

Role of CMRDI in Enhancing Competitiveness in Flat Steel Processing Sector

دور مركز بحوث وتطوير الفلزات في تعزيز
تنافسية قطاع تصنيع الصلب المسطح

By

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Hot Rolled Steel products

- Hot Rolled steel Products contain two main sectors;
 1. Long Products (rebars)
 2. Flat Products

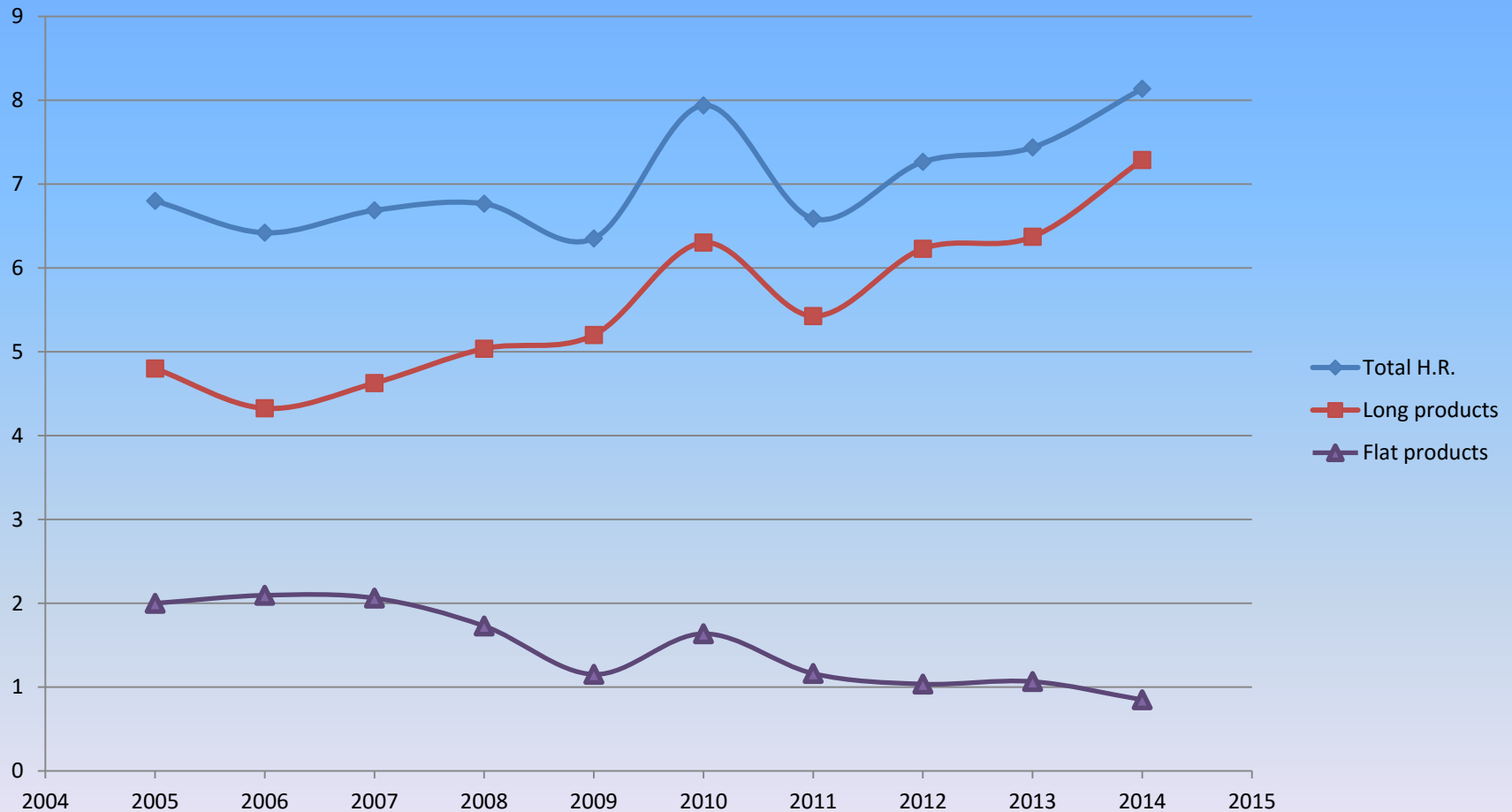
Hot Rolled Flat Steel products

- Flat steel Products contain two main divisions;
 1. Plat products (length sized)
 2. Sheet products(coils)

Flat Steel Processing Sector

- We are focusing on **efforts done by CMRDI** for developing Flat Steel processing Sector;
 1. Not at the expense of long steel products
 2. Not by addition extra new facilities (investments)
 3. Make benefit of already existing facilities
 4. Implementing value added flat steel grades by either;
- **Adapted technology transfer, or**
- **New brand processing technology package**

Statistical Analysis of 10 years Hot Rolled Steel Production in Egypt



Deficiency of Flat steel production

- On 2010, a melting facility (EAF) has been used for processing long products.
- More than 1 M.ton Long products were increased at the expense of Flat steel products.
- This means market loss of Flat steel sector
- Now, we are encouraging the Flat steel sector to start again to regain the market with:
 1. Carbon Flat steel products
 2. Value added flat steel products

Value added Flat steel grades

- More Profitable steel grades.
- Do not need extra investments (facilities).
- Implementation need only;
 1. either adapted technology transfer
 2. or know how for a complete technology package
- Extra demands due to different uses in different applications in different industries.

