711А

Mõõteriistad:
Digitaalne nihik 125/0,01
Nooniusega nurgamõõdik UM</td></tr>
<tr><td colspan="2">Koostas:
R. Kuusk</td><td>Kuupäev:
Allkiri:</td><td colspan="2">Kontrollis:
M. Pakkin</td><td colspan="2">Kuupäev:
Allkiri:</td></tr>
</table>

Lisa 9

<table>
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Tehnikakõrgkool
Masinaehitusteaduskond</td><td colspan="3">MARSRUUTKAART</td><td colspan="2">Leht/lehti:
2/6</td></tr>
<tr><td>Tähis:
V410.01</td><td colspan="3">Nimetus:
CORE</td><td colspan="2">Detaili mass:
10,57 kg</td></tr>
<tr><td colspan="4">Materjal (toorik):
ORVAR SUPREME (156 x 60 x 172)</td><td colspan="2">Tooriku mass:
12,56 kg</td></tr>
<tr><td>Oper. nr.</td><td colspan="3">Operatsiooni nimetus ja sisu</td><td colspan="2">Seade, rakis, töö- ja mõõteriistad</td></tr>
<tr><td>3</td><td colspan="3">Avade puurimine ja töötlemine:

Puurida ava Ø 4 mm 4 tk, ava Ø 39 mm H6, jätta varu 4 mm 1 tk, töötelda ava Ø 39 mm H6 lõppmõõduni 39,5 mm, ava Ø 18 mm 2 tk, keermestada avad M8 4 tk, puurida ava Ø 8 mm, keermestada ava R1/8</td><td colspan="2">Seade:
Koordinaatpuurpink 2A554

Kinnitusklambrid
Puurid: Ø 4, Ø 18, Ø 35, Ø 8, M8 P6M5 tsangpadrun
LLAMBRICH koonusega puurpadrun

Mõõteriistad:
Digitaalne nihik 125/0,01
Mõõdulint 5 m</td></tr>
<tr><td>4</td><td colspan="3">Freesimine:

Freesida kõrgus 136,31 mm, jätta varu 0,6 mm, freesida paksus 44,56 mm, jätta varu 1,2 mm, freesida mõõde 50 mm</td><td colspan="2">Seade:
Vertikaalne töötlemiskeskus CINCINNATI ARROW 750

Rakis:
Masinkruustangid
Jäigad toed

Terahoidja: Sandvik CoroMill 390 R390-025A25-11M
Frees: Silinderfrees Ø 25
Terad: R-390-11 T3 04M-PM

Mõõteriistad:
Digitaalne nihik 125/0,01</td></tr>
<tr><td>Koostas:
R. Kuusk</td><td colspan="2">Kuupäev:
Allkiri:</td><td colspan="2">Kontrollis:
M. Pakkin</td><td>Kuupäev:
Allkiri:</td></tr>
</table>

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Tallinna Tehnikakõrgkool Masinaehitusteaduskond	**MARSRUUTKAART**	Leht/lehti: 3/6
Tähis: V410.01	Nimetus: CORE	Detaili mass: 10,57 kg
Materjal (toorik): ORVAR SUPREME (156 x 60 x 172)		Tooriku mass: 12,56 kg

Oper. nr.	Operatsiooni nimetus ja sisu	Seade, rakis, töö- ja mõõteriistad
5	Termiline töötlemine: Termiline töötlemine, saavutatav kõvadus HRC 48...50	Seade: SARLIN Lämpökäsittely 465 Tüüp: 1300 H-336 10 kW, 3x380 V ja 35 A, maks. 1300 C°
6	Horisontaalne tasapinnaline lihvimine: Lihvida mõõde 169,28 mm, lihvida lõppmõõde 44,56 mm, lihvida lõppmõõde 58,37 mm, lihvida lõppmõõde 149.06 mm Kontrollida, et detail oleks paralleelne ja mõõdus	Seade: Tasalihvpink 3Д711A Mõõteriistad: Digitaalne nihik 125/0,01 Nooniusega nurgamõõdik UM

Koostas: R. Kuusk	Kuupäev: Allkiri:	Kontrollis: M. Pakkin	Kuupäev: Allkiri:

Lisa 9

<table>
<tr><td colspan="2">Tallinna
Tehnikakõrgkool
Masinaehitusteaduskond</td><td colspan="3">MARSRUUTKAART</td><td colspan="2">Leht/lehti:
4/6</td></tr>
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V410.01</td><td colspan="3">Nimetus:
CORE</td><td colspan="2">Detaili mass:
10,57 kg</td></tr>
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<tr><td>Oper. nr.</td><td colspan="3">Operatsiooni nimetus ja sisu</td><td colspan="3">Seade, rakis, töö- ja mõõteriistad</td></tr>
<tr><td>7</td><td colspan="3">Erosioontöötlus:

