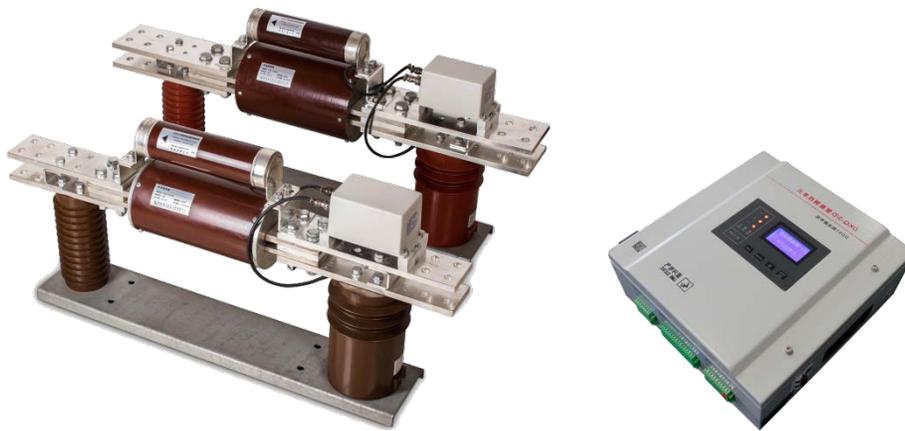




DDX1系列短路电流限制器

DDX1 Series Of Fault Current Limiter



陕 西 蓝 河 电 气 工 程 有 限 公 司
SHAANXI LANHE ELECTRIC ENGINEERING CO., LTD.

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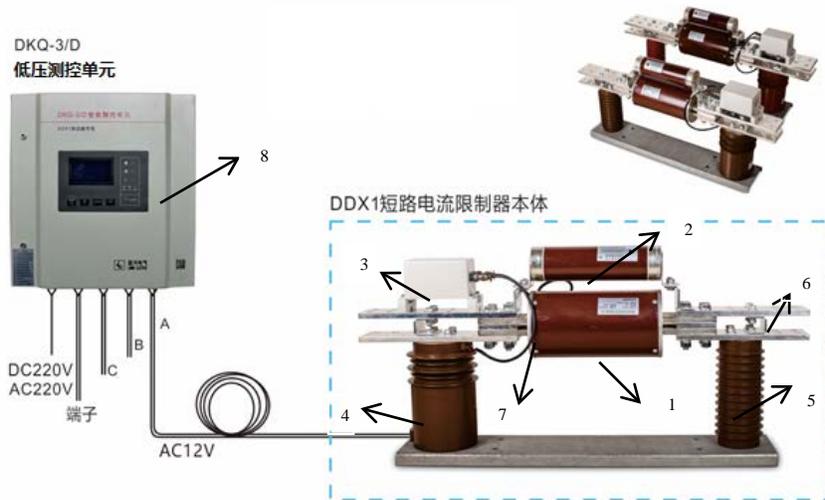
◆ 应用特点

- 1) 全球开断速度最快的大容量开关设备
- 2) 已有近千套产品应用于国内外配电系统，验证了产品功能及可靠性
- 3) 降低变电站造价
- 4) 保护“体弱”的电力设备
- 5) 解决新电源接入后短路电流超标问题
- 6) 优化系统运行方式
- 7) 在很多情况下，提供唯一合理的技术解决方案
- 8) 实际出现的电流将远低于预期电流的峰值
- 9) 首半波极早期限流
- 10) 限流电抗器理想的节能、降损方案

◆ Application Characteristics

- 1) The world's fastest breaking high-capacity switchgear
- 2) There are nearly a thousand sets of production have been used in power distribution systems at home and abroad, the function and reliability of the productions have been verified.
- 3) Reduce the cost of substation.
- 4) Protect the frail power equipment
- 5) Solve the problem of short circuit current exceeding standard after new power supply is connected.
- 6) Optimize operation mode of the system.
- 7) In many cases, provide the only reasonable technical solution
- 8) The actual current will be much lower than the peak of prospective current.
- 9) Current limiting very early at the first half wave.
- 10) The ideal plan to energy saving and loss reduction for the current limiting reactor.

1 原理及特性 Principle And Characteristics



- 1—基于爆破切割技术的快速隔离器
- 2—特种高压限流熔断器
- 3—电子控制器
- 4—高压隔离变压器
- 5—支撑绝缘子
- 6—主导电母线
- 7—电流传感器（内置）
- 8—模拟测控单元

- 1--Fast-speed Dis-connector Base on Demolish-Cutting Technology
- 2--Special High-Voltage Current Limiting Fuse
- 3--Electrical Controller
- 4-- High-Voltage Isolated Transformer
- 5-- Insulator
- 6-- Main Bus
- 7-- Current Tranducer （Inside）
- 8-- Analog measurement and control unit

