Application of new feeding system products for the production of high chrome iron steel alloys

Introduction

High Chrome Alloys have good wear resistant properties ranging between 2.5 to 3.5% C and 15 to 27% Cr. These alloys achieve highest wear resistance properties during the stress-hardening process between 900°C and 1050°C followed by fast quenching or gentle air-cooling owing to the predominantly martensitic structure. These fast freezing alloys are poured at relatively low temperatures between 1380°C and 1500°C.

Contraction of these alloys lies betwen 6 to 8% and in the case of natural side riser conventional feeding method, casting yields are rather poor. During the fettling operation of the feeder from the casting, fracture or cracking of the casting section often occurs, due to stress development. It is possible to heat treat and then fettle to minimise crack development but afterwards hardening of the casting may be a necessity.

In many European foundries exothermic insulating neck-down feeders are predominantly applied as top feeders for improved yield and also fettling operations; which are knocked off, since neck apertures are much smaller than those of the natural sand feeders. Top feeder application sometimes creates more casting space on the pattern plate thereby improving productivity. These feeders can be readily applied to resin moulds, however in high-presure green sand moulding systems, neck-down exothermic insulating feeder sleeves are sometimes impossible. Conventional fettling may cause cracking in the casting and in this case repair is a costly affair.

Thick-wall high-modulus, low-volume, fast-igniting, high-strength feeder sleeves such as Feedex HDV neck-down sleeves are ideally suitable for effective top-risering of high chrome alloys. The advantages are quite obvious!

- ❑ No dilation of the feeder sleeves
- ❑ Knock off of the feeder is relatively easier and often no other fettling is necessary
- ❑ In most applications feeding yields are as much as 90% since more than 50% of the feed metal volume of the feeder may be utilised to feed the castings.
- ❑ Feeder neck apertures are fractionally smaller than the conventional exothermic insulating feeder sleeves.
- ❑ Neck areas are reduced by one third to one quarter.

Feeding system calculation guidelines for HDV feeder sleeve application

I – High Chrome Alloy Characteristics

- ❑ Pouring Temperatures : 1380 – 1550°C
- ❑ Carbon Content : 2.5 % - 3.5 %
- ❑ Alloy Elements : Mo : 0.5 – 1.0 %
  Mn : 0.5 – 1.0 %
  Cr : 18 – 27 %
- ❑ Contraction : 6 – 7 %
- ❑ Hardness : Very High
- ❑ Crack-Prone

II – Feeding System Calculations

- ❑ Due to the high volume demand from the casting (6 – 7%), the V riser is always determined by volume instead of modulus.
- ❑ It can be considered that the V riser is able to give 50% of its volume to the casting:

  Casting weight : 100 kgs
  Contraction : 6 % (6 kgs)
  Mini-riser weight : 12 kgs
  Mini-riser volume : 1600 cm^3

III – Casting Characteristics

- ❑ Principal property : Abrasion resistent
- ❑ Application : - Quarry mills, stone crusher
  - Cement plants
  - Shot-blasting equipment
- ❑ Design : Variable but not Complex
- ❑ Very low added value
- ❑ Very high fettling cost

Case studies

Casting No.1

One of the first castings made with the new feeding system for High Chrome Alloys was a Hazemag APK 0805 reinforced rotor ledge ref.960 (with 60 mm thickness). It is a 70 kg liner plate casting (see Figures 1-4).

Figure 1: Two castings on the pattern plate; on the left-hand side the requisite pattern for a FEEDEX HDV 780/10 Q and on the right-hand side, the feeder sleeve already located on the pattern plate.

Figure 2: The mould turned over where breaker cores can be seen.

Figure 3: The casting with the riser.

Figure 4: The casting with the knocked-off riser. In the riser casting interface, shrinkage cavity can be seen, otherwise the casting is sound.

Since it is a first casting the standard breaker core which is normally used for iron casting was used in this trial.

By increasing the breaker core breaking aperture, the entire casting was sound. Table 1 shows the casting and costing details with conventional neck-down insulating/exothermic feeder sleeve and highly exothermic FEEDEX HDV 780/10 Q (L – larger aperture) sleeve.

Table 1: **Case study 1**

CASTING ALLOY:	GX300 CrMo26.2	CASTING WEIGHT (Kg):	70.00
POURING TEMPERATURE:	1350°C	NUMBER OF FEEDERS/CASTING:	1
CASTING MODULUS:	3.45cms	FEEDER MODULUS:	4.20cms

CASTING DATA & E.V.C.