1- API steel grades

- Low carbon steel containing micro-alloying with Ti, V, Nb.
- Thermo-mechanically treated (Finish rolling beyond the T_r followed by controlled cooling at the R.O.T.
- The steel appears excellent strength in combination with considerable ductility
- Good toughness properties even at low temperatures (-50 °C)
- 1st trial, ANSDK (2001), 160 tons steel were processed as X52
- 2nd trial, EFS (2003), 175 tons steel were processed as X60 & X70.

API steel grades

scientific contribution

- 4 articles were published
- 1 Ph.D. & 2 M.Sc. Thesis were obtained
- Ph.D. Thesis of Eng. Maha El-Meligy, at Faculty of Engineering, Benha University, " Effect of alloying with both Ti and Nb and Thermo-mechanical treatment on properties of Low carbon Steel". on October, 2007.
- M.Sc. Thesis of Eng. Elmeslehy M. Elmeslehy , at Helwan University, Faculty of Engineering "Effect of Thermomechanical Processing of Nb-microalloyed High Strength Low alloy (HSLA) Steels". on October, 2008.
- M.Sc. Thesis of Eng. Nader Fouad Dauood, at Helwan University, Faculty of Engineering " Thermo-mechanical Treatment of Low carbon Multi-alloyed steel“ on January 2012.

2- Weathering steels

- Low alloy steels
- Alloyed with 0.2-0.4% Cu in combination with 0.08-0.15% P
- Atmospheric corrosion resistance due to formation of a thin tightly adherent Cu-oxide film (Patina) on the steel surface.
- **One trial** (160 tons) was processed at ANSDK on 2005 as a **request from SIMAF** company for building the frame of the underground unites.

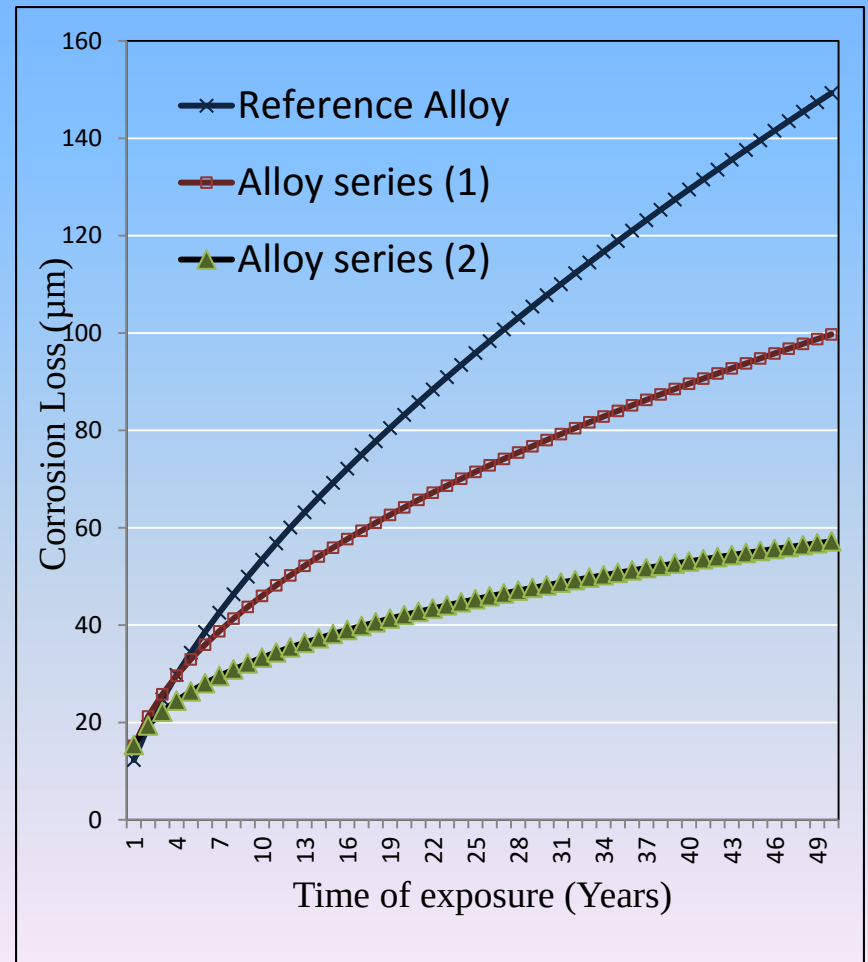
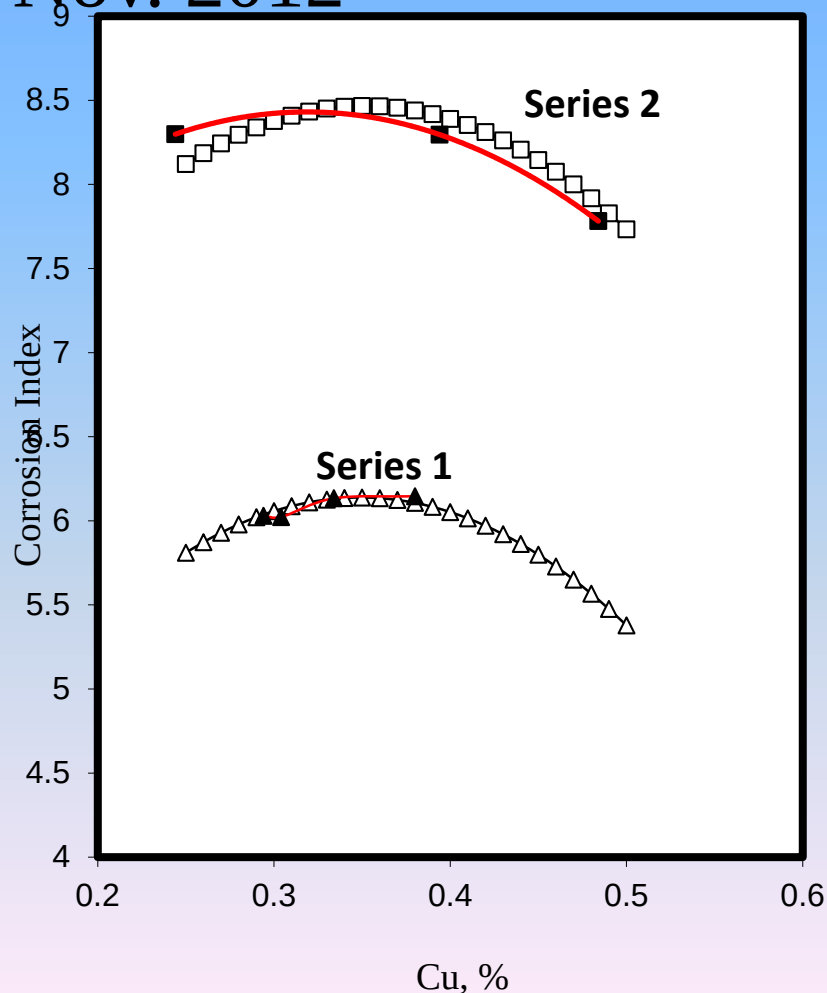
corrosion index I