Traaterosioonlõikamine ava Ø 39 H6 lõppmõõde, kontuuri lõikamine 58,37 mm, 40,13 mm, ava 13,33 mm ja 26,53 mm kalle 10,00 mm ja 10,66 mm ning 9,09 mm</td><td colspan="3">Seade:
Traaterosioonpink ROBOCUT ALPHA 1iA

Rakis: Magnetkinnitus ja kruustangid

Mõõteriistad:
Indikaatorkell ja mõõtepea</td></tr>
<tr><td>8</td><td colspan="3">Erosioontöötlus:

Mahterosioontöötlus kujupind 133,97 mm</td><td colspan="3">Seade:
Mahterosioonpink MAKINO EDNC 40

Elektrood: Grafiit

Puhastamine</td></tr>
<tr><td colspan="2">Koostas:
R. Kuusk</td><td colspan="2">Kuupäev:
Allkiri:</td><td colspan="2">Kontrollis:
M. Pakkin</td><td>Kuupäev:
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<tr><td colspan="2">Tallinna
Tehnikakõrgkool
Masinaehitusteaduskond</td><td colspan="3">MARSRUUTKAART</td><td colspan="2">Leht/lehti:
5/6</td></tr>
<tr><td colspan="2">Tähis:
V410.01</td><td colspan="3">Nimetus:
CORE</td><td colspan="2">Detaili mass:
10,57 kg</td></tr>
<tr><td colspan="5">Materjal (toorik):
ORVAR SUPREME (156 x 60 x 172)</td><td colspan="2">Tooriku mass:
12,56 kg</td></tr>
<tr><td>Oper. nr.</td><td colspan="3">Operatsiooni nimetus ja sisu</td><td colspan="3">Seade, rakis, töö- ja mõõteriistad</td></tr>
<tr><td>9

10</td><td colspan="3">Freesimine:

Freesida üle kõrgus 136,31 mm, freesida kujupind Ø 45,50 mm, freesida 5,08 mm,

Lukksepp:

Väljatõukajate reguleerimine ja seadistamine templi sisse</td><td colspan="3">Seade:
Vertikaalne töötlemiskeskus
CINCINNATI ARROW 750

Rakis:
Masinkruustangid
Jäigad toed

Terahoidja: Sandvik CoroMill 390 R390-025A25-11M
Frees: Silinderfrees Ø 25
Terad: R-390-11 T3 04M-PM

Mõõteriistad:
Digitaalne nihik 125/0,01</td></tr>
<tr><td colspan="2">Koostas:
R. Kuusk</td><td>Kuupäev:
Allkiri:</td><td colspan="2">Kontrollis:
M. Pakkin</td><td colspan="2">Kuupäev:
Allkiri:</td></tr>
</table>

Lisa 9

<table>
<tr><td colspan="2">Tallinna Tehnikakõrgkool
Masinaehitusteaduskond</td><td colspan="2">MARSRUUTKAART</td><td colspan="2">Leht/lehti:
6/6</td></tr>
<tr><td colspan="2">Tähis:
V410.01</td><td colspan="2">Nimetus:
CORE</td><td colspan="2">Detaili mass:
10,57 kg</td></tr>
<tr><td colspan="4">Materjal (toorik):
ORVAR SUPREME (156 x 60 x 172)</td><td colspan="2">Tooriku mass:
12,56 kg</td></tr>
<tr><td>Oper. nr.</td><td colspan="3">Operatsiooni nimetus ja sisu</td><td colspan="2">Seade, rakis, töö- ja mõõteriistad</td></tr>
<tr><td>11</td><td colspan="3">Erosioontöötlus:

Mahterosioontöötlus kujupind 136,31 mm, kujupinna töötlus 138,49 mm, kujupinna töötlus 10,95 mm ja kujupinnatöötlus 4,46 mm</td><td colspan="2">Seade:
Mahterosioonpink MAKINO EDNC 40

Elektrood: Grafiit

Puhastamine</td></tr>
<tr><td colspan="2">Koostas:
R. Kuusk</td><td>Kuupäev:
Allkiri:</td><td colspan="2">Kontrollis:
M. Pakkin</td><td>Kuupäev:
Allkiri:</td></tr>
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