图 1 基本构成

Fig1 The Basic Parts Of DDX1

1.1 DDX1 基本构成

The Basic Parts Of DDX1

从图 1 中可以看出 DDX1 短路电流限制器的基本构成，其中基于爆破切割技术的快速隔离器 1、特种高压限流熔断器 2、电子控制器 3 是 DDX1 的核心部件。快速隔离器 1 和熔断器 2 并联构成 DDX1 的导电主回路，电子控制器 3 控制快速隔离器 1 的爆破切割，模拟测控单元 8 用于供电并指示 DDX1 的工作状态。

The Basic Parts Of DDX1 are show in Fig1。The fast-speed dis-connector 1、the fuse 2 and the electrical controller 3 are the key parts of DDX1。The main passage of current is the parallel loop made up by the fast-speed dis-connector 1 and the fuse 2。The cutting action of the fast-speed dis-connector 1 is controlled by the electrical controller 3。The Analog measurement and control unit 8 is used to indicate the operating conditions of DDX1, also is the power supply of DDX1。

1.2 原理描述 Description Of The Principle

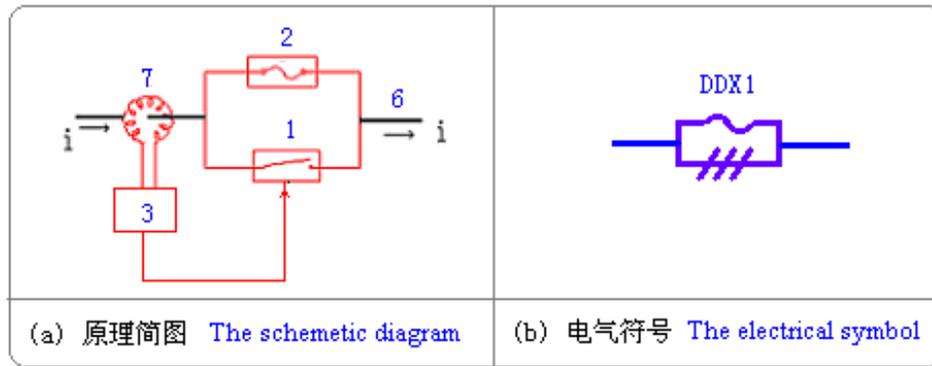


图 2 原理简图及电气符号 Fig2 The schematic diagram and the electrical symbol

图 1 及图 2 中，模拟测控单元 8 通过高压隔离变压器 4 给电子控制器 3 供电，并采用灯光、继电器接点、记数器等手段指示 DDX1 的工作状态。快速隔离器 1 和特种高压限流熔断器 2 在电气上是并联的，由于前者电阻为微欧级，后者电阻为毫欧级，故正常运行情况下母线电流几乎全部流过快速隔离器 1。当系统发生短路事故时，置于快速隔离器 1 内部的电流传感器 7 将母线 6 中的短路电流信号通过信号电缆传递给电子控制器 3，由 3 进行信号的分析处理。若短路电流信号超过整定值，3 将输出点火脉冲信号，使快速隔离器 1 中的执行元件——爆破切割系统动作，将隔离器导电回路在几百微秒的时间内高速断开；在隔离器导电回路断开的过程中，故障电流转移到特种高压限流熔断器 2 中，由 2 最后开断短路电流、切除故障。

In fig1 and fig2 Analog measurement and control unit 8 supply power for the electrical controller 3 through the isolated transformer 4, and indicate the operating conditions of DDX1 by LED、LCD、the contacts of relays or counter etc。The main passage of current is the parallel loop made up by the fast-speed dis-connector 1 and the fuse 2 are in parallel and form the main passage of DDX1 current。But because the resistance of dis-connector 1 is in misro-ohm and the fuse 2 is in milli-ohm, so almost all the current in main loop is flow through the dis-connector 1 in normal situation。The current signal is transmited to the controller 3 by current transducer 7 sealed in dis-connector 1 When a fault occurs, and it will be analysed in controller 3。The controller 3 will output a powerful tringle pulse to dis-connector 1 when the fault current signal exceeds its settings, and this result the demolish cutting in dis-connector 1, the current passage in dis-connector 1 is opened in several hundred millisecond, then the fault current is transfered to fuse 2 and be broken in several microsecond。

DDX1 开断短路电流的动作时序如图 3 所示:

Fig3 is the sketchmap of the time sequence of DDX1's current breaking process:

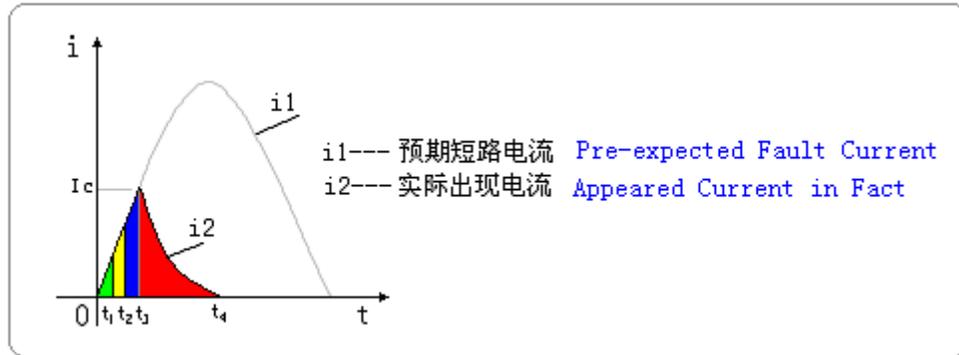


图 3 DDX1 限流器动作时序示意图 Fig3 The sketch map of DDX1's breaking process

$t=0$ 短路故障发生。

$t=0$, the short-circuit occurs.