- A numerical corrosion index I was developed by the **ASTM Standard**,
- I is a function of chemical composition.
- $$I = 26.01 (\%Cu) + 3.88 (\%Ni) + 1.2 (\%Cr) + 1.49 (\%Si) + 17.28 (\%P) - 7.29 (\%Cu) (\%Ni) - 9.1 (\%Ni) (\%P) - 33.39 (\%Cu)^2$$
- I should be equal to or **greater than 6** to accept resistance to atmospheric corrosion

Contribution of CMRDI

- Two semi-industrial steel trials were developed;
- **Series 1** contain (0.3-0.4)% Cu
- **Series 2** contain (0.2-0.5)% Cu + 0.13% P
- **For Series 1**, 0.3-0.35% Cu is the optimum
- > 0.35%), results in formation of a thicker CuO layer with a more rough surface on the steel substrate leading to a friable coat.
- **For Series 2**, 0.25-0.4% Cu in combination with 0.13% P are the optimum.

The results are abstracted from Ph.D. thesis at the
Faculty of Engineering, Benha University
The thesis were carried by Eng. Maha Mohee, on
Nov. 2012



3- Si steel thin sheets

- Low carbon ($< 0.08 \%$)
- Contains mainly **Si** and possibly **Al**
- **Low Si**-steel contains 0.6% Si
- **Medium Si**-steel contains 1.0-1.5% Si
- **High Si**-steel contains 2.0-3.5% Si
- Used mainly for Electrical power transformation
- Two main types;
 1. Grain oriented Si-steel represents 20%
 2. Non-oriented grain represents 75%
 3. Others 5%

Metallurgical effects of Si

- Silicon increases the volume resistivity of the steel and thereby **reduces the eddy currents loss**.
- silicon reduces the amount of energy expended in magnetizing the core and consequently, **the hysteresis component is also reduced**.
- Contrary, as the Si-content is increased, the mechanical properties of the steel may be adversely affected.

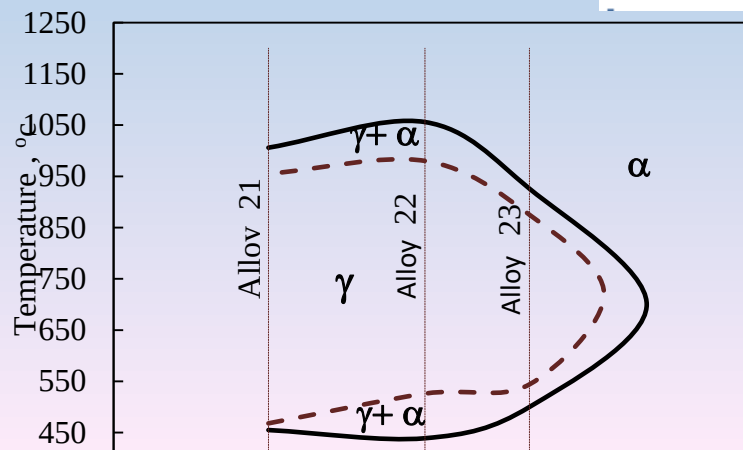
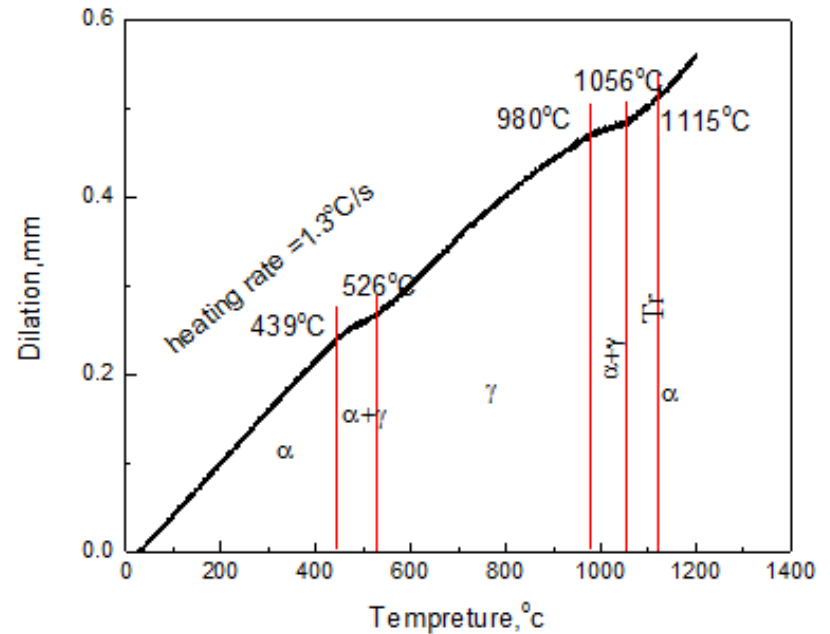
ANSDK 1st trial