SLEEVE TYPE	KALMINEX TA5	HDV780/ 10Q / 0212Q
Feeder volume (dm^3)	3	0.78
Feeder weight (Kg)	24	6.25
Casting yield (%)	74.47	91.80
Neck grinding area (cm^2)	38.50	6.20/11.50
Grinding time	8 min 20 sec	1 min 20 sec/2 min 30 sec
Knock off cost (EURO)	3.46	0.55/1.10
Returned estimated cost (EURO)	21.70	7.48
Moulding man power cost (EURO)	0.12	
Cost of sleeve (EURO)	5.24	9.23
Total cost (EURO/Sleeve)	30.52	17.81
Savings (EURO/casting)		11.61

NOTES: **- The casting results as per the enclosed figures shows shrinkage in the casting on the feeder/interface due to too small Feeder aperture of 6.20cm^2. By increasing the breaking aperture to 11.5cm^2 casting was sound. The moulding time with the HDV sleeve is reduced and the sleeve support is also significantly reduced. However, if the casting is poured at a higher temperature of 1400°C, we need to have a larger sleeve HDV 1140/0212Q (Breaker core for steel castings).**

Casting No.2

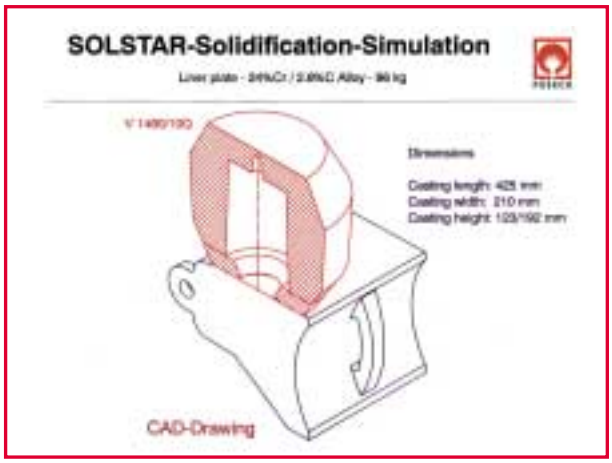


Figure 5: CAD drawing section through the casting and casting dimensions.

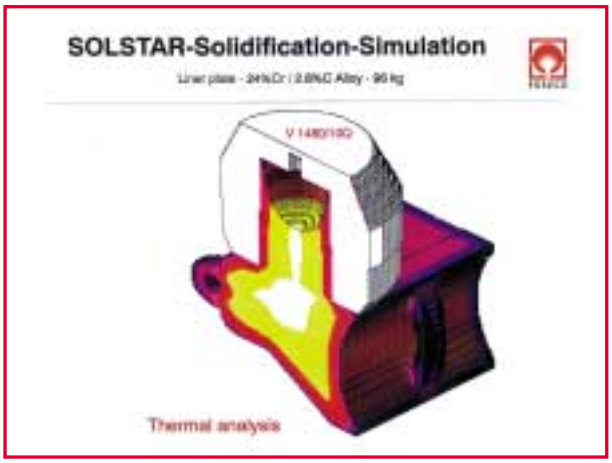


Figure 6: SOLSTAR Isochronal Thermal Analysis through the feeder and the casting sectioned through X-axis. Shrinkage on top of the feeder can be clearly seen.

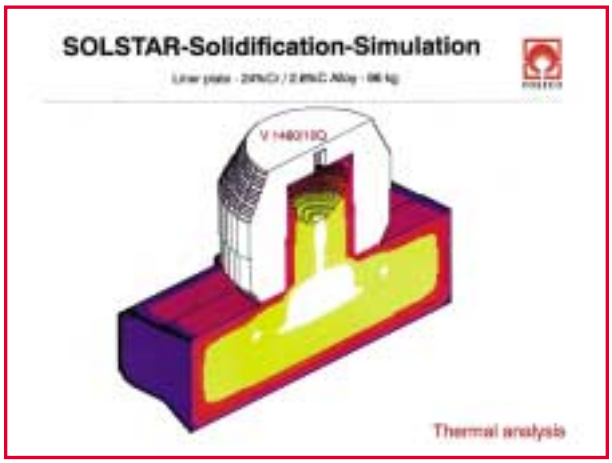


Figure 7: SOLSTAR Isochronal Thermal Analysis through the feeder and the casting sectioned through Y-axis.