$t=t_1$ 电子控制器探测到故障并建立点火信号, 此时间与预期短路电流的大小、电子控制器动作整定值及短路发生时的相位角均有关系, 一般大于 $600\mu s$ 。

$t=t_1$, the response time of the electrical controller which is related with the value of the pre-expected fault current、the settings of the controller and the phase angle between current and voltage when short occurs, nomally longer then 600 millisecond. During this time, the controller will found the fault and fire the trigle pulse.

$t=t_2$ 快速隔离器断口打开, 电流转移到限流熔断器中, (t_2-t_1) 约为 $200\mu s$ 。

$t=t_2$, the disconnector is open, and the current is transferred to the fuse. t_2-t_1 is the response time of the demolish-cutting, nomally in 200 millisecond.

$t=t_3$ 熔断器开始起弧, (t_3-t_2) 为熔断器的弧前时间, 一般为一个毫秒左右, 图中的 I_c 即为限流峰值。

$t=t_3$, the fuse is arcing, I_c is named cut-off current. t_3-t_2 is the melting duration (pre-arcing time) of the fuse, nomally in a microsecond.

$t=t_4$ 熔断器内电弧熄灭, 故障电流被彻底开断, (t_4-t_3) 为熔断器的燃弧时间, 一般小于 $5ms$ 。 (t_4-t_1) 称为全开断时间, 小于 $10ms$ 。

$t=t_4$, the arc in the fuse is extinguished, the fault current has been broken. t_4-t_3 is the arcing duration of the fuse, nomally shorter then 5 microsecond. t_4-t_1 is named the total breaking duration of DDX1, shorter then 10 microsecond.

图 4 为电力系统典型短路电流的波

The topical fault current waveform in power system, also the comparision in breaking feature between DDX1 and nomal

形及 DDX1 与普通断路器开断性能比较的示意图。可以看出，DDX1 在短路故障发生后几毫秒内完成限流开断，普通断路器则由于继电保护和操作机构的固有特性需要经过数个周波、在短路电流自然过零时才能开断。

circuit-breaker are shown in fig4. We can see, DDX1 just need several microsecond and have obvious current-limiting feature to break a fault current, but above a hundred microseconds for normal circuit breaker because of its relay-protection and its operating mechanism with no current-limiting feature.

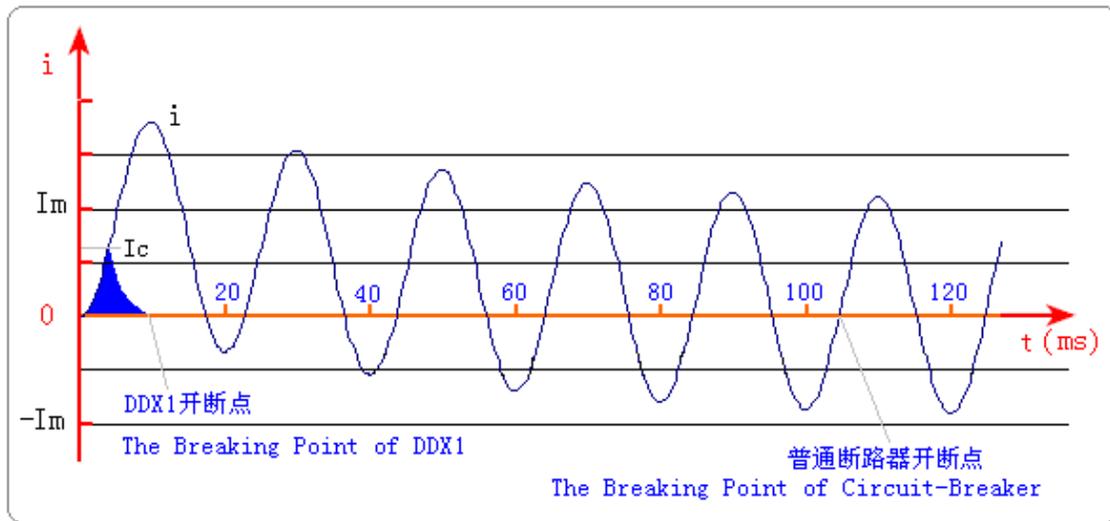


图4 短路电流波形及 DDX1 与普通断路器开断性能比较示意图

Fig4 The typical current waveform in power system and the comparison sketch map in breaking feature between DDX1 and normal circuit-breaker

综合图 3 及图 4，可以看出：DDX1 可在预期短路电流尚未发展到峰值之前将其高速限流开断，实际通过电力设备的短路电流的峰值 I_c 在第一个半波被限制到预期短路电流峰值的 (15~50) %，短路电流的持续时间小于 10 ms，大大降低了故障电流的总能量 $\int i^2 dt$ (约为普通断路器的 1/200)，从而更有效地保护了电力主设备免受损坏。

Through fig3 and fig4, we can see: DDX1 can break the fault current at very first current rise before peak value of the pre-expected short-current is arrived. The cut-off current I_c which flow through the electrical apparatus actually is about (15~50) % of the peak value of the pre-expected short-current. The total breaking duration is less than 10ms, this results in a deep reduction of the fault current energy $\int i^2 dt$ (about 1/200 of the value of a normal circuit-breaker) and be more efficient to the protection of main electrical apparatus.