- 160 tons low carbon (0.04%)
- Contains low Si (0.6%)
- Hot rolled 3.0 mm coils
- Cold rolling to (+ annealing were carried out at Kandil Steel (under the supervision of CMRDI)

Role of CMRDI

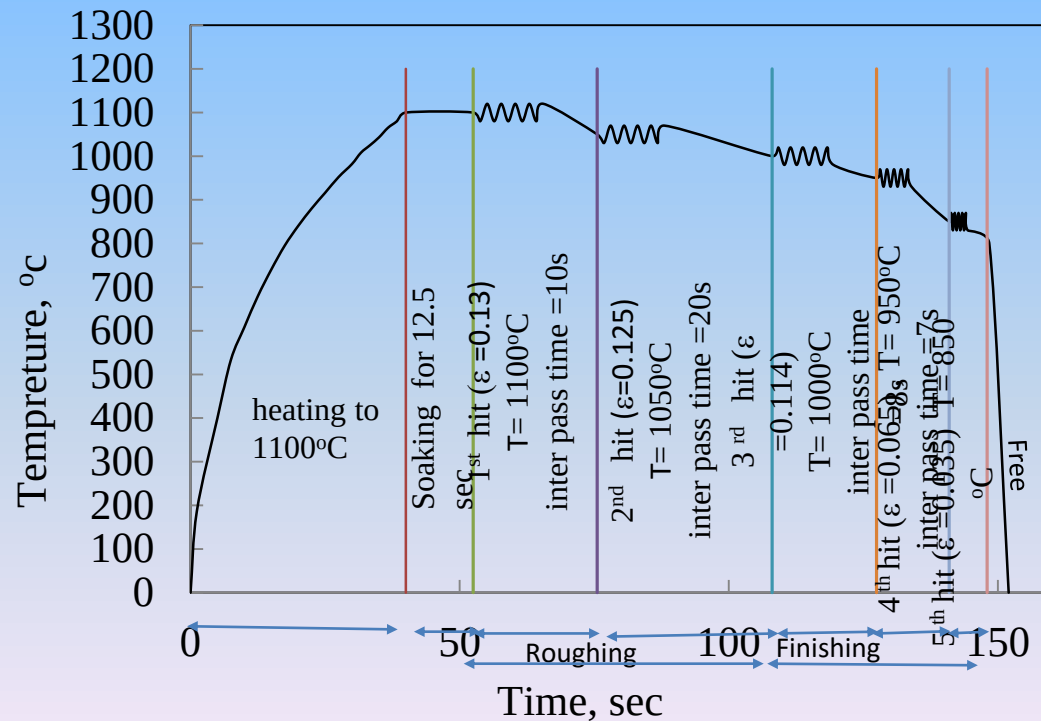
- **CMRDI** signed a contract with **STDF** to introduce a technology package to process **NOG medium Si-steel thin sheets** for electrical motors.
- A technology package is almost finished

Dilation investigation



Design of the thermo-mechanical processing parameters

- (heating rate, holding temp. and time, amount of reduction, and cooling after deformation)



Technology package **Customers**

- **ANSDK and or EFS (hot rolled coils 2-3 mm thickness)**
- **Abou Zaabal Engineering Industries Co (Factory 100) for flat cold rolling - annealing**
- **Shoubra for Engineering Industries (Factory 27) (final client)**

Scientific outputs

- **T. El-Bitar, M. El-meligy and E. El-Shenawy "Detection of dynamic softening during hot deformation of medium Si-steels by a thermo- mechanical simulator (Gleeble 3500)", International Journal of Mechanical and Production Engineering Research and Development (IJMPERD), Vol. 5, Issue 6, Dec 2015.**
- **El-Bitar, Taher ; El-Meligy, Maha; El-Shenawy , Eman"Physical Simulation for Hot Rolling Policy of Electrical Si–Steels" submitted to Modeling and Simulation in Materials Science and Engineering (MSMSE)**

4- Dual Phase steel for automotive industries

- Dual-phase steel offers impressive **mechanical properties**, such as;
 1. continuous yielding behavior and
 2. superior strength–ductility combination.
 3. It is used for wide applications in automobile components, such as car body panels, wheels, bumpers.