Figure 8: SOLSTAR X-ray Analysis of the casting. The shrinkage is located on the top of the riser, entire casting is otherwise sound.

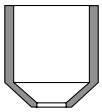
Figure 9: The actual casting lengthways with the riser.

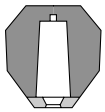
Figure 10: Side view of the casting with the riser.

Table 2: **Case study 2**

CASTING ALLOY:	3% C	18% Cr	CASTING WEIGHT (Kg):		95
POURING TEMPERATURE:		1.420°C	NUMBER OF FEEDERS/CASTING:		1

COST CALCULATION (E.V.C.)





SLEEVE TYPE	KALMINEX 150E H:200 / D:150	FEEDEX HD1 V 1480/10Q
Sleeve volume (cm²)	3.200	1.480
Sleeve weight (Kg)	25,0	11,5
Casting yield (%)	79,2	89,2
Liquid metal cost (EURO/Kg)	0,27	0,27
Liquid metal cost (EURO/Sleeve)	6,74	3,12
Neck section (cm²)	78,5	28,3
Knockoff cost (EURO/Sleeve)	1,50	0,70
Fettling cost (EURO/cm²)	0,15	0,15
Fettling cost (EURO/Sleeve)	11,78	4,25
Scrap rate (%)	6,0	2,0
Scrap cost (EURO/Sleeve)	9,00	3,00
Sleeve selling price (EURO/Sleeve)	2,37	13,69
TOTAL COST (EURO/Sleeve)	**31,38**	**24,75**
CUSTOMER SAVING (EURO/SLEEVE)		**6,63**

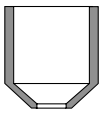
NOTES:
- **This miniriser was specially designed for this casting by FOSECO GmbH.**
- **The scrap is due to severe cracks after heat treatment.**
- **Additional benefit for the customer: 17 moulds/ladle instead of 15.**

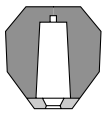
Tables 3-6 show the casting details and EVC comparison for four castings weighing 45 kgs, 30kgs and 9kgs + 1,25kg.

Table 3: **Case study 3**

CASTING ALLOY:	2,8% C	26% Cr	CASTING WEIGHT (Kg):		45
POURING TEMPERATURE:		1.450°C	NUMBER OF FEEDERS/CASTING:		1

COST CALCULATION (E.V.C.)





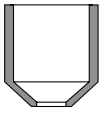
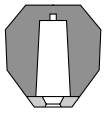
SLEEVE TYPE	KALMINEX 125/60E H:180 / D:125	FEEDEX HD1 V 770/0212Q
Sleeve volume (cm²)	2.000	770
Sleeve weight (Kg)	15,6	6,0
Casting yield (%)	74,3	88,2
Liquid metal cost (EURO/Kg)	0,30	0,30
Liquid metal cost (EURO/Sleeve)	4,68	1,80
Neck section (cm²)	28,3	9,0
Knockoff cost (EURO/Sleeve)	0,70	0,30
Fettling cost (EURO/cm²)	0,15	0,15
Fettling cost (EURO/Sleeve)	4,25	1,35
Padding (cm²/Sleeve)	15,0	0,0
Padding cost (EURO/Sleeve)	2,25	0,00
Sleeve selling price (EURO/Sleeve)	1,64	6,58
TOTAL COST (EURO/Sleeve)	**13,52**	**10,03**
CUSTOMER SAVING (EURO/SLEEVE)		**3,48**

NOTES:
- **The 0212Q breaker core has a bit wider neck than the standard oval 40Q.**
- **Additional benefit for the customer: 17 moulds/ladle instead of 15.**

Case study 4

CASTING ALLOY:	3,5% C	20% Cr	CASTING WEIGHT (Kg):		30
POURING TEMPERATURE:		1.520°C	NUMBER OF FEEDERS/CASTING:		1

COST CALCULATION (E.V.C.)