根据电力系统短路电流的特性，

According to the feature of the fault current

DDX1 限流器的电子控制器设定了电流瞬时值 i 及电流瞬时变化率 di/dt 两个启动判据。只有当两者同时大于设定值时才输出动作信号，从而增强了电子控制器的抗干扰能力，同时保证了 DDX1 的快速动作。DDX1 动作后的快速隔离器及特种限流熔断器的结构解剖图见图 5。

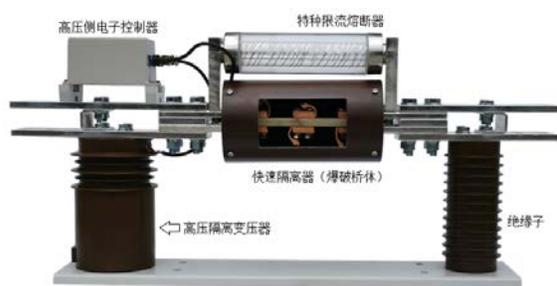


图 5 DDX1 动作后的形态照片

1.3 特性描述（大容量、高速、限流）

(1) High ability to break a fault current: 50kA~200kA

(2) High breaking speed: <10 ms

(3) Obvious current-limiting feature: 15%~50%

- 额定电流 630A~6300A
- 额定电压 3.6kV~40.5kV
- 额定短路开断电流 50kA~200kA
- 全开断时间小于 10ms
- 限流特性：可将短路电流限制到预期水平的 15%~50%
- 快速隔离器和熔断器全密封，可靠性高、

in power system, two settings for controller been recommended are the instantaneous value of current i and the instantaneous value of current variation di/dt . The controller can output the trigle pulse only when the two settings meet its demands simultaneously, thus enhance the ability to resist interference and ensure the fast operation of DDX1. The internal dissected structure pictures of the dis-connector and the fuse are shown in fig 5.



Fig5 The pictures after DDX1 is done
Description Of the Characteristics

- Rated current: 630A~6300A
- Rated voltage: 3.6kV~40.5kV
- Rated short-breaking current: 50kA~200kA
- Total breaking duration:<10ms
- Obvious current-limiting feature:can limit the fault current to (15~50)% of its pre-expected value
- The fast-speed disconnector and the fuse are sealed fully,less noise、high reliability and can

- 噪音小、可户内及户外使用
- 其动作行为可以通过电子控制器实现电流及电流变化率双判据整定
- 电流传感器封装在快速隔离器内，达到了结构最简
- 世界上速度最快的短路电流开断设备
- 自主研发，专利技术
- 采用军事尖端技术：可控爆破切割技术
- 可有效保护电力系统及主设备的安全
- 短路电流的克星，节能新产品。

- be used indoor or outdoor
- The operation behavior can be set by i and di/dt
- The current transducer is sealed inside the disconnect, achieve a simplified structure
- The world's fastest switching device
- Patent technology
- The military high-technology: demolish cutting technology under control
- More efficient to protect the power system and the main equipments
- The powerful weapon to treat fault current, new apparatus to avoid energy loss

2 主要技术参数 Main Technical Data

表1 主要技术参数

Table1 Main Technical Data Of DDX1

序号 Number	项 目 Items	单位 Units	技术参数 Technical Data
1	额定电流 Rated current	A	630/2000/4000/6300
2	额定电压 Rated voltage	kV	3.6/7.2/12/20/40.5
3	额定频率 Rated frequency	Hz	50/60
4	额定预期短路开断电流 Rated pre-expected short-circuit breaking current	kA	50/63/100/150/200
5	全开断时间 The total breaking duration	ms	<10
6	额定绝缘水平（工频/雷电） Rated Insulation Level (power frequency/lighting)	3.6kV	/
		7.2kV	23/60
		12kV	42/75
		20kV	50/125
7	截止电流/预期短路电流峰值 Cut-off Current/ the peak Value of Pre-expected Fault Current	40.5kV	95/185
			15~50
8	主回路直流电阻 DC resistance of main loop	$\mu\Omega$	<40
9	动作电流整定范围 The range of settings	kA	5~60
10	特种高压限流熔断器额定开断电流 Rated short-circuit breaking current of the special type HV current-limiting fuse	kA	63/100/150/200
11	主回路额定短时耐受电流 Rated Short-time withstand current of main loop	kA/s	40/3
12	主回路额定峰值耐受电流 Rated peak value withstand current of main loop	kA	100
13	相间及相对地空气净距（户内时） Net distance between phases and to the earth(indoor)	mm	100/125/180/300

14	支柱绝缘子爬电比距（额定线电压为准） The unit Creeping distance	mm/ kV	>25（3级污区）
15	支柱绝缘子机械破坏负荷（弯曲及拉伸） Destroy mechanical load on insulator	kN	>12

表 2 结构尺寸参数（仅作参考）

Table2 The Structure Demensions(For reference only)

额定电压 (kV)	额定电流 (A)	A (mm)	B (mm)	C(户内/户外) (mm)	D (mm)	E (mm)	F (mm)	G (mm)	Φ_1 (mm)	Φ_2 (mm)	重量 (kg)
3.6	800	1024	849	180	420	409	190	90	125	88	45
	1250~5000	1024	849		434	409			175		54/67
	8000	1125	905		445	460			205		75
7.2	630	1044	869	285/310	525	429	190	90	125	88	48
	1250~4500	1044	869		534	429			175		61/77
	7000	1145	970		545	525			205		87
12	630	1139	964	285/310	525	524	190	90	125	88	56
	1250~4000	1139	964		534	524			175		70/77
	6300	1240	1020		545	575			205		87
20	1250~3150	1316	1141	380/-	629	714	190	90	175	120	73/80
	5000	1417	1197		640	752			190		90
40.5	1500	1464	1289	390/430	668	849	220	110	175	120	82
	3150	1464	1289		686	849					220

注：单相宽度及重量与额定电流有关。

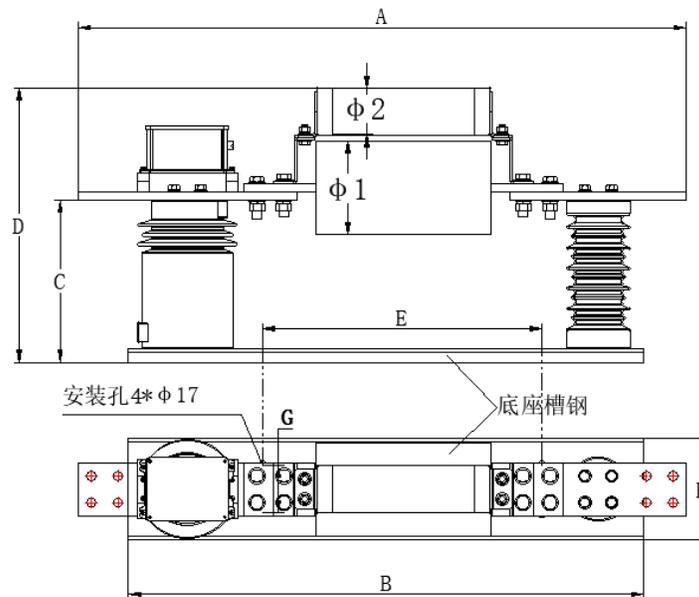


图 6 结构参数示意图

Fig6 The sketchmap of Structure Demensions

3 典型结构及工程实例 The Topical Structure And The Project Examples

3.1 分相使用实例 Examples Of Single-phase Application



(a) 户外使用 outdoor use



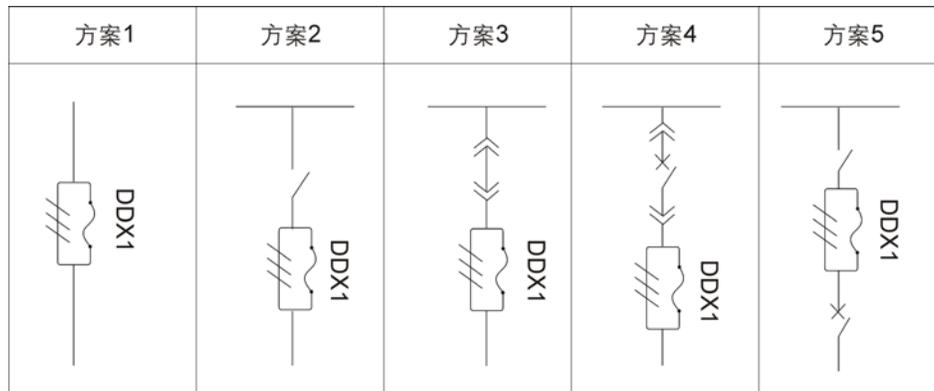
(b) 户内使用 indoor use

图6 DDX1 分相使用(旁路限流电抗器)

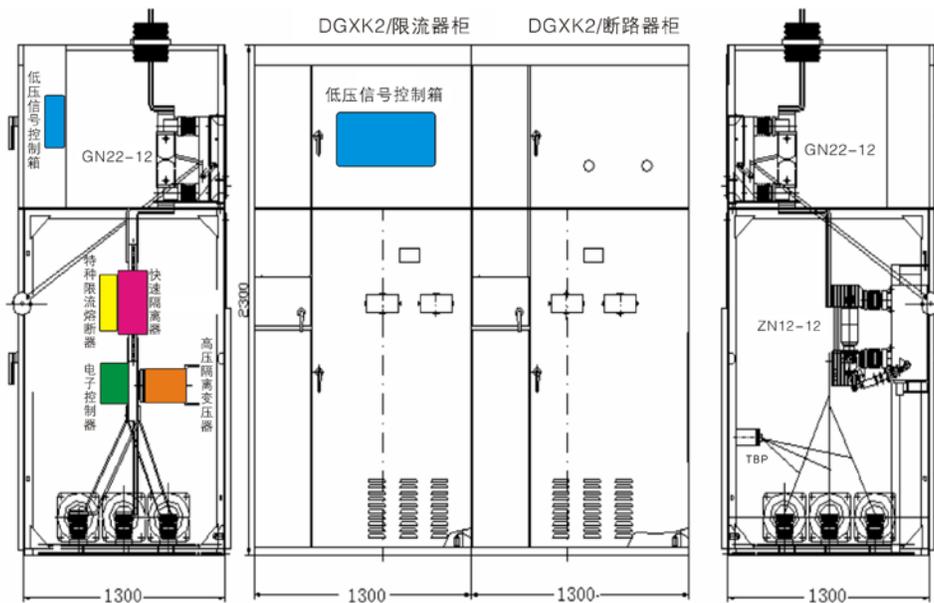
Fig6 DDX1' single-phase application(Reactor bypass)

3.2 组柜方案及实例 The Schemes To Form a Cubic And Some Examples

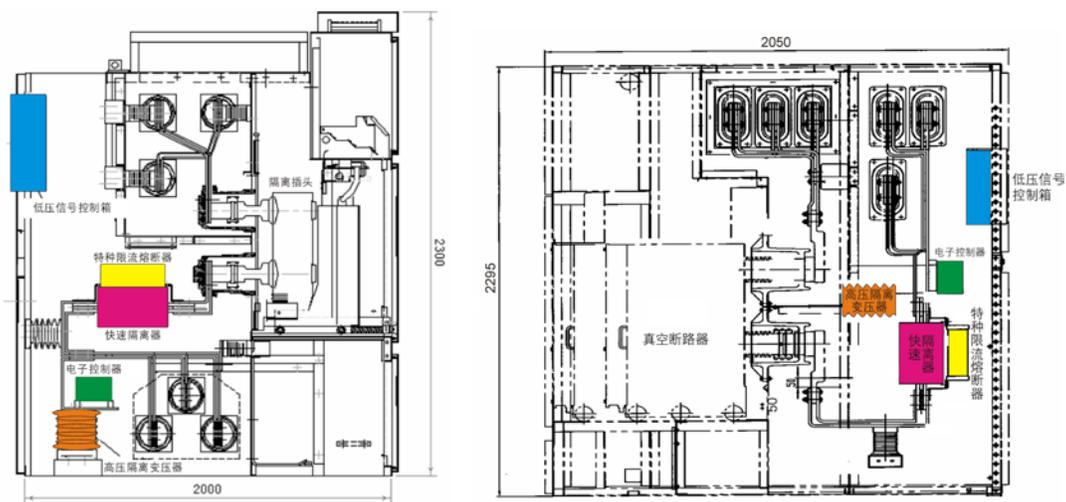
3.2.1 组柜的主接线方案 The Single Line Diagram Of The Schemes



3.2.2 典型结构实例 The Examples of Topical Structure



(a) 实例之一 Example 1



(b) 实例之二 Example 2





(c) 实物照片

Some pictures

图7 柜体典型结构示例

Fig7 The examples of topical cubic structure

4 典型应用 The Topical Applications

4.1 DDX1用于旁路限流电抗器(图8)

DDX1 used in current-limiting reactor bypass (Fig8)

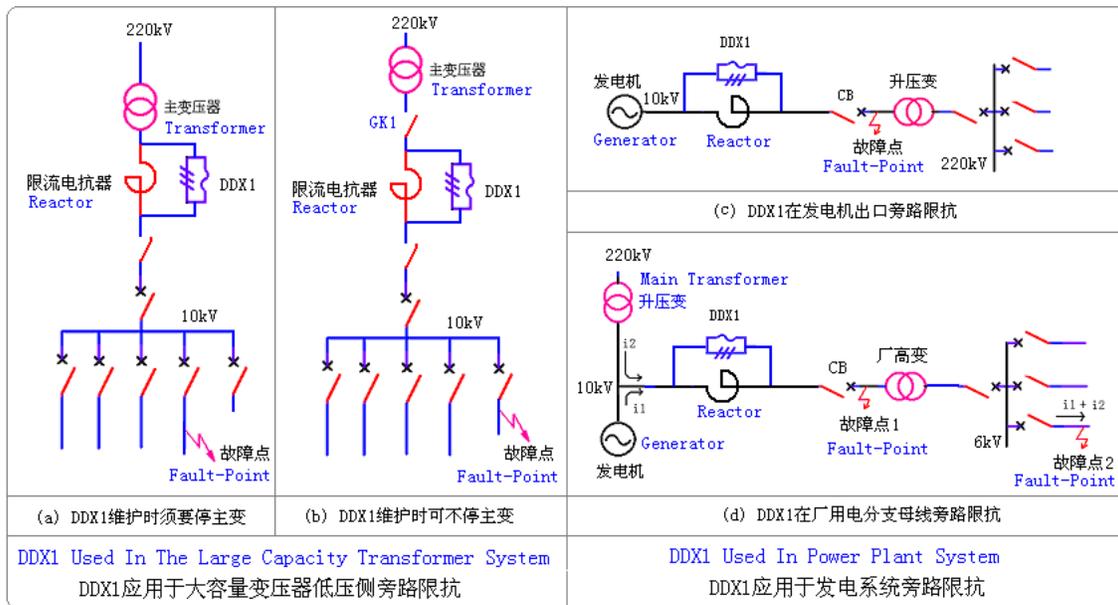


图8 (Fig 8)

DDX1 与限流电抗器并联使用的优点:

DDX1 in reactor bypass, advantages:

- 消除电抗器的有功损耗
- 消除电抗器阻抗引起的电压降落
- 避免电抗器的电磁场

- Avoid coppers loses of reactor
- Avoid voltage drop of reactor
- Avoid electro-magnetical field on the reactor

4.2 使分段母线并列运行（图9） DDX1 used in busbar system (Fig9)

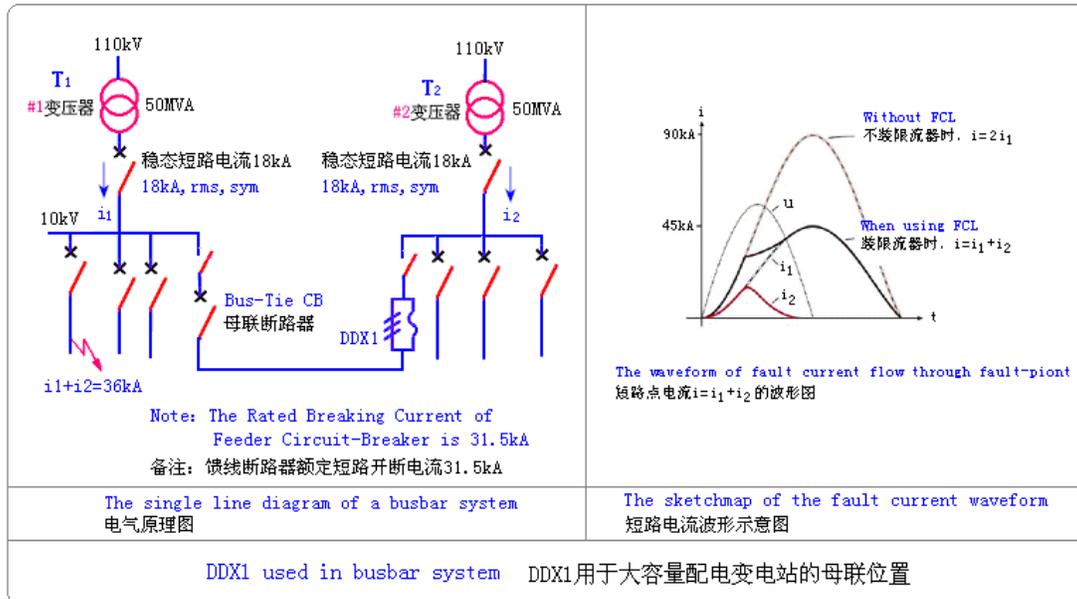


图9 (Fig 9)

在母联位置安装 DDX1 的优点:

- 改善电压质量
- 增强系统的可靠性
- 降低网络阻抗
- 优化负荷分配
- 扩容时现有的母线结构不用改动
- 增强运行方式的灵活性

DDX1 installed in bus-tie, Advantages:

- Improving power quality
- Increasing the reliability of the system
- Reduction of the network-impedence
- Optimal load flow
- Existing busbar system has not to be changed
- strenthen the operation flexibility

4.3 用于发电机组上网保护(图10) DDX1 used in generator feeder(Fig10)

DDX1用于发电机上网保护的优点: DDX1 used in generator feeder Advantages:

- 发电机的接入不需要考虑系统的短路容量
 - 不需要采用价格昂贵的发电机断路器
 - 现有的母线结构不用改动
- Generator can be connected independent on the short-circuit capability of the system
 - No need of expensive generator breaker
 - Existing bus bar system has not to be changed

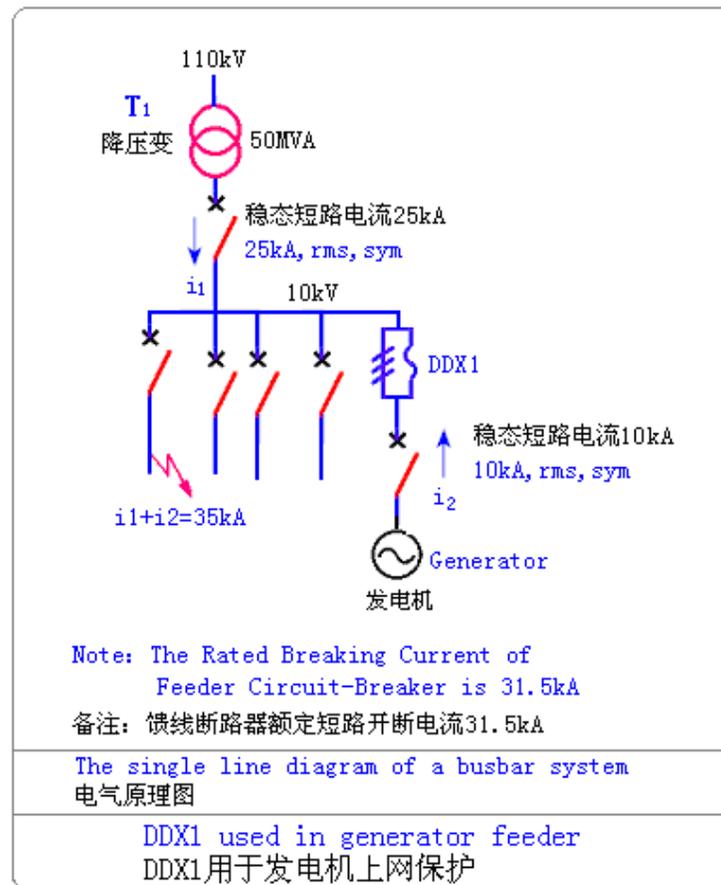


图10 (Fig 10)

4.4 用于发电系统或大容量变压器低压侧(图11)

DDX1 used in power plant system or large capacity transformer system (Fig11)

DDX1 此类用法的优点:

- 不需要采用价格昂贵的发电机断路器
- 不需要采用昂贵的封闭母线
- 不需要装设限流电抗器
- 与断路器配合实现短路电流的全面保护，更有利于系统及主设备的安全

Advantages of this application:

- No need of expensive generator breaker
- No need of expensive isolated busbar
- No need of reactor
- By cooperated with CB, to give a more efficient protection to system and main equipment

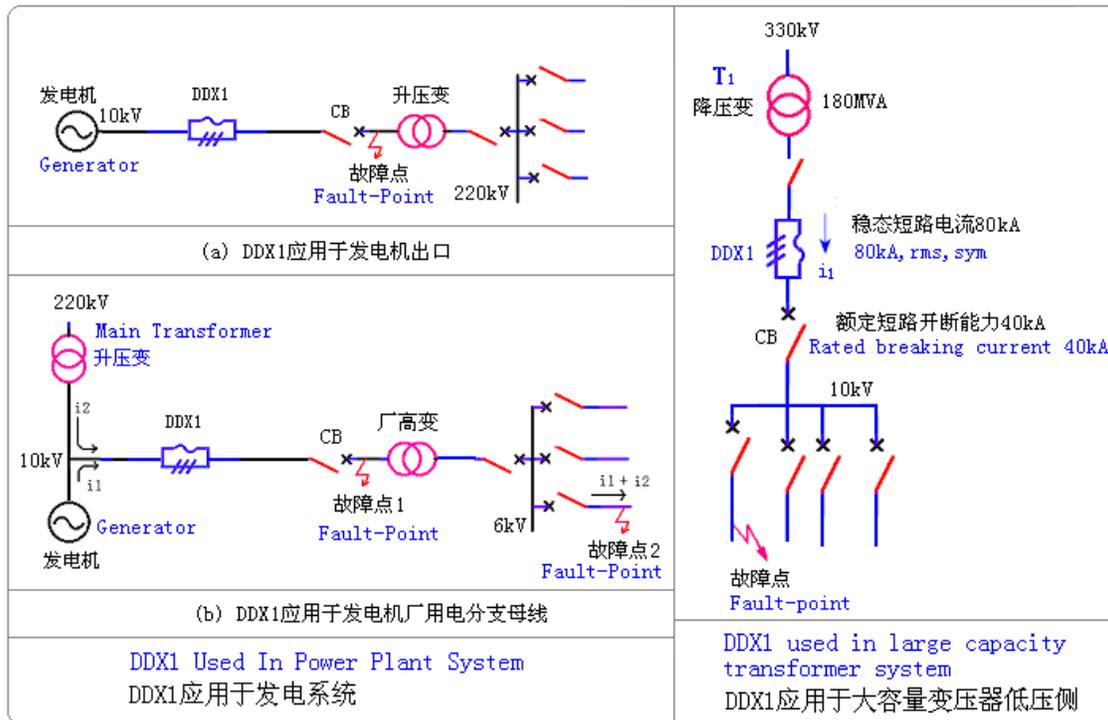


图 11 (Fig 11)



陕西蓝河电气工程有限公司

地址：中国陕西西安高新区西部大道 190 号

电话：(+86)029-84251056

网站：www.sxlhdq.com

SHAAN XI LANHE ELECTRIC ENGINEERING CO.,LTD.

Add: No.190 Western Avenue GaoXin area Xi' An PR.China

Tel: (+86)029-84251056

E-mail: sxlhdq@126.com

Web: www.sxlhdq.com