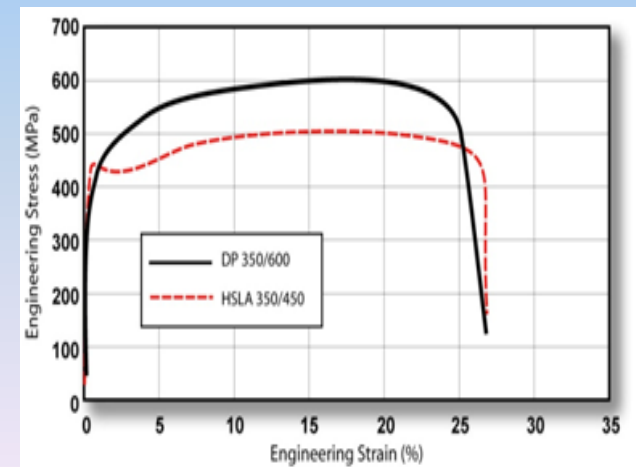
Dual-phase steels constituents

- Dual-phase steels usually consist of
 1. a specific volume fraction of high-strength phase, such as martensite or bainite, within
 2. a softer ferrite matrix, [3].
- 3. Two types of Dual phase are existing;
 - Ferrite-martensite dual-phase (FMDP) steel.
 - Have not been used successfully for complex press-formed parts such as chassis or wheels, because of softening in the heat affected zone.
- **Ferrite - Bainite Dual Phase (FBDP)** steels are more suitable for cold-formed components.

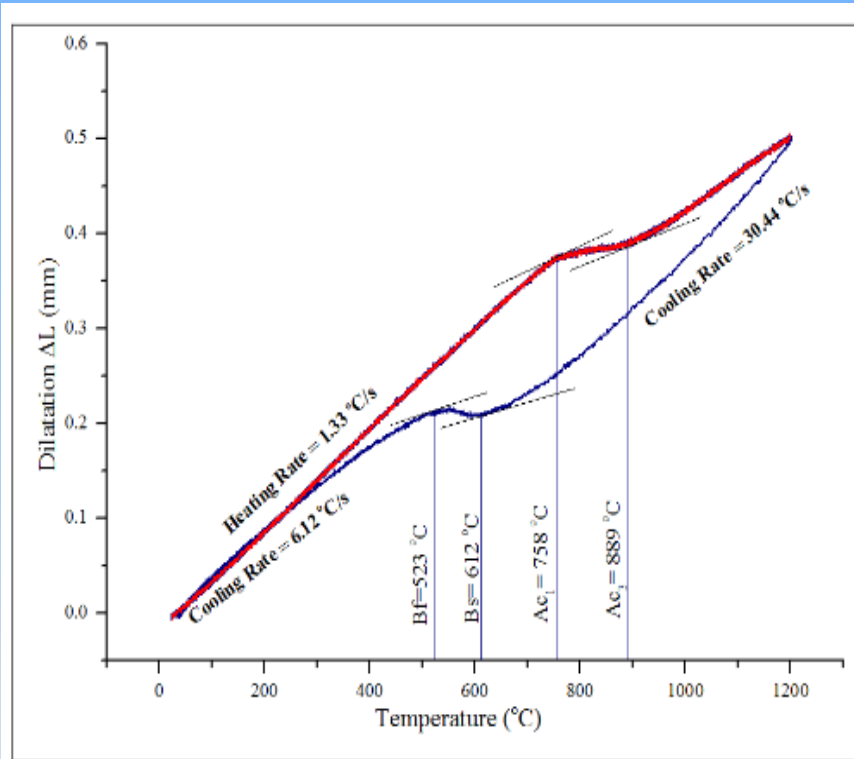
Ferrite - Bainite Dual Phase (FBDP) steel project

- Funded by **STDF** in Egypt
- Aims at submitting a technology package suitable for CSP-direct rolling.
- The technology package can be adapted for any other steel processing roots.
- The investigation is not yet finished. However, we got excellent results regarding;

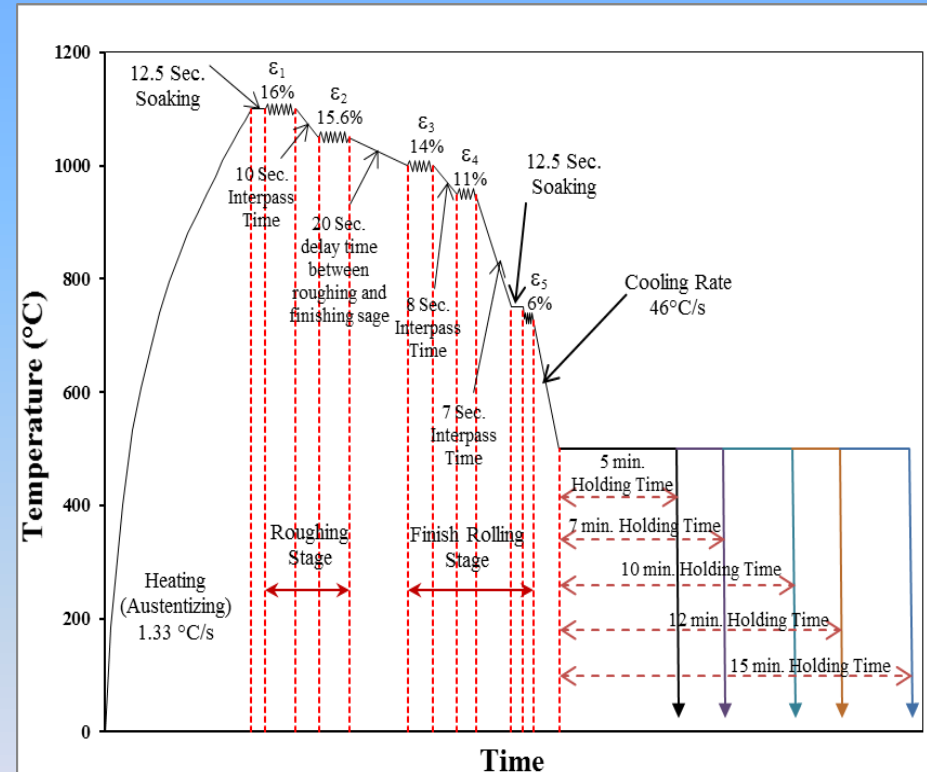
1. Continuous yielding
2. Excellent strength and ductility
3. Considerable toughness



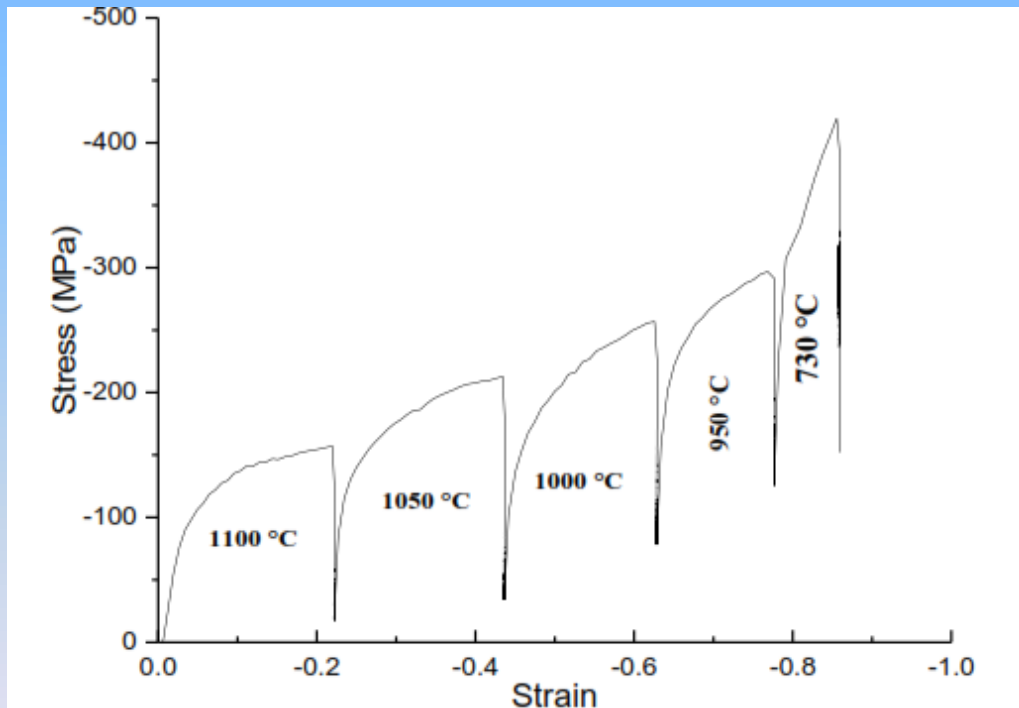
Critical and allotropic phase transformation temperatures



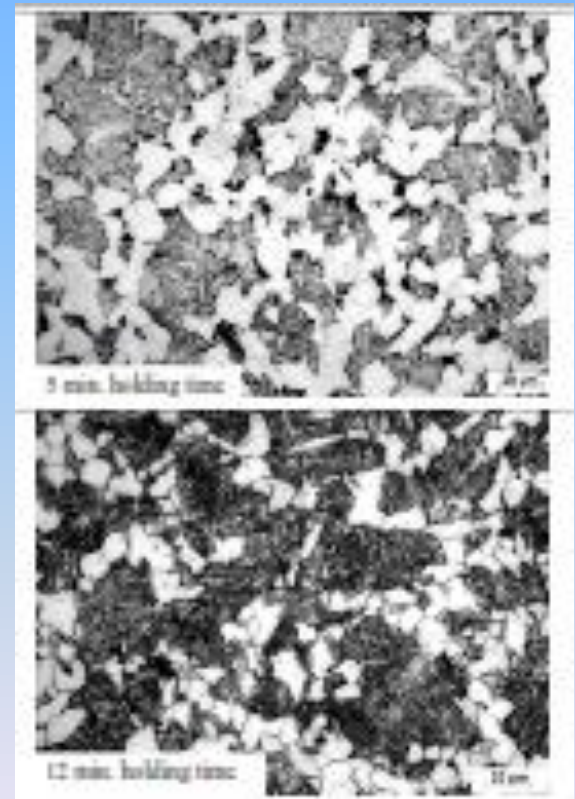
Design of the thermo-mechanical processing parameters



Flow curves of the 5-consecutive passes



Microstructure created after
5 and 12 min. at 500 oC



Scientific outputs

1. Taher El-Bitar, Eman El-Shenawy& Maha El-meligy, “**Development of Ferrite–Bainite Dual Phase (FBDP) high strength steel for automotive industries**”, Key Engineering Materials Vols. 622-623 (2014) pp 840-845
1. Taher El-Bitar, Eman El-Shenawy, Maha El-meligy, “**Physical simulation of thermo-mechanical processing of ferritic-bainitic dual phase (FBDP) steel**”, Intl’ Conf. on Processing & Manufacturing of Advanced Materials (Thermec’2016) Conference , May 29-June 03, 2016, Graz, Austria

5- Development of Martensitic High Strength Steel (HSS) plates for Armoring Troops Carriers

The project was funded by the national authorization for military products

The project was implemented at:

- Abou Zabaal Company for Engineering Industries (Military Factory 100)

And carried out under the supervision of

- Central Metallurgical R&D Institute (CMRDI)

Essential requirement

- **Terrorist** attacks targeting security and safety of the country.
- Battle against terrorism depends mainly on **troops**.
- Troops need **armored carriers** for transportation.
- The troops carriers should withstand against **ballistic shooting**

Specific dimensional goals & Challenge

- 6 mm thickness,
- 1500 mm width, and
- 6 m length.
- The challenge was the processing of such steel grade without any additional investments.

Steel chemical composition

Element	C	Si	Mn	P	S
Stand.	.29-.32	.1-.4	1.1-1.2	$\leq .010$	$\leq .010$
Actual	0.3	0.24	1.11	0.010	0.009

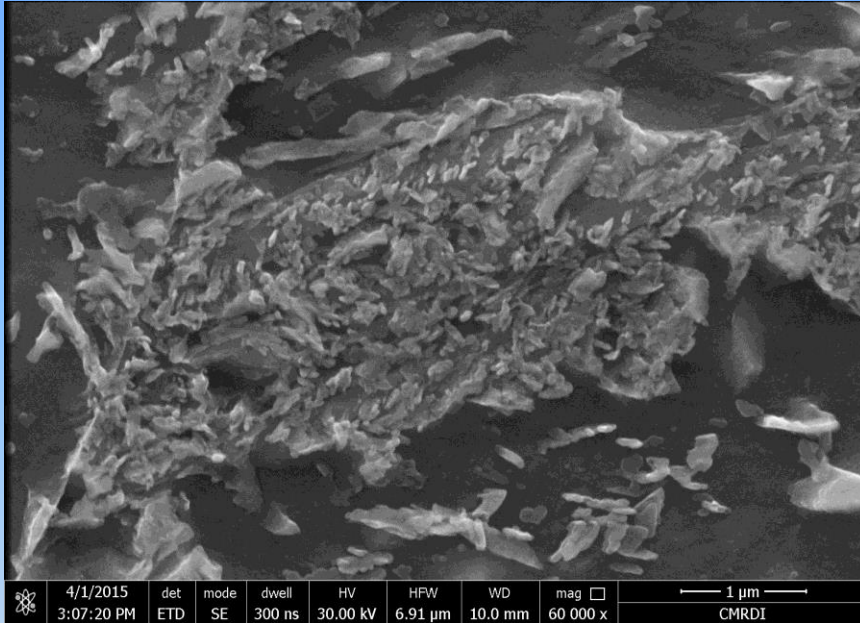
Cr	Mo	Ni	Al	Cu	B
.9-1.1	.6-.7	1.7-1.8	.02-.05	≤ 0.1	.004-.0045
0.93	0.62	1.76	0.034	0.07	0.004

Steel Processing

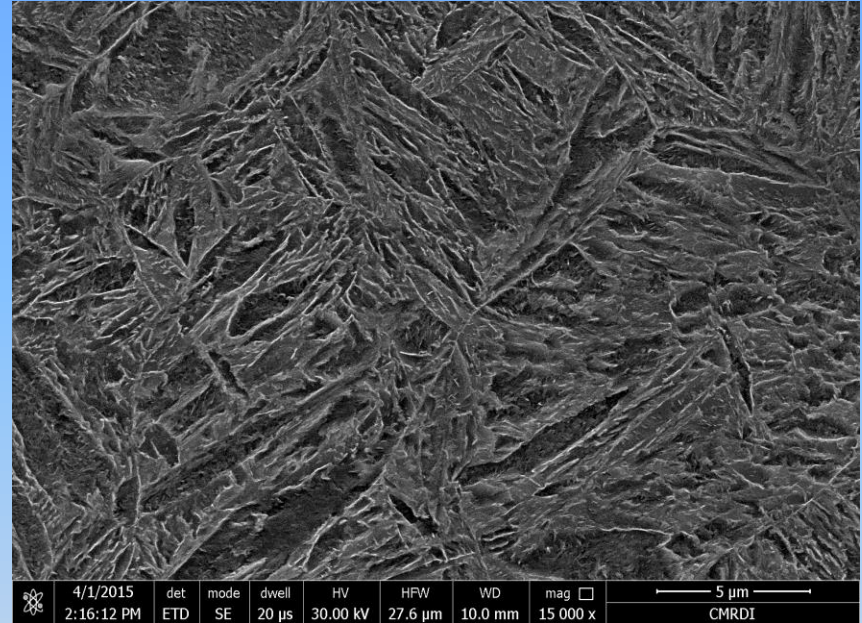
❖ 20 ton

- 3 Cast steel ingots 5-6 tons each
- Cross-sectional dimensions 360x1000 mm
- **Ingots stress relief at 650 °C**
- **Critical and allotropic transformation temperatures (**Ac1, Ac3, Ms, Mf, Tr**)**
- Hot rolling (2 stages hot deformation)
- Quenching-Tempering

Filed emission microstructure of 80 mm thickness slab



Q. +Tempering at 250°C for 20 min.



Successful Ballistic resistance testing after Armor-Piercing (AP) projectiles shooting



Ballistic resistance certificates

قطاع مراقبة و تأكيد الجودة
ادارة الاختبارات الباليستيكية
التاريخ : ٢٠١٤ / ١٢ / ٢٢

تقرير اختبار صلب مدرع

بالإشارة إلى خطاب م / ١٠٠ الحربي بتاريخ ١٥ / ١٢ / ٢٠١٤ قيد رقم ١ / ١٨٠ / درفله بخصوص اجراء الاختبار على عدد (١٠) عينة صلب سمك ٦ مم ARMOX500 باستخدام ذخيرة ٧,٦٢ × ٥١ مم ball لعدد (٥) عينة متوسط السرعة ٧,٥ م / ث باستخدام ذخيرة ٥,٥٦ × ٤٥ مم SS109 لعدد (٥) عينة متوسط السرعة ٧,٥ م / ث و قد تمت التجارب بحضور مندوب م / السيد المهندس / شحاتة محمد شحاتة السيد المهندس / محمود أحمد حسن

أولاً ذخيرة ٧,٦٢ × ٥١ مم ball

م	رقم الدرع الصلب	سمك الدرع مم	مسافة الاختراق بالمتر	الزاوية	عدد الطلقات	النتيجة
						النتيجة
						إجمالي
						اختراق
						عدم اختراق
١	٢/٢/١٣٠٠	٦مم	١٠مم	صفر	٣	صفر/٣
٢	٣/١٣٠٠	٦مم	١٠مم	صفر	٣	صفر/٣
٣	٢/١٣٠١	٦مم	١٠مم	صفر	٣	صفر/٣
٤	٢/٣/١٣٠١	٦مم	١٠مم	صفر	٣	١/٣
٥	١/١٣٠١	٦مم	١٠مم	صفر	٣	صفر/٣

ثانياً : ذخيرة ٥,٥٦ × ٤٥ مم SS109

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						نتائج الاختبار	
						إجمالي	اختراق
١	٢/٢/١٣٠٠	٦مم	١٠م	صفر	٣	صفر/٣	عدم اختراق
٢	٣/١٣٠٠	٦مم	١٠م	صفر	٣	صفر/٣	اختراق
٣	٢/١٣٠١	٦مم	١٠م	صفر	٣	صفر/٣	عدم اختراق
٤	٢/٣/١٣٠١	٦مم	١٠م	صفر	٣	صفر/٣	اختراق
٥	١/١٣٠١	٦مم	١٠م	صفر	٣	صفر/٣	عدم اختراق

مهندس
رئيس قطاع الجودة

أخصائي

مدير عام الاختبارات



قطاع مراقبة و تأكيد الجودة
ادارة الاختبارات الباليستيكية
التاريخ : ٢٠١٤ / ١٢ / ٧

تقرير اختبار صلب مدرع

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م	رقم الدرع الصلب	سمك الدرع مم	مسافة الاختراق بالمتر	الزاوية	عدد الملاحظات	النتيجة	
						نتائج الاختبار	
						إجمالي	النتيجة
١	٢ / ١٣٠١	٦	١٠	صفر	٣	صفر / ٣	اختراق
						صفر / ٣	عدم اختراق
٢	١ / ١٢٩٩	٦	١٠	صفر	٣	٢ / ٢	٢
٣	٢ / ١٢٩٩	٦	١٠	صفر	٣	صفر / ٣	/
٤	٣ / ١٢٩٩	٦	١٠	صفر	٣	صفر / ٣	/
٥	١٣٠٠	٦	١٠	صفر	٣	٣ / ١	١

ثانياً : ذخيرة ٥,٥٦ × ٤٥ مم SS109

م	رقم الدرع الصلب	سمك الدرع مم	مسافة الاختراق بالمتر	الزاوية	عدد الطلقات	النتيجة
						النتيجة
						نتائج الاختبار
						إجمالي
						اختراق
						عدم اختراق
١	٢ / ١٣٠١	٦	١٠	صفر	٣	صفر / ٣
٢	١ / ١٢٩٩	٦	١٠	صفر	٣	صفر / ٣
٣	٢ / ١٢٩٩	٦	١٠	صفر	٢	٣ / ١
٤	٣ / ١٢٩٩	٦	١٠	صفر	٣	صفر / ٣
٥	١٣٠٠	٦	١٠	صفر	٣	صفر / ٣

مهندس

رئيس قطاع الجودة



أخصائي
مدير عام الاختبارات

Scientific outputs

1. T. El-Bitar, E. El-Shenawy, M. El-Meligy, A. Mohammed, and N. Dawood, “**Armor steel (ARMOX 500B) from an essential requirement into a real fact**”, Industry Academia Collaboration Technology for Development, 7-9 April 2015, Cairo, Egypt.
2. Taher El-Bitar, Eman El-Shenawy, Maha El-meligy, Almosilhy Almosilhy, and Nader Dawood, “ **Development of armor High Strength Steel (HSS) martensitic plates for troops Carriers**” Intl’ Conf. on Processing & Manufacturing of Advanced Materials (Thermec’2016) Conference , May 29-June 03, 2016, Graz, Austria
3. Taher El-Bitar, Eman El-Shenawy, Maha El-Meligy, Almosilhy Almosilhy, and Nader Dawood, “**Thermo-mechanical Processing of Armor Steel Plates**” Metal Forming Conf. 2016



Thank you!