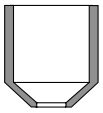
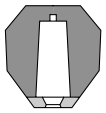
SLEEVE TYPE	KALMINEX 125/60E H:180 / D:125	FEEDEX HD1 V 590/40Q
Sleeve volume (cm²)	2.000	590
Sleeve weight (Kg)	15,6	4,6
Casting yield (%)	65,8	86,7
Liquid metal cost (EURO/Kg)	0,30	0,30
Liquid metal cost (EURO/Sleeve)	4,68	1,38
Neck section (cm²)	28,3	6,2
Knockoff cost (EURO/Sleeve)	0,70	0,20
Fettling cost (EURO/cm²)	0,15	0,15
Fettling cost (EURO/Sleeve)	4,25	0,93
Sleeve selling price (EURO/Sleeve)	2,20	5,48
TOTAL COST (EURO/Sleeve)	**11,83**	**7,99**
CUSTOMER SAVING (EURO/SLEEVE)		**3,83**

Table 4

Case study 5

CASTING ALLOY:	3,5% C	20% Cr	CASTING WEIGHT (Kg):		9
POURING TEMPERATURE:		1.520°C	NUMBER OF FEEDERS/CASTING:		1

COST CALCULATION (E.V.C.)

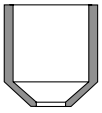
SLEEVE TYPE	KALMINEX 65E H:95 / D:65	FEEDEX HD1 V 121/10Q
Sleeve volume (cm²)	290	121
Sleeve weight (Kg)	2,3	0,9
Casting yield (%)	79,9	90,5
Liquid metal cost (EURO/Kg)	0,30	0,30
Liquid metal cost (EURO/Sleeve)	0,68	0,28
Neck section (cm²)	8,6	2,8
Knockoff cost (EURO/Sleeve)	0,30	0,05
Fettling cost (EURO/cm²)	0,15	0,15
Fettling cost (EURO/Sleeve)	1,29	0,42
Sleeve selling price (EURO/Sleeve)	0,62	1,88
TOTAL COST (EURO/Sleeve)	**2,89**	**2,63**
CUSTOMER SAVING (EURO/SLEEVE)		**0,26**

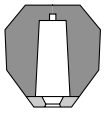
Table 5

Case study 6

CASTING ALLOY:	3% C	18% Cr	CASTING WEIGHT (Kg):		1.250
POURING TEMPERATURE:		1.420°C	NUMBER OF FEEDERS/CASTING:		7

COST CALCULATION (E.V.C.)





SLEEVE TYPE	KMX OVAL 170-110E H:200 / D:250-175	FEEDEX HD1 V 2565/2565D/10Q
Sleeve volume (cm^2)	6.600	2.565
Sleeve weight (Kg)	51,5	20,0
Casting yield (%)	77,6	89,9
Liquid metal cost (EURO/Kg)	0,27	0,27
Liquid metal cost (EURO/Sleeve)	13,90	5,40
Neck section (cm^2)	163,5	50,3
Knockoff cost (EURO/Sleeve)	2,50	0,15
Fettling cost (EURO/cm^2)	0,15	0,15
Fettling cost (EURO/Sleeve)	24,53	7,55
Padding (cm^2/Sleeve)	50,0	0,0
Padding cost (EURO/Sleeve)	10,00	0,00
Sleeve selling price (EURO/Sleeve)	4,25	34,82
TOTAL COST (EURO/Sleeve)	**55,17**	**47,92**
CUSTOMER SAVING (EURO/SLEEVE)		**7,26**

NOTES:

Table 6

Advantages

Advantages of Feedex HDV Sleeves

- ❑ Yield Increase:
  - Much smaller size
  - Blind sleeve always has constant metal weight
- ❑ Productivity Increase:
  - More moulds per ladle
- ❑ Easier knock-off
- ❑ Much lower fettling cost:
  - Reduction of fettling time and consumables
  - Reduction of cracks during fettling
- ❑ No need of metal paddings

Conclusions

These case studies clearly show that highly exothermic, high density Feedex HDV feeder sleeves which ignite in 5 to 7 sec. at 1400 °C can increase the casting yield to as much as 90% and reduce the casting cleaning aperture area or riser knock-off area by as much as 70%.

In many cases the conventional feeder is often difficult to knock off since the breaking aperture of the feeder is too large.

In such cases the feeder is first partly cut and then knocked off. The breakages of the feeder are often irregular, causing high grinding costs. This grinding process may also cause stress in the casting resulting in cracks and therefore lead to scrap casting or costly repairing